M.SC.,
MICROBIOLOGY

SYLLABUS

FROM THE ACADEMIC YEAR
2023 - 2024

TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION, CHENNAI – 600 005

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.

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)	• The lowest level of questions require student store call in formation from the course content • Knowledge questions usually require students to identify information in the text book.
Understanding (K2)	• Understanding off act sand ideas by comprehending organizing, comparing ,translating, inter polating and interpreting in their own words. • The questions go beyond simple recall and require students to combine data together
Application (K3)	• Students have to solve problems by using/applying a concept learned in the class room. • Students must use their knowledge to determine a exact response.
Analyze (K4)	• Analyzing the questionisonethatasksthestudentstobreakdownsomethingintoit scomponentparts. • Analyzingrequiresstudentstoidentifyreasonscausesormotivesa ndreachconclusionsorgeneralizations.
Evaluate (K5)	• Evaluation requires an individual to make judgment on something. • Questionstobeaskedtojudgethevalueofanidea,acharacter,aworko fart,orasolutiontoaproblem. • Students are engaged indecision-making and problem–solving. • Evaluation questions do not have single right answers.
Create (K6)	• The questions of this category challenge students to get engaged increative and original thinking. • Developing original ideas and problem solving skills

Credit Distribution for PG Courses
First Year
M.Sc., Microbiology
Semester-I

Sem	Course	Course Code	Course Title	T/P	Credit	No. of Hours	Marks		
							Int.	Ext.	Total
I	Core-I	23MMI1C1	General Microbiology and Microbial Diversity	T	5	6	25	75	100
	Core-II	23MMI1C2	Microbial Physiology	T	5	6	25	75	100
	Core – III	23MMI1P1	Practical I – General Microbiology, Microbial Diversity and Microbial Physiology	P	4	6	25	75	100
	Elective -I Discipline Centric	23MMI1E1/ 23MMI1E2/ 23MMI1E3	Forensic Science/ Nanobiotechnology/ Microalgal Technology	T	3	5	25	75	100
	Elective-II Generic:	23MMI1E4/ 23MMI1E5/ 23MMI1E6	Bioinstrumentation/ Herbal Technology and Cosmetic Microbiology / Essentials of Laboratory Management and Biosafety	T	3	5	25	75	100
	PCS	23MMI1S1	Entrepreneurship in Biobusiness	T	2	2	25	75	100
			Total		**22**	**30**	**150**	**450**	**600**
II	Core IV	23MMI2C1	Medical Bacteriology and Mycology	T	5	6	25	75	100
	Core V	23MMI2C2	Medical Virology and Parasitology	T	5	6	25	75	100
	Core VI	23MMI2P1	Practical II - Medical Microbiology	P	4	6	25	75	100
	DSE-III	23MMI2E1/ 23MMI2E2/ 23MMI2E3	Epidemiology/ Clinical Diagnostic Microbiology/ Bioremediation	T	3	4	25	75	100
	DSE-IV	23MMI2E4/ 23MMI2E5/ 23MMI2E6	Bioinformatics/ Biosafety, Bioethics and IPR / Clinical Research and Clinical Trials	T	3	4	25	75	100
	Skill Enhancement I	23MMI2S1	Vermitechnology	T	2	4	25	75	100
			Total		**22**	**30**	**150**	**450**	**600**
III	Core-VII	23MMI3C1	Immunology, Immunotechnology and Microbial Genetics	T	5	6	25	75	100
	Core-VIII	23MMI3C2	Molecular Biology and Recombinant DNA Technology	T	5	6	25	75	100
	Core – IX	23MMI3P1	Practical III - Immunology, Microbial Genetics and Molecular Biology	P	4	6	25	75	100
	Core – X	23MMI3C3	Fermentation Technology and Pharmaceutical Microbiology	T	4	6	25	75	100

	DSE -V	23MMI3E1/ 23MMI3E2/ 23MMI3E3	Soil Microbiology and Microbial Ecology/ Microbial Toxicology/ Water Conservation and Water Treatment Technologies	T	3	4	25	75	100
	Skill Enhancement II	23MMI3S1	Organic Farming and Biofertiliser Technology	T	2	2	25	75	100
		--	Internship / Industrial Activity		2	-	25	75	100
				Total	**25**	**30**	**175**	**525**	**700**
IV	Core-XI	23MMI4C1	Food and Environmental Microbiology	T	3	4	25	75	100
	Core-XII	23MMI4P1	Practical IV - Applied Microbiology	P	4	6	25	75	100
	Core-XIII	23MMI4C2	Research Methodology and Biostatistics	T	3	4	25	75	100
		23MMI4PR	Project with Viva Voce		6	10	25	75	100
	DSE-VI	23MMI4E1/ 23MMI4E2/ 23MMI4E3	Bioenergy/ Marine Microbiology/ Life Science for Competitive Examinations (20% Theory ,80% Practical)	T& P	3	4	25	75	100
	Skill Enhancement course	23MMI4S1	Microbial Quality Control and Testing	T	2	2	25	75	100
		--	Extension Activity		1	-	-	-	-
				Total	**22**	**30**	**150**	**450**	**600**
				Grand Total	**91**	**-**	**625**	**1875**	**2500**

PCS-Professional Competency Skill

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
23MMI1C1	**General Microbiology and Microbial Diversity**	**Core Course I**	**-**	**T**	**-**	**-**	**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.

	Details	**No.of Hours**	**Course Objectives**
UNIT I	History and Scope of Microbiology.Microscopy– Principles and applications. Types of Microscopes - Bright field, Dark-field, Phase-contrast, Fluorescence microscope, Transmission electron microscope (TEM) and Scanning electron microscope (SEM). Sample preparation for SEM & TEM. Atomic force, Confocal microscope. Micrometry – Stage, Ocular and its applications.	20	CO1
UNIT II	Microbial techniques - Safety guidelines in Microbiology Laboratories. Sterilization, Disinfection and its validation. Staining methods – Simple, Differential and Special staining. Automated Microbial identification systems - Pure cultures techniques – Cultivation of Anaerobic organisms. Maintenance and preservation of pure cultures. Culture collection centres - National and International.	15	CO4
UNIT III	Algae - Distribution, morphology, classification, reproduction and economic importance. Isolation of algae from soil and water. Media and methods used for culturing algae, Strain selection and large-scale cultivation. Life cycle - *Chlamydomonas*, *VolvoxSpirogyra* (Green algae), *Nostoc* (Cyanobacteria) *Ectocarpus, Sargassum* (Brown algae), *Polysiphonia*, *Batrachospermum* (Red algae).	15	CO3
UNIT IV	BacterialStructure, properties and biosynthesis of cellular components – Cell wall. Actinomycetes and Fungi - Distribution, morphology, classification, reproduction and economic importance. Sporulation. Growth and nutrition - Nutritional requirements, Growth curve, Kinetics of	20	CO2

	growth, Batch culture, Synchronous growth, Measurement of growth and factors affecting growth.		
UNIT V	Biodiversity - Introduction to microbial biodiversity – Thermophiles - Classification, Thermophilic Archaebacteria and its applications. Methanogens - Classification, Habitats, applications. Alkaliphiles and Acidophiles - Classification, discovery basin, its cell wall and membrane. Barophiles - Classification and its applications. Halophiles - Classification, discovery basin, cell walls and membranes – purple membrane, compatible solutes. Microbial stress response - Osmoadaptation / halotolerance - Applications of halophiles.	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
23MMI1C2	**Microbial Physiology**	**Core Course II**	**-**	**T**	**-**	**-**	**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
UNIT I	Nutrition – Nutritional requirements and types in bacteria – Phototrophs, Chemotrophs, Autotrophs and Heterotrophs. Nutrient transport mechanisms- Passive diffusion, Facilitated diffusion, Active transport, Group translocation and Specific transport system..	20	CO1
UNIT 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
UNIT III	Enzymes – properties, functions and regulation. Basic concepts of metabolism, Oxidation – reduction reactions, Energy generation by anaerobic metabolism – Glycolysis, Pentose Phosphate pathway, ED pathway, Fermentation. Energy generation by Aerobic metabolism - TCA cycle, Glycoxylate pathway and Electron Transport chain, Mechanism of ATP synthesis – Chemiosmosis, Pasteur effect. Metabolism of lipids-β oxidation.	25	CO3
UNIT 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
UNIT V	Photosynthesis – process, antenna of light-harvesting pigments, Photochemical reaction centers, Photosynthetic Electron Transport Chain-Cyclic and Non-cyclic. Oxygenic and Anoxygenic Photosynthesis. Calvin-Benson cycle. Bioluminescence - Process and application.	12	CO5

	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. 2ndEdn. 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?journalC

	ode=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
23MMI 1P1	Practical I – General Microbiology, Microbial Diversity and Microbial Physiology	**Core Practical I**	**-**	**-**	**P**	**-**	**4**	**6**	**25**	**75**	**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**
UNIT I	Microscopic Techniques: Light microscopy: Hay infusion broth. Wet mount to show different types of microbes, hanging drop. Micrometry. Dark field microscopy – Motility of Spirochetes. Washing and cleaning of glass wares: Sterilization methods: moist heat, dry heat, and filtration. Quality control check for each method.	20	CO1
UNIT II	Staining techniques - Simple staining, Gram's staining, Acid fast staining, Meta chromatic granule staining, Spore, Capsule, Flagella.	20	CO2
UNIT III	Media Preparation: Preparation of liquid, solid and semisolid media. Agar deeps, slants, plates. Preparation of basal, enriched, selective and enrichment media. Preparation of Biochemical test media, media to demonstrate enzymatic activities.	20	CO3
UNIT 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
UNIT V	Bacterial growth curve. Effect of physical and chemical factors on growth. Anaerobic culture methods.	20	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Apply microscopic techniques and staining methods in the	PO1, PO6, PO7, PO8,

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

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.	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. 2nd edn. Wm. C. Brown publishers, Dubugue.
4.	Gottschalk, G. (1986). Bacterial Metabolism.2nd Edn. Springer-Verlag, New York.
5.	Rose, A.H. (1976). An Introduction to Microbial Physiology. 3rd Edn. Plenum, New York.

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	
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	Total	100 Marks

Methods of Assessment	
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Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14
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
23MMI1E1	**Forensic Science**	**Elective Course I A**	**-**	**T**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives			
CO1	Understand the Scope, need and learn the tools and techniques inforensic 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	Recognizemedico legal post mortem procedures and their importance.		
UNIT	**Details**	**No.of Hours**	**Course Objectives**
UNIT 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
UNIT II	Forensic science laboratories - Organizational setup of a forensic science laboratory. Central and State level laboratories in India. Mobile forensic science laboratory and its functions. Forensic microbiology - Types and identification of microbial organisms of forensic significance.	12	CO2
UNIT 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
UNIT IV	DNA profiling - Introduction, history of DNA typing. Extraction of DNA from blood samples -Organic and Inorganic extraction methods. DNA fingerprinting - RFLP, PCR, STR. DNA testing in disputed paternity.	12	CO4
UNIT V	Forensic toxicology - Introduction and concept of forensic toxicology. Medico legal post mortem and their examination. Poisons - Types of poisons and their mode of action.	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
23MMI1E2	Nano biotechnology	Elective Course I B	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
UNIT I	Introduction to nanobiotechnology, Nano size-changing phenomena at nano scale, Classification of nanomaterials based on their dimensions (0D, 1D, 2D and 3D materials) and based on realization of their applications (The First, second, third and fourth generation materials),Class of nanomaterials and their applications. Need for nanomaterials and the risks associated with the materials.	12	CO1
UNIT 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
UNIT III	Characterization of nanoparticles – Based on particle size/morphology- Dynamic light scattering (DLS),Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy(AFM), Based on surface charge-zeta potential, Based on structure –X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), Energy dispersive X-ray analysis (EDX),Based on optical properties- UV – Spectrophotometer, Based on magnetic properties-Vibrating sample magnetometer(VSM).	12	CO3
UNIT IV	Nanomaterial based Drug delivery and therapeutics-surface modified nano particles, MEMS/NEMS based devices, peptide/DNA coupled nanoparticles, lipid and inorganic nano particles for drug delivery, Metal/metaloxide nano particles as antibacterial, antifungal and antiviral agents. Toxicity of nanoparticles and Toxicity Evaluation.	12	CO4
UNIT 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
23MMI 1E3	Microalgal Technology	Elective CourseI C	-	T	-	-	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
UNIT I	Introduction to Algae - General characteristics. Classification of algae according to Fritsch. Salient features of different groups of algae. Distribution - Freshwater, brackish water and marine algae. Identification methods. An overview of applied Phycology. Economically important microalgae.	12	CO1
UNIT II	Cultivation of freshwater and marine microalgae - Growth media. Isolation and enumeration of microalgae. Laboratory cultivation and maintenance. Outdoor cultivation - Photobioreactors - construction, types and operation; raceway ponds - Heterotrophic and mixotrophic cultivation - Harvesting of microalgae biomass.	12	CO2
UNIT III	Microalgae in food and nutraceutical applications - Algal single cell proteins. Cultivation of *Spirulina* and*Dunaliella.* Microalgae as aquatic, poultry and cattle feed. Microalgalbiofertilizers. 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
UNIT IV	Microalgae in environmental applications. Phycoremediation - Domestic and industrial waste water treatment. High-rate algal ponds and surface-immobilized systems - Treatment of gaseous wastes by microalgae. Sequestration of carbon dioxide. Scavenging of heavy metals by microalgae. Negative effects of algae. Algal blooms, algicides for algal control.	12	CO4
UNIT V	Microalgae as feed stock for production of biofuels - Carbon-neutral fuels. Lipid-rich algal strains - *Botryococcusbraunii*. 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 useof 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 andSustainability. 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. CRCPress.
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 /	MCQ, True/False, Short essays, Concept explanations, Short summary or

Comprehend (K2)	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
23MMI1E4	Bioinstrumentation	Elective Course II A	-	T	-	-	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
UNIT I	Basic laboratory Instruments. Aerobic and anaerobic incubator – Biosafety Cabinets - Fume Hood, pH meter, Lyophilizer, Flow cytometry. Centrifugation techniques: Basic principles of centrifugation - Standard sedimentation coefficient - measurement of sedimentation co-efficient; Principles, methodology and applications of differential, rate zonal and density gradient centrifugation - Applications in determination of molecular weight.	12	CO1
UNIT II	General principles of chromatography - Chromatographic Performance parameters; Types- Thin layer chromatography, Paper Chromatography, Liquid chromatography (LPLC &HPLC), Adsorption, ion exchange, Gel filtration, affinity, Gas liquid (GLC). Flash Chromatography and Ultra Performance convergence chromatography. Two dimensional chromatography. Stimulated moving bed chromatography (SEC).	12	CO2
UNIT III	Electrophoresis: Principle and applications - paper electrophoresis, Serum electrophoresis, starch gel electrophoresis, Disc gel, Agarose gel, SDS – PAGE, Immuno electrophoresis. Blotting techniques -Southern, northern and western blotting.	12	CO3
UNIT IV	Spectroscopic techniques: Principle, simple theory of absorption of light by molecules, electromagnetic spectrum, instrumentation and application of UV- visible, FTIR spectrophotometer, Atomic Absorption Spectrophotometer, Flame spectrophotometer, NMR, ESR, Emission Flame Photometry and GC-MS. Detection of molecules in living cells - FISH and GISH. Biophysical methods: Analysis of biomolecules by Spectroscopy UV/visible.	12	CO4

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 1E5	**Herbal Technology and Cosmetic Microbiology**	**Elective Course II B**	**-**	**T**	**-**	**-**	**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
UNIT I	Herbs, Herbal medicine - Indian medicinal plants: Scope and Applications of Indian medicinal plants in treating bacterial, fungal and viral diseases. Basic principles involved in Ayurvedha, Sidha, Unani and Homeopathy.	12	CO1
UNIT II	Collection and authentication of selected Indian medicinal plants: *Emblica officinalis, Withania somnifera, Phyllanthus amarus, Tinospora cordifolia, Andrographis paniculata, Piper longum, Ocimum sanctum, Azardirchata indica, Terminalia chebula, Allium sativum*. Preparation of extracts- Hot and cold methods. Preparation of stock solutions.	12	CO2
UNIT III	Antimicrobial activity of selected Indian medicinal Plants: - In vitro determination of antibacterial and fungal activity of selected whole medicinal plants/ parts – well-diffusion methods. MIC - Macro and micro dilution techniques. Antiviral activity- cell lines- cytotoxicity, cytopathic and non-cytopathic effect.	12	CO3
UNIT IV	History of Cosmetic Microbiology – Need for cosmetic microbiology, Scope of cosmetic microbiology, - Role of microbes in cosmetic preparation. Preservation of cosmetics. Antimicrobial properties of natural cosmetic products – Garlic, neem, turmeric, aloe vera and tulsi. Sanitary practices in cosmetic manufacturing - HACCP protocols in cosmetic microbiology.	12	CO4
UNIT V	Cosmetic microbiology test methods - Antimicrobial preservative efficacy, microbial content testing and biological toxicological testing. Validation methods - bioburden and Pharmacopeial microbial assays. Preservatives of cosmetics - Global regulatory and toxicological aspect of cosmetic preservatives.	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
23MMI1E6	**Essentials of Laboratory Management and Biosafety**	**Elective Course II C**	**-**	**T**	**-**	**-**	**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
UNIT I	Introduction to the laboratory and laboratory hazards - General laboratory facilities – Occupational safety- Lab accidents - Fires, chemical burns, slips and falls, Animal bites. Cuts from broken glass. Toxic fume inhalation. General laboratory rules, Good laboratory practice (GLP). Laboratory plan.	12	CO1
UNIT II	Common hazards in laboratory: Chemical hazards- Safe handling of chemicals and gases, hazard labels and symbols. Material safety datasheet (MSDS), Chemical handling-Fume hood, Storage of chemicals. Chemical Waste Disposal Guideline. Physical hazards - Physical agent data sheets (PADS), Electric hazards- Electrical shock, Electrical explosions, Electrical burns. Safe work practices. Potential ignition sources in the lab. Stages of Fire. Fire Extinguishers. Fire Response.	12	CO2
UNIT III	Prevention and First aid for laboratory accidents. Personal protective equipment (PPE), Proper attire (Eye/Face Protection, laboratory coats, gloves, respirators. Disposal/Removal of PPE. Emergency equipment safety - Showers/ Eye Washes. Laboratory security and emergency response. First aid for- Injuries caused by broken glass, Acid/Alkali splashes on the skin, swallowing acid/alkali, burns caused by heat, electric shock.	12	CO3
UNIT IV	Biosafety - Historical background. Blood borne pathogens (BBP) and laboratory-acquired infections. Introduction to biological safety cabinets. Primary containment for biohazards. Biosafety levels of specific microorganisms. Recommended biosafety. Levels for infectious agents and infected animals. Risk groups with examples - Risk assessment. Safety levels. Case studies - Safe working, hand hygiene. Laboratory instruments, packing, sending, transport, import and export of biological agents. Hygiene, disinfection, decontamination, sterilization.	12	CO4
UNIT V	Biosafety regulations and guidelines. Centers for disease control and prevention and the National institutes of health. Occupational	12	CO5

	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.		
	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). (5th Edition). Lulu.com.
4.	Kanai. L. Mukherjee. (Medical Laboratory Technology(4th Edition). CBS Publishers.
5.	Ramakrishnan (2012). Manual of Medical Laboratory Techniques. JP brothers.
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			

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMIPS1	**Entrepreneurship in Biobusiness**	**Professional Competency Course**	**-**	**T**	**-**	**-**	**2**	**2**	**25**	**75**	**100**

Course Objectives

CO1	Understanding basic concepts in the area of entrepreneurship, the role and importance of entrepreneurship for economic development.
CO2	Developing personal creativity and entrepreneurial initiative, adopting of the key steps in the elaboration of business idea.
CO3	Understanding the stages of the entrepreneurial process and the resources needed for the successful development of entrepreneurial ventures.
CO4	Explain the central components of successful business strategies in biotechnology, and create a business plan.
CO5	Acquire knowledge about proposal preparation, funding and face challenges in biobusiness.

UNIT	Details	No.of Hours	Course Objectives
UNIT I	Bio Entrepreneurship - Introduction to bio-business, SWOT analysis of bio-business. Ownership. Development of Entrepreneurship. Stages in entrepreneurial process. Government schemes and funding. Small scale industries - Definition, characteristics, need and rationale.	6	CO1
UNIT II	Entrepreneurship opportunity in agricultural Microbiology - Business opportunity, Essential requirement, marketing, strategies, schemes, challenges and scope. Case study on Plant cell and tissue culture technique, polyhouse culture. Herbal bulk drug production, nutraceuticals, value added herbal products. Bioethanol production using agricultural waste, algal source. Integration of system biology for agricultural applications. Biosensor development in agri management.	6	CO2
UNIT III	Entrepreneurship opportunity in industrial biotechnology - Business opportunity, Essential requirement, marketing strategies, schemes, challenges, and scope. Pollution monitoring and Bioremediation for Industrial pollutants. Integrated compost production- microbe enriched compost. Bio pesticide/ insecticide production. Biofertilizers. Single cell protein.	6	CO3
UNIT IV	Therapeutic and Fermented products - Stem cell production, stem cell bank, production of monoclonal/polyclonal antibodies, secondary metabolite production – antibiotics, probiotic and prebiotics.	6	CO4
UNIT V	Project Management, Technology Management and Startup Schemes - Building Biotech business challenges in Indian	6	CO5

	context-biotech partners (BIRAC, DBT, Incubation centers. etc.,), operational biotech parks in India. Indian Company act for Biobusiness-schemes and subsidies. Project proposal preparation, Successful start-ups-case study.		
	Total	30	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Describe and apply several entrepreneurial ideas and business theories in practical framework.	PO1, PO2, PO4, PO5, PO8, PO12
CO2	Analyse the business environment in order to identify business opportunities, identify the elements of success of entrepreneurial ventures, evaluate the effectiveness of different entrepreneurial strategies and interpret their own business plan.	PO1, PO2, PO4, PO7, PO10, PO11
CO3	Express the mass production of microbial inoculants used as Biofertilizers and Bioinsecticides in response with field application and crop response.	PO1, PO4, PO5, PO8, PO9, PO11
CO4	Analyze the application and commercial production of Monoclonal antibodies, Cytokines. TPH and teaching kits.	PO2, PO4, PO8, PO11
CO5	Integrate and apply knowledge of the regulation of biotechnology industries, utilize effective team work skills within an effective management team with a common objective, and gain effective team work skills, with an awareness of cultural diversity and social inclusiveness.	PO4, PO5, PO8, PO9, PO12

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

References Books	
1.	Crueger, W, and Crueger. A. (2017). Biotechnology: A TextBook of Industrial Microbiology. (2ndEdition). Medtech. ISBN-10 : 9385998633
2.	Teng P. S.(2008). Bioscience Entrepreneurship in Asia.World Scientific Publishing Company. 2008.

3.	Agarwal S., Kumari S. and Khan S. (2021). Bioentrepreneurship and Transferring Technology into Product Development. Business Science Reference. ISBN-10 : 1799874125
4.	Krishnamurthy A.G. Dirubai Ambani Against All Odds. McGraw Hills.
5.	Peter F. Drucker. Innovation and Entrepreneurship (1985).

Web Resources

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

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				S		
CO2	S	S		S			S			S	S			
CO3	S			S	S			S	S		S			
CO4		S		S				S			S			
CO5				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
23MMI2C1	**Medical Bacteriology and Mycology**	**Core Course IV**	**-**	**T**	**-**	**-**	**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.

	Details	**No. of Hours**	**Course Objectives**
UNIT I	Classification of medically important bacteria, Normal flora of human body, Collection, transport, storage and processing of clinical specimens, Microbiological examination of clinical specimens, antimicrobial susceptibility testing. Handling and maintenance of laboratory animals – Rabbits, guinea pigs and mice.	20	CO1
UNIT II	Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of *Staphylococci, Streptococci, Pneumococci, Neisseriae*., *Bacillus, Corynebacteria, Mycobacteria* and *Clostridium.*	20	CO2
UNIT III	Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by Enterobacteriaceae members, *Yersinia, Pseudomonas, Vibrio, Mycoplasma, Helicobacter, Rickettsiae, Chlamydiae, Bordetella, Francisella., Spirochaetes-Leptospira, Treponema*and *Borrelia*. Nosocomial, zoonotic and opportunistic infections -prevention and control.	20	CO3
UNIT IV	Morphology, taxonomy and classification of fungi. Detection and recovery of fungi from clinical specimens. Dermatophytes and agents of superficial mycoses. *Trichophyton, Epidermophyton&Microsporum*. Yeasts of medical importance – *Candida, Cryptococcus*. Mycotoxins. Antifungal agents, testing methods and quality control.	15	CO4
UNIT V	Dimorphic fungi causing Systemic mycoses, *Histoplasma, Coccidioides, Sporothrix, Blastomyces.* Fungi causing EumycoticMycetoma, Opportunistic fungi-Fungi causing secondary infections in	15	CO5

	immunocompromised patients. Immunodiagnostic methods in mycology- Recent advancements in diagnosis. Antifungal agents.		
	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'sText 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.9thedn. Edward Arnold, London.
5.	Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology.Pfaller. 7thedn. 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
CO 1	M				S				M					
CO 2	M				S				M					
CO 3	M				S				M					
CO 4					S				M					
CO 5					S				M					

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI2C2	**Medical Virology and Parasitology**	**Core Course V**	**-**	**T**	**-**	**-**	**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.

	Details	**No. of Hours**	**Course Objectives**
UNIT I	General properties of viruses - Structure and Classification - viroids, prions, satellite RNAs and virusoids. Cultivation of viruses -embryonated eggs, experimental animals and cell cultures. Purification and Assay of viruses – Physical and Chemical methods (Electron Microscopy, Protein and Nucleic acids studies.) Infectivity Assays (Plaque and end-point).	20	CO1
UNIT II	Virus Entry, Host Defenses Against Viral Infections, Epidemiology, pathogenic mechanisms, Pathogenesis, laboratory diagnosis, treatment for the following viruses: DNA Viruses- Pox , Herpes , Adeno , Papova and Hepadna , RNA Viruses- Picorna, Orthomyxo, Paramyxo, Rhabdo, Rota, HIV and other Hepatitis viruses, Arbo – Dengue virus, Ebola virus, Emerging and reemerging viral infections	20	CO2
UNIT III	Bacterial viruses - ΦX 174, M13, MU, T4, lambda, Pi; Structural organization, life cycle and phage production. Lysogenic cycle-typing and application in bacterial genetics. Diagnosis of viral infections –conventional serological and molecular methods. Antiviral agents and viral vaccines.	15	CO3
UNIT IV	Introduction to Medical Parasitology – Classification, host-parasite relationships. Epidemiology, life cycle, pathogenic mechanisms, laboratory diagnosis, treatment for the following: Protozoa causing human infections – *Entamoeba,* Aerobic and Anaerobic amoebae, *Giardia, Trichomonas, Balantidium. Toxoplasma, Cryptosporidium, Leishmania,* and *Trypanasoma.*	15	CO4
UNIT V	Classification, life cycle, pathogenicity, laboratory diagnosis and treatment for parasites – Helminthes - Cestodes – *TaeniaSolium, T. Saginata, T. Echinococcus*. Trematodes – *Fasciola Hepatica, FasciolopsisBuski, Paragonimus, Schistosomes*. Nematodes - *Ascaris, Ankylostoma, Trichuris, Trichinella, Enterobius,*	20	CO5

	*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.		
	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, NewDelhi.
5.	Arora, D. R. and Arora B. B. (2020). Medical Parasitology. (5thEdition). 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	PO10	PO11	PO12	PO13	PO14
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
23MMI2P1	**Practical II - Medical Microbiology**	**Core Practical II**	**-**	**-**	**P**	**-**	**4**	**6**	**25**	**75**	**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.

	Details	**No. of Hours**	**Course Objectives**
UNIT I	Staining of clinical specimens - Wet mount, Differential and Special staining methods. Isolation and identification of bacterial pathogens from clinical specimens - cultivation in basal, differential, enriched, selective and special media – Biochemical identification tests. Enumeration of bacteria in urine to detect significant bacteriuria. Antimicrobial sensitivity testing - Kirby Bauer method and Stokes method. Minimum inhibitory concentration (MIC) test. Minimum bactericidal concentration (MBC) test.	20	CO1
UNIT II	Identification and Classification of common fungi. Examination of different fungi by Lactophenol cotton blue staining. Examination of different fungi by KOH staining. Cultivation of fungi and their identification - *Mucor, Rhizopus, Aspergillus, Penicillium.* Microscopic observation of different asexual fungal spores. Microscopic observation of fungal fruiting bodies. Identification of Dermatophytes.	20	CO2
UNIT 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
UNIT IV	Examination of parasites in clinical specimens - Ova/cysts in faeces. Concentration: methods – Floatation methods-simple Saturated salt solution method – Zinc sulphate methods - Sedimentation methods- Formal ether	15	CO4

	method. Blood smear examination for malarial parasites. Thin smear by Leishman's stain – Thick smear by J.B. stain.		
UNIT V	Identification of common arthropods of 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.	ParijaS. C. (2012). Textbook of Practical Microbiology. Ahuja Publishing House.
4.	Cappuccimo, J. and Sherman, N. (2002) Microbiology: A Laboratory Manual, (6th Edition). 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
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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							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
23MMI 2E1	Epidemiology	Elective Course III A	-	T	-	-	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.

	Details	No. of Hours	Course Objectives
UNIT I	Fundamentals of epidemiology - Definitions of epidemiology – Epidemiology of infectious diseases in Public Health. Natural history of disease -Historical aspects of epidemiology. Common risk factors- Epidemiologic Triad-Agent factors, host factors and environmental factors. Transmission basics- Chain of infection, portal of entry. Modes of transmission-Direct and indirect. Stages of infectious diseases. Agents and vectors of communicable diseases of public health importance and dynamics of disease transmission. Epidemiology of Zoonosis- Factors, routes of transmission of bacterial, viral, parasitic and fungal zoonotic agents. Control of zoonosis.	12	CO1
UNIT II	Tools of Epidemiology - Measures of Disease -Prevalence, incidence. Index case. Risk rates. Descriptive Epidemiology - Cohort studies, measuring infectivity, survey methodology including census procedures. Surveillance strategies - Disease surveillance, geographical indication system, outbreak investigation in public health andcontact investigation.	12	CO2
UNIT III	Epidemiological aspects of diseases of national importance-Background to communicable and non-communicable diseases. Vector borne diseases in India. Diarrhoeal diseases.Zoonoses. Viral haemorrhagic fevers. Mycobacterial infections. Sexually transmitted diseases. Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS). Emerging disease threats- Severe Acute Respiratory Syndrome (SARS), Covid-19, Ebola, MDR-TB,Malaria, Mucor mycosis, Avian flu. Dengue, Swine Flu, Chikungunya. Epidemiology, prevention, and control of non-communicable diseases- Asthma, Coronary heart disease, Malignancy, diabetes mellitus, respiratory diseases, eye diseases, Dental disorders. Emerging and Re-emerging Diseases.	12	CO3

UNIT IV	Mechanisms of Antimicrobial resistance - Multidrug Efflux pumps, Extended Spectrum β-lactamases (ESBL). Hospital acquired infections-Factors, infection sites, mechanisms, Role of Multidrug resistant pathogens. Role of *Pseudomonas, Acinetobacter, Clostridium difficile,*HBV, HCV, Rotavirus*, Cryptosporidium* and *Aspergillus* in Nosocomial infections. Prevention and management of nosocomial infections.	12	CO4
UNIT V	National Programmes related to Communicable and Non-Communicable diseases - National Malaria Eradication Programme, Revised National Tuberculosis Control Programme, Vector Borne Disease Control Programme, National AIDS Control Programme, National Cancer Control Programme and National Diabetes Control Programme. Biochemical and immunological tools in epidemiology- Biotyping, Serotyping, Phage typing, FAME (Fatty acid methyl ester analysis), Curie Point PyMS (Pyrolysis Mass spectrometry), Protein profiling, Molecular typing methods.	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 design the control of antimicrobial resistance and its management.	PO5,
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.5thedn. 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.	TopleyW.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	PO10	PO11	PO12	PO13	PO14
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
23MMI2 E2	Clinical Diagnostic Microbiology	Elective Course III B	-	T	-	-	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.		
	Details	**No. of Hours**	**Course Objectives**
UNIT I	Microbiology Laboratory Safety Practices -General Safety Guidelines, Handling of Biological Hazards, Infectious health care waste disposal - Biomedical waste management, Emerging and Re-emerging infections.	12	CO1
UNIT II	Diagnostic procedures - General concept of Clinical specimen collection, transport, storage and general processing in Microbiology laboratory - Specimen acceptance and rejection criteria.	12	CO2
UNIT III	Diagnosis of microbial diseases - Clinical, differential, Microbiological, immunological and molecular diagnosis of microbial diseases. Modern and novel microbial diagnostic methods. Automation in Microbial diagnosis.	12	CO3
UNIT IV	Antibiotic sensitivity tests - Disc diffusion - Stokes and Kirby Bauer methods, E test - Dilution - Agar dilution & broth dilution - MBC/MIC - Quality control for antibiotics and standard strains.	12	CO4
UNIT 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.	BennettJ.E., Dolin R. and BlaserM.J. (2019). Principles and Practice of Infectious Diseases. (9thEdition). 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 WinnW.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	
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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14
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
23MMI2E3	Bioremediation	Elective Course III C	-	T	-	-	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.		
	Details	**No.of Hours**	**Course Objectives**
UNIT I	Bioremediation- process and organisms involved. Bioaugmentation - Ex-situ and in-situ processes; Intrinsic and engineered bioremediation. Major pollutants and associated risks; organic pollutant degradation. Microbial aspects and metabolic aspects. Factors affecting the process. Recent developments and significance.	12	CO1
UNIT II	Microbes involved in aerobic and anaerobic processes in nature. Water treatment- BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal.Secondary waste water treatments - use of membrane bioreactor. Aquaculture effluent treatment. Aerobic sludge and landfill leachate process. Aerobic digestion.	12	CO2
UNIT III	Composting of solid wastes, anaerobic digestion - methane production and important factors involved, Pros and cons of anaerobic process, sulphur, iron and nitrate reduction, hydrocarbon degradation, degradation of nitroaromaticcompounds.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
UNIT IV	Microbial leaching of ores- process, microorganisms involved and metal recovery with special reference to copper and iron. Biotransformation of heavy metals and xenobiotics. Petroleum biodegradation - reductive and oxidative.Dechlorination. Biodegradable of plastics and super bug.	12	CO4
UNIT V	Phytoremediation of heavy metals in soil - Basic principles of phytoremediation - Uptake and transport, Accumulation and sequestration. Phytoextraction. Phytodegradation.	12	CO5

	Phytovolatilization. Rhizodegradation.Phytostabilization – Organic and synthetic amendments in multi metal contaminated mine sites. Role of Arbuscularmycorrhizal 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 Arbuscularmycorrhizal 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
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									
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
23MMI 2E4	Bioinformatics	Elective Course IV A	-	T	-	-	3	4	25	75	100

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.

	Details	No.of Hours	Course Objectives
UNIT I	Biological Data Mining –Exploration of Data Mining Tools. Cluster Analysis Methods. Data Visualization. Biological Data Management. Biological Algorithms – Biological Primary and Derived Databases. Concept of Alignment, Pairwise Sequence Alignment (PSA), Multiple Sequence Alignment (MSA), BLAST, CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).	12	CO1
UNIT II	Phylogenetic Tree Construction - Concept of Dendrograms. Evolutionary Trees - Distance Based Tree Reconstruction - Ultrametric trees and Ultrametric distances – Reconstructing Trees from Additive Matrices - Evolutionary Trees and Hierarchical Clustering - Character Based Tree Reconstruction - Maximum Parsimony Method, Maximum likelihood method - Reliability of Trees – Substitution matrices – Evolutionary models.	12	CO2
UNIT III	Computational Protein Structure prediction – Secondary structure – Homology modelling- Fold recognition and ab initio 3D structure prediction – Structure comparison and alignment – Prediction of function from structure. Geometrical parameters – Potential energy surfaces – Hardware and Software requirements-Molecular graphics – Molecular file formats-Molecular visualization tools.	12	CO3
UNIT IV	Prediction of Properties of Ligand Compounds – 3D Autocorrelation -3D Morse Code-Conformation Dependent and Independent Chirality Codes –Comparative Molecular Field Analysis – 4 D QSAR –HYBOT Descriptors – Structure Descriptors – Applications – Linear Free Energy Relationships – Quantity Structure - Property Relationships –Prediction of the Toxicity of Compounds	12	CO4
UNIT V	Molecular Docking- Flexible - Rigid docking- Target- Ligand	12	CO5

	preparation- Solvent accessibility- Surface volume calculation, Active site prediction- Docking algorithms- Genetic, Lamarckian - Docking analyses- Molecular interactions, bonded and nonbonded - Molecular Docking Software and Working Methods. Genome to drug discovery – Subtractive Genomics – Principles of Immunoinformatics and Vaccine Development.		
	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.	BaxevanisA. D. andOuellette 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.	HarshawardhanP.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
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	PO10	PO11	PO12	PO13	PO14
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
23MMI2E5	**Biosafety, Bioethics and IPR**	**Elective Course IV B**	**-**	**T**	**-**	**-**	**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		
	Details	**No.of Hours**	**Course Objectives**
UNIT I	Intellectual Property Rights: Different forms of Intellectual Property Rights – their relevance, importance to industry, Academia. Role of IPR's in Biotechnology, Patent Terminology - Patents, trademarks, copyrights, industrial designs, geographical indications, trade secrets, non-disclosure agreements. Patent life and geographical boundaries. International organizations and IPR - Overview of WTO, TRIPS, WIPO, GATT, International conventions, Trade agreements, Implication of TRIPS for developing countries.	12	CO1
UNIT 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
UNIT 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

UNIT IV	Introduction to bioethics - need of bioethics, applications and issues related to bioethics, social and cultural issues. Bioethics and biodiversity - conserving natural biodiversity, convention on protecting biodiversity, protocols in exchanging biological material across borders. Bioethics & GMO's - issues and concerns pertaining to genetically modified foods and food crops, organisms and their possible health implications and mixing up with the gene-pool.	12	CO4
UNIT V	Bioethics in medicine - Protocols of ethical concerns related to prenatal diagnosis, gene therapy, organ transplantation, xeno transplantation, ethics in patient care, informed consent. bioethics and cloning - permissions and procedures in animal cloning, human cloning, risks 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 associated with HGP, clinical research, stem cell therapy.	PO1, PO3, PO5, PO6, 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.	GoelParashar. 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 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

	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
23MMI2E6	Clinical Research And Clinical Trials	Elective Course IV C	-	T	-	-	3	4	25	75	100

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.

	Details	No.of Hours	Course Objectives
UNIT I	Introduction to Clinical Research: Clinical Research: An Overview, Different types of Clinical Research. Clinical Pharmacology: Pharmacokinetics, Pharmacodynamics, Pharmacoepidemiology, Bioavailability, Bioequivalence, Terminologies and definition in Clinical Research. Drug Development Process: Drug Discovery Pipeline, Drug Discovery Process. Preclinical trail, Human Pharmacology (Phase-I), Therapeutic Exploratory trail (Phase-II), Therapeutic Confirmatory Trail (Phase-III) and Post marketing surveillance (Phase-IV).	12	CO1
UNIT II	Ethical Considerations and Guideline in Clinical Research: Historical guidelines in Clinical Research-Nuremberg code, Declaration of Helsinki, Belmont report. International Conference on Harmonization (ICH)-Brief history of ICH, Structure of ICH & ICH Harmonization Process, Guidelines for Good Clinical Practice. Regulation in Clinical Research-Drug and cosmetic act, FDA, Schedule-Y- Ethics Committee and their responsibilities. Clinical Research Regulatory Submission & approval Process- IND, NDA and ANDA submission Procedure. DCGI submission procedure. Other Regulatory authorities- EMEA, MHRA, PhRMA.	12	CO2
UNIT III	Clinical Trial Management: Key Stakeholders in Clinical Research, Ethics Committees and Institutional Review Board,Responsibilities of Sponsor. Responsibilities of Investigator, Protocol in Clinical Research Clinical Trial Design, Project Planning Project Managements - Informed Consent, Investigator's Brochure (IB), Selection of an Investigator and Site, Patient screening, Inclusion and exclusion criteria, Randomization, Blinding. Essential Documents in clinical research -IB, ICF, PIS, TMF, ISF, CDA & CTA.	12	CO3
UNIT 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.		
UNIT V	Business Development in the Clinical Research Industry: Introduction & Stages of Business Development-Start-up Phase, Growth Phase, Maturity Phase, Decline Phase. Outsourcing in Clinical Research, Reasons for outsourcing to contract research organizations, The India Advantage, Scope and Future of CRO, List of Clinical Research Organizations in India, List of IT companies offering services in Clinical Research. Role of business development manager.	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., OgnibeneF. 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, 4thedn, 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, 2nd Edition Academic Press, London.
5.	E1-Mansi, E.M.T., Bryce, C.F.A., Demain, A.L. and Allman,A.R. (2007). Fermentation Microbiology and Biotechnology. 2nd Edition, CRC press, Taylor and Francis Group.
Web Resources	
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	PO10	PO11	PO12	PO13	PO14
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
23MMI 2S1	Vermitechnology	Skill Enhancement Course I	-	T	-	-	2	4	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.		
	Details	**No.of Hours**	**Course Objectives**
UNIT I	Introduction to Vermiculture - Definition, classification, history, economic importance- In sustainable agriculture, organic farming, earthworm activities, soil fertility & texture, soil aeration, water impercolation, decomposition & moisture, bait & food and their value in maintenance of soil structure. Its role in the bio transformation of the residues generated by human activity and production of organic fertilizers. Choosing the right worm. Useful species of earthworms. Local species of earthworms. Exotic species of earthworms. Factors affecting distribution of earthworms in soil.	6	CO1
UNIT II	Earthworm Biology and Rearing - Key to identify the species of earthworms. Biology of *Eiseniafetida.* a) Taxonomy Anatomy, physiology and reproduction of Lumbricidae. b) Vital cycle of *Eiseniafetida*: alimentation, fecundity, annual reproducer potential and limiting factors (gases, diet, humidity, temperature, PH, light, and climatic factors). Biology of *Eudriluseugeniae*. c) Taxonomy Anatomy, physiology and reproduction of Eudrilidae. d) Vital cycle of *Eudriluseugeniae*: alimentation, fecundity, annual reproducer potential and limit factors (gases, diet, humidity, temperature, PH, light, and climatic factors).	6	CO2
UNIT III	Vermicomposting Process - Feeds for Vermitech systems- Animal manures- Kitchen Waste and Urban waste- Paper pulp and card board solids- Compost and waste products- Industrial Wastes. Vermicomposting Basic process- Initial pre-composting phase- Mesophilic phase- Maturing and stabilization phase- Mechanism of Earthworm action. Methods of vermicomposting- a) windrows system; b) wedge system; c) container system-pits, tanks & cement rings; commercial model; beds or bins-top fed type, stacked type, d) Continuous flow system.	6	CO3
UNIT IV	Vermicomposting - Trouble Shooting-Temperature-Aeration-Acidity- Pests and Diseases- Ants, rodents, Birds, Centipedes, sour crop, Mite pests. Odour problems. Separation techniques-Light Separation-Sideways Separation-Vertical Separation-	6	CO4

	Gradual transfer. Harvesting Earthworms- manual method-migration method. Packing & Nutritional analysis of vermicompost.		
UNIT V	Applications of Vermiculture - Vermiculture Bio-technology, use of vermi castings in organic farming/horticulture, as feed/bait for capture/culture fisheries; forest regeneration. Application quantity of vermicompost in Agricultural fields-crops, fruits, vegetables & flowers. By-products and value-added products- Verm wash- vermicompost tea-vermi meal-enriched vermicompost-pelleted vermicompost.	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 andVermitechnology, 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/	
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	PO10	PO11	PO12	PO13	PO14
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							

SECONDYEAR
THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 3C1	**Immunology, Immuno technology and Microbial Genetics**	**Core Course VII**	**-**	**T**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives	
CO1	Discuss immunity, organs and cells involved in immunity. Compare the types of antigens and their properties.
CO2	Describe immunoglobulin and its types. Categorize MHC and understand its significance.
CO3	Elucidate the mechanisms of different hypersensitivity reactions. List out the Vaccines and discuss their development.
CO4	Acquire knowledge the structure DNA in prokaryotes and eukaryotes
CO5	Explain out gene transfer studies in microbes.

	Details	**No. of Hours**	**Course Objectives**
UNIT I	Introduction to biology of the immune system – Cells and organs of Immune System. T and B lymphocytes – Origin, development, differentiation, lymphocyte subpopulation in humans. Innate immunity- Complement, Toll-like receptors and other components. Acquired immunity – Active and Passive immunity. Antigens - features associated with antigenicity and immunogenicity. Basis of antigen specificity. MHC genes and products, Structure of MHC molecules, Genetics of HLA Systems – Antigens and HLA typing. Antigen processing and presentation to T-lymphocytes.	20	CO1
UNIT II	Immunoglobulins. Theories of antibody production. Class switching and generation of antibody diversity. Monoclonal and polyclonal antibodies. Complement system – mode of activation- Classical, Alternate and Lectin pathways, biological functions. Antigen recognition – TCR, Diversity of TCR, T cell surface alloantigens, lymphocyte activation, clonal proliferation and differentiation. Physiology of acquired immune response – various phases of HI, CMI – Cell mediated cytotoxicity, DTH response.	20	CO2
UNIT III	Hypersensitivity – Types and mechanisms, Autoimmunity, Tumor Immunity and Transplantation immunology. Immunodeficiency-Primary immunodeficiency and Secondary immunodeficiencies. Genetics of Immunohematology – Genetic basis and significance of ABO and other minor blood groups in humans, Bombay	25	CO3

	blood group, Secretors and Non-secretors, Rh System and genetic basis of D- antigens. Diagnostic Immunology - Precipitation reaction, Immunodiffusion methods - SRID, ODD. Immunoelectrophoresis - Rocket and Counter current electrophoresis. Agglutination - Hemagglutination - Hemagglutination inhibition. Labeled Assay- Immunofluorescence assay, Radio immunoassay, FISH, ELISA. Flow cytometry. Immune regulation mechanisms – immuno-induction, immuno- suppression, immuno-tolerance, immuno-potentiation, Immunomodulation. Role of cytokines, lymphokines and chemokines. Introduction to Vaccines and Adjuvants - Types of vaccines. Development of vaccines and antibodies in plants. Immunomics - Introduction and Applications. Antigen engineering for better immunogenicity and use for vaccine development-multiepitope vaccines. Reverse vaccinology.		
UNIT IV	Structural of prokaryotic and eukaryotic genome. Introduction to prokaryotic genomic structure, Eukaryotic Genome - Structure of chromatin, chromosome, centromere, telomere, nucleosome. Modifications- methylation, acetylation, phosphorylation and its effect on structure and function of chromatin, DNA methylation and gene imprinting, organelle genome.	13	CO4
UNIT V	Gene Transfer Mechanisms- Conjugation and its uses. Transduction, Generalized and Specialized, Transformation– Natural Competence and Transformation. Transposition and Types of Transposition reactions. Insertion sequences, complex and compound transposons – T10, T5, and Retroposon. Mechanism – Transposons of *E. coli*, Bacteriophage and Yeast. Importance of transposable elements in horizontal transfer of genes and evolution.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Categorize the immune response to a variety of antigens. Identify different immune cells involved in immunity.	PO1, PO4, PO6, PO7, PO9
CO2	Justify the significance of MHC molecules in immune response and antibody production.	PO1, PO4, PO5,PO6, PO9
CO3	Design antibodies and evaluate immunological assays in patient samples.	PO4, PO6, PO7, PO8, PO9, PO10
CO4	Analyze genomic DNA of prokaryotes and eukaryotes.	PO4,PO5, PO6, PO7, PO9, PO10
CO5	Summarize gene transfer mechanisms for experimental study.	PO4,PO5, PO6, PO7, PO9, PO10

Text Books

1.	Coico R., Sunshine G. and Benjamini E. (2003). Immunology – A Short Course. (5th Edition). Wiley-Blackwell, New York.
2.	Owen J. A., Punt J., Stranford S. A. and Kuby J. (2013). Immunology, (7th Edition). W. H. Freeman and Company, New York.
3.	Abbas A. K., Lichtman A. H. and Pillai S. (2021). Cellular and Molecular Immunology. (10thEdition).Elsevier.
4.	Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi.
5.	Gardner E. J. Simmons M. J. and Snusted D.P. (2006). Principles of Genetics. (8th Edition). Wiley India Pvt. Ltd.
References Books	
1.	Travers J. (1997). Immunobiology - The Immune System in Health and Disease. (3rd Edition). Current Biology Ltd. New York.
2.	Delves P.J., Martin S., Burton D. R. and Roitt I. M. (2006). Roitt's Essential Immunology. (11th Edition). Wiley-Blackwell.
3.	Hay F. C. and Westwood O. M. R. (2002). Practical Immunology (4thEdition). Wiley-Blackwell.
4.	Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press.
5.	Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Edition.
Web Resources	
1.	https://www.ncbi.nlm.nih.gov/books/NBK279395/
2.	https://med.stanford.edu/immunol/phd-program/ebook.html
3.	https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/
4.	[PDF] Lehninger Principles of Biochemistry (8th Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in
5.	https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/

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
23MMI 3C2	**Molecular Biology and Recombinant DNA Technology**	**Core Course VIII**	**-**	**T**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives

CO1	Provide knowledge on the structure, replication and repair mechanisms of DNA. Illustrate the structure, functions and significance of RNA.
CO2	Discuss the gene regulatory mechanisms in prokaryotes and eukaryotes and importance of mutations.
CO3	Provide in depth knowledge about artificial gene transfer mechanisms and selection of Recombinants.
CO4	Impart knowledge on various molecular techniques and their importance in biotechnology.
CO5	Explain the applications of genetic engineering in various fields.

	Details	No. of Hours	Course Objectives
UNIT I	DNA replication – modes and enzymes involved. Detailed mechanism of semi-conservative replication. Prokaryotic and eukaryotic transcription. Structure and processing of m-RNA, r-RNA and t-RNA. Ribosomes. Genetic Code and Wobble hypothesis, Translation in prokaryotes and eukaryotes, post translational modifications.	20	CO1
UNIT II	Gene regulation and expression – Lac operon, arabinose and tryptophan operons. Gene regulation in eukaryotic systems-repetitive DNA, gene rearrangement, promoters, enhancer elements. Molecular basis of gene mutation - Types of mutations - base substitutions, frame shift, deletion insertion, duplication, inversion. Silent, conditional and lethal mutation. Chemical mutagenesis. Repair of DNA damage. Photoreactivation. SOS repair mechanism. Base excision repair. Nucleotide excision repair. Detection and analysis of mutations (Replica plating, Antibiotic enrichment, Ames test).	20	CO2
UNIT III	Tools and methods in gene cloning. Restriction endonucleases – nomenclature, classification and characteristics - DNA methylases, DNA polymerases, Ligases. Adapters, linkers and homopolymer tailing. Artificial gene transfer techniques - electroporation, microinjection, protoplast fusion and microparticle bombardment. Screening for recombinants. Gene cloning vectors for prokaryotes and eukaryotes - cloning properties and types of plasmids vectors (pBR322 and derivatives, pUC vectors and pGEM3Z) - Phage Vectors(M13 and Lambda), cosmids, phasmids, phagemids and BACs - Eukaryotic vectors - Yeast vectors – Animal and plant vectors – expression vectors. Shuttle vectors - Expression of foreign	20	CO3

	genes in bacteria, animal, plant, algae and fungi – merits and demerits.		
UNIT IV	Genomic DNA and cDNA library-Construction and Screening. Substrative hybridization for tissue specific DNA libraries. Techniques in genetic engineering Characterization of cloned DNA: Hybrid arrested translation (HAT) - Restriction mapping - restriction fragment length polymorphism (RFLP) - Polymerase chain reaction (PCR) – Principles, types and their applications. DNA sequencing - Primer walking, Sanger's method and automated sequencing methods. Pyrosequencing – DNA chips and micro array. Protein engineering and techniques Site directed mutagenesis – methods - Design and construction of novel proteins and enzymes, Basic concepts in enzyme engineering, engineering for kinetic properties of enzymes. protein folding, protein sequencing, protein crystallization. Applications of protein engineering.	15	CO4
UNIT V	Plant biotechnology - constituents and concepts of sterilization - preparation, isolation and selection of explant. Suspension cell culture, callus culture, protoplast isolation, culture & fusion. Anther and pollen culture for production. Animal biotechnology – equipment and media used for animal cell culture technology. Primary and established cell line culture and culture media. Applications of animal cell cultures. Serum protein media viability and cytotoxicity. Applications of Genetic Engineering - transgenic animals, Recombinant Cytokines and their use in the treatment of animal infections. Monoclonal Antibodies in Therapy- Vaccines and their Applications in Animal Infections - Human Gene Therapy-Germline and Somatic Cell Therapy-Ex-vivoGene Therapy. In-vivoGene Therapy. Vectors in Gene Therapy-Viral and Non-Viral Vectors. Transgenic Plants.	15	CO5
	Total	90	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Analyze, demonstrate and appreciate DNA replication and protein synthesis.	PO4, PO6, PO9
CO2	Investigate the types of mutation and its impact on microbes. Illustrate various strategies on gene cloning.	PO4, PO6, PO9
CO3	Analyze, modify and characterize DNA modifying enzymes.	PO4, PO6, PO9
CO4	Illustratively assess the molecular techniques for DNA and protein analysis.	PO4, PO6, PO9
CO5	Adopt the applications of Genetic Engineering in the field of agriculture and medicine towards scientific research.	PO1, PO3, PO4, PO5, PO6, PO7, PO8, PO9

Text Books	
1.	Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi.
2.	Snusted D.P. and Simmons M. J. (2019). Principles of Genetics. (7th Edition). John Wiley and Soms, Inc.
3.	Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.
4.	Primrose S.B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics. (7th Edition). Blackwell Publishing.
5.	Maloy S. R. Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2nd Edition). Narosa Publishing House Pvt. Ltd.
	References Books
1.	Brown T. A. (2016). Gene Cloning and DNA Analysis- An Introduction. (7th Edition). John Wiley and Sons, Ltd.
2.	Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press.
3.	Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Edition.
4.	Synder L., Peters J. E., Henkin T.M. and Champness W. (2013). Molecular Genetics of Bacteria. (4th Edition). ASM Press Washington-D.C. ASM Press.
5.	Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.
Web Resources	
1.	https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/
2.	https://geneticeducation.co.in/what-is-transcriptomics
3.	https://www.molbiotools.com/usefullinks.html
4.	https://geneticeducation.co.in/what-is-transcriptomics
5.	https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 3P1	**Practical III – Immunology, Microbial Genetics and Molecular Biology**	**Core Practical III**	**-**	**-**	**P**	**-**	**4**	**6**	**25**	**75**	**100**

Course Objectives	
CO1	Acquire adequate skills to perform blood grouping and serological reactions.
CO2	Provide fundamental skills in preparation, separation and purification of immunoglobulin.
CO3	Illustrate the significance of artificial transformation and mutations.
CO4	Familiarize with routine molecular biological techniques.
CO5	Discuss blotting techniques and PCR.

	Details	**No. of Hours**	**Course Objectives**
UNIT I	Hematological reactions - Blood Grouping – forward and reverse, Rh Typing Identification of various immune cells by morphology – Leishman staining, Giemsa staining. Agglutination Reactions- Latex Agglutination reactions- RF, ASO, CRP.Detection of HBs Ag by ELISA. Precipitation reactions in gels– Ouchterlony double immunodiffusion (ODD) and Mancini's single radial immunodiffusion (SRID) Immuno-electrophoresis and staining of precipitin lines- Rocket immuno electrophoresis and counter current immuno electrophoresis.	20	CO3
UNIT II	Preparation of lymphocytes from peripheral blood by density gradient centrifugation. Purification of immunoglobulin– Ammonium Sulphate Precipitation. Separation of IgG by chromatography using DEAE cellulose or Sephadex.	10	CO4
UNIT III	Artificial Transformation Detection of Antibiotic resistant mutants Identification of mutants by replica plating method.	20	CO5
UNIT IV	Isolation of genomic DNA from *E. coli* and analysis by agarose gel electrophoresis Separation of proteins by polyacrylamide gel electrophoresis (SDS-PAGE) Plasmid DNA isolation from *E.coli*.	20	CO4
UNIT V	Amplification of DNA by PCR Western blotting - Demonstration Southern blotting – Demonstration	20	CO5
	Total	90	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Perform and evaluate immunological reactions to aid diagnosis.	PO4, PO6, PO7, PO9, PO11
CO2	Assess the level of lymphocytes in a blood sample and purify immunoglobulin employing appropriate techniques.	PO4, PO6, PO7, PO10, PO11
CO3	Perform DNA extraction and gene transfer mechanisms, analyze and identify by gel electrophoresis	PO1, PO4, PO5, PO7, PO8
CO4	Utilize various molecular techniques for gene manipulation and detection of mutants.	PO1, PO4, PO5, PO7, PO8
CO5	Undertake novel research with techniques like PCR and blotting analysis.	PO5, PO10

Text Books	
1.	Roitt R.I.M (2001). Essential Immunology.10thEdn. Blackwell Scientific Publishers.
2.	Glick B. R. and Patten C. L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA (5th Edition). ASM Press.
3.	Gunasekaran P. (2007). Laboratory Manual in Microbiology. New Age International.
4.	James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual. (5th Edition). The Benjamin publishing company. New York.
5.	Russell P. J. (2019). Genetics – A Molecular Approach (3rd Edition). Pearson Education, Inc.

References Books	
1.	Stites D.P.,Abba I.Terr, Parslow T.G.(1997). Medical Immunology. 9thedn, Prentice-HallInc.
2.	Tizard, R.I.(2000) Immunology- An Introduction. 4thedn. Saunders College Publishing, Philadelphia.
3.	Dale J. W., Schantz M. V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.
4.	Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. (7th Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press.
5.	Brown T.A. (2016). Gene Cloning and DNA Analysis. (7th Edition). John Wiley and Jones, Ltd.

Web Resources	
1.	https://www.molbiotools.com/usefullinks.html
2.	https://geneticgenie.org3.
3.	https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5
4.	https://vlab.amrita.edu/index.php?sub=3&brch=272
5.	https://nptel.ac.in/courses/102105087

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	40 Marks
	Attendance and Class Participitation	

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

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 3C3	**Fermentation technology and Pharmaceutical Microbiology**	**Core Course X**	**-**	**T**	**-**	**-**	**4**	**6**	**25**	**75**	**100**

Course Objectives	
CO1	Discuss about fermentation and its types, sensitize on methods of strain development for improved yield.
CO2	Impart knowledge on the fermenter design and types.
CO3	Acquire knowledge on the effective recovery and purification of the products.
CO4	Explain the importance of pharmaceutical microbiology.
CO5	Illustrate methods for production products using microorganisms and their quality control.

	Details	**No. of Hours**	**Course Objectives**
UNIT I	Bioprocesses - concepts and design. Industrially important microorganisms – Isolation, primary and secondary screening, preservation and improvement of industrially important strains. Upstream processing - Development of inoculums for fermentation process. Media for industrial fermentation - Formulation, optimization. Sterilization. Stages of upstream - Growth of inoculums, fermenter pre-culture and production fermentation. Types of fermentation - Batch, continuous, dual or multiple, surface, submerged, aerobic and anaerobic.	12	CO1
UNIT II	Fermenter – Design, types and construction, Instrumentation and control. Productivity. Yield coefficients. Heat production. Aeration and agitation. Gas exchange and mass transfer. Computer Applications in fermentation technology. Fermentation Economics.	12	CO2
UNIT III	Downstream Processing- Recovery and purification of intracellular and extracellular products. Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration - Physical, chemical and enzymatic methods. Extraction - Solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods. Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.	12	CO3
UNIT IV	Overview of pharmaceutical microbiology - Ecology of microorganisms - Atmosphere, water, skin, respiratory flora of workers, raw materials, packaging, building equipment and their control measures. Design and layout of sterile manufacturing unit. Contamination and Spoilage of Pharmaceutical products - sterile injectable and non-injectable, ophthalmologic preparation, implants.	12	CO4

UNIT V	Production of pharmaceutical products and quality assurance – Vaccines, immunodiagnostics, immuno-sera, immunoglobulin. Antibiotics - Penicillin, Griseofulvin, Metronidazole. Enzymes - Streptokinase, Streptodornase. Quality assurance and quality management in pharmaceuticals – In-Process, Final-Product Control and sterility tests. Regulatory aspects - BIS (IS), ISI, ISO, WHO and US certification.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Develop microbial strains, carry out fermentation and recover the products of the process.	PO6, PO7, PO8, PO9
CO2	Design fermenters according to needs for various products.	PO6, PO7, PO8, PO9
CO3	Recover the end products of the fermentation process economically.	PO4, PO6, PO7, PO8, PO9
CO4	Utilize the knowledge on pharmaceutical microbiology for industrial production of products.	PO6, PO7, PO8
CO5	Produce therapeutic products from microbes employing technology and analyze the quality the products.	PO6, PO7, PO8

Text Books	
1.	Patel A.H. (2016). Industrial Microbiology. (2nd Edition). Laxmi Publications, New Delhi.
2.	Casida L.E.J.R. (2019). Industrial Microbiology. New Age International Publishers.
3.	SathyanarayanaU. (2005). Biotechnology. (1st Edition). Books and Allied (P) Ltd.
4.	Reed G. (2004). Prescott and Dunn's Industrial Microbiology. (4th Edition). CBS Publishers & Distributors.
5.	Waites M. J., Morgan N. L., Rockey J. S. and Higton G. (2013). Industrial Microbiology: An Introduction. Wiley Blackwell Publishers.

References Books	
1.	Stanbury P.T. and Whitaker. (2016). Principles of Fermentation Technology. (3rd Edition). Pergamon Press. NY.
2.	Handa S. S. and Kapoor V. K. (2022). Pharamcognosy, (4th Edition). VallabhPrakashan Publishers, New Delhi.
3.	Kokate C. K., Durohit A. P. and Gokhale S. R. Pharmacognosy. (2002). (12th Edition). NiraliPrakasham Publishers, Pune.
4.	Hugo W. B. and Russell A. D. (2004). Pharmaceutical Microbiology. (7th Edition). Blackwell Scientific Publication, Oxford.
5.	Wallis, T.E. (2005). Text book of Pharmacognosy. (5th Edition). CBS publishers and distributors, New Delhi.

Web Resources	
1.	https://ib.bioninja.com.au/options/untitled/b1-microbiology organisms/fermenters.html
2.	https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/penicilli

	n.html
3.	https://www.sciencedirect.com/topics/biochemistry-genetics-andmolecular-biology/ethanol-fermentation
4.	https://www.usp.org/sites/default/files/usp/document/harmonization/genmethod/q05b_pf_ira_34_6_2008.pdf
5.	http://www.simbhq.org/

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Test	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

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI3E1	**Soil Microbiology and Microbial Ecology**	**Elective V A**	**-**	**T**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives	
CO1	Explain the role of microorganisms in soil fertility.
CO2	Discuss the harmful effects of micro organisms in soil.
CO3	Create awareness. about microbial interactions.
CO4	Acquire in depth knowledge about microbial communities and ecosystem.
CO5	Develop knowledge about quantitative ecology.

	Details	**No. of Hours**	**Course Objectives**
UNIT I	Soil Microbiology– Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity, and distribution of major group of microorganisms in soil. Quantification of soil microflora, role of microorganism in soil fertility. Mineralization of Organic & Inorganic matter in soil. Biological nitrogen fixation- Chemistry and Genetics of BNF.	20	CO1
UNIT II	Phytopathology and Disease cycle of Plant pathogens - Tikka and Citrus canker, Types of disease symptoms, Structural and Inducible biochemical defenses - Systemic Acquired Resistance (SAR), pathogenesis related (PR) proteins, Plantibodies, Phenolics, Phytoalexins.	20	CO2
UNIT III	Interactions among microbial populations- Single microbial populations, positive and negative interactions. Interaction between diverse microbialpopulations. Population within biofilms. Interaction between microbes and plants – Rhizosphere and mycorhizae. Interactions with animals – contribution of microbes in animal nutrition and diseases.	15	CO3
UNIT IV	Microbial Communities and Ecosystems – Development of microbial community. Microbial community and dynamics and nature. .Succession within biofilm communities.	15	CO4
UNIT V	Quantitative Microbial Ecology – Sample collection, detection of microbial populations, determination of microbial numbers, detecting non culturable bacteria and determination of microbial biomass.	20	CO5
	Total	90	

Course Outcomes	
Course	On completion of this course, students will;

Outcomes		
CO1	Depict diversity and significance of soil microbes and predict the role of microbes in biological nitrogen fixation.	PO1
CO2	Apply the knowledge on plant pathology in agriculture.	PO1, PO7, PO8
CO3	Utilize the knowledge of microbial interactions in various fields.	PO1, PO5, PO6, PO7, PO8
CO4	Predict community ecosystem and their dynamics.	PO1, PO5
CO5	Apply quantitative microbial ecology for the benefit of mankind.	PO1, PO5
Text Books		
1.	Subba Rao. N. S. (2017). Soil Microbiology. (5th Edition). MedTech Publishers.	
2.	Rangaswami. G. and Mahadevan. A. (2006). Diseases of Crop Plants in India. (4th Edition). Prentice–Hall of India Pvt. Ltd	
.3.	Larry.L. Barton and Diana .E. Northup. (2011). Microbial Ecology. Wiley Publishers.	
4.	McArthur. (2006). MicrobialEcology – An Evolutionary Approach AP Publishers.	
5.	Subba Rao. N.S. (2005). Soil microorganisms and Plant Growth. (4th Edition). Oxford and IBH Publishing Pvt. Ltd.	
References Books		
1.	Bartha .A (2009). Microbial Ecology- Fundamentals and applications. 4thEdn. Pearson Education.	
2.	Robert. LTate. (2003).Soil Science – An inter-disciplinary approach to soil research. Lipincott Williams and Wilkins.	
3.	Terry J. Gentry and Jeffry. J. Fuhrmann, David A Zuberer. (2021). Principle and application of soil Microbiology. 3rdEdn. Elsiver publications.	
4.	Shrivastava A.K. (2003). Environment Auditing. A. P. H. Publishing Corporation.	
5.	Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan.	
Web Resources		
1.	https://staff.oouagoiwoye.edu.ng	
2.	http://www.scribd.com	
3.	www.environmentshumail.blogspot.in/	
4.	https://www.soinc.org	
5.	https://www.onlinebiologynotes.com	
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													
CO2	M						M	M						
CO3	M				S	S	S	S						
CO4	M				M									
CO5	M				M									

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 3E2	Microbial Toxicology	Elective Course V B	-	T	-	-	3	4	25	75	100

Course Objectives	
CO1	Recognize the various categories of environmental toxins and their hazardous consequence
CO2	Enhance the knowledge of underlying etiology of bacterial diseases.
CO3	Promote technical skills for identification of fungal toxins.
CO4	Gain Knowledge about algal toxins and their effects.
CO5	Illustrate various techniques to isolate and characterize the toxin.Examine, interpret and discuss the certainty of toxic substances.

	Details	No. of Hours	Course Objectives
UNIT I	General Introduction - Definition of toxins, different categories of toxins.	12	CO1
UNIT II	Bacterial toxins - Bacterial toxins Bacterial toxinogenesis, endotoxins, exotoxins, exotoxins, bacterial protein toxins with special reference to cholera, diphtheria and tetanus toxins, molecular mechanism of action of endotoxins, exotoxins, enterotoxins, neurotoxins and mycotoxins.	12	CO2
UNIT III	Fungal Toxins – Structure, Properties of Aflatoxin, OchratoxinPatulin, Leukosytrine, Trichothecenes, Fumonisins and Ergot alkaloids.	12	CO3
UNIT IV	Algal Toxins- Structure, Properties of Cyanotoxins-Microcystins, Nodularins, Anatoxin- A, Saxitoxin-Aetokthonotoxin. Others-Hepatotoxin, Neurotoxins, LPS.	12	CO4
UNIT V	Tools for isolation and characterization of toxins - Multidimensional chromatographic techniques (gel-filtration, ion-exchange reverse-phase HPLC, SDS-PAGE, 2-dimensional gel electrophoresis).	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Perceive the adverse effects of toxin and its potential role in research.	PO1, PO2, PO9
CO2	Assess the toxicity, properties and mode of actions of bacterial toxins.	PO2, PO4, PO6, PO10
CO3	Explicate the mode of actions and their biological significance of fungal toxins.	PO1, PO2, PO4
CO4	Evaluate the mode of action and consequences of algal	PO6, PO7. PO9.PO11

	toxins.	
CO5	Evaluate the toxicity level with the help of advanced techniques.	PO4, PO5, PO6, PO8, PO9

	Text Books
1.	Holst O. (2008). Bacterial Toxin –Methods & Protocols. Humana Press.ISBN 9781592590520.
2.	Shier W. T. (1990). Handbook of Toxinology. CRC Press. ISBN 9780824783747.
3.	Wilson K. and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. (7thEdition). Cambridge University Press India Pvt.Ltd. ISBN 1-4051-3544-1.
4.	Pholtan Rajeev S.R. (2021Pictorial handbookfor toxinology. Rudra Publications.
5.	Cora Lancester. (2015). Molecular Toxinology Handbook. Callisto Reference
	References Books
1.	Reilly M.J. (2018). Bioinstrumentation. CBS Publishers and Distributors Pvt Ltd. ISBN 13 978-8123928395.
2.	Greenberg M., Hamilton R., Phillips S. and McCluskey G. J. (2003). Occupational, Industrial and Environmental Toxicology. St Louis: C.V. Mosby.
3.	Wiley-Vch. (2005). Ullmann's Industrial Toxicology. New York: John Wiley & Sons.
4.	Winder C. and Stacey N.H. and Boca Raton F. L.(2004). Occupational Toxicology. (2ndEdition). CRC Press.
5.	Gopalakrishnakone(2015). Biological Toxins and Bioterrorism. Springer.
	Web Resources
1.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5869414/
2.	https://www.reseachgate.net/publication/269037373_TOXIN_AS_A_MEDICINE
3.	https://www.toxinology.org/
4.	https://www.mdpi.com/journal/toxins/special_issues/snakebite_clinical_toxinology
5.	https://pubmed.ncbi.nlm.nih.gov/12807310

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 3E3	Water Conservation and Water Treatment Technologies	Elective Course V C	-	T	-	-	3	4	25	75	100

Course Objectives	
CO1	Explain how societal and climatic changes will distress water supply and water demand in future
CO2	Ascertain promising elucidations to the global water crisis and assess the pros and cons
CO3	Acquire knowledge to identify the quality of water by standard method
CO4	Illustrate the methods of water treatment technologies and assessing the impact of HWTS
CO5	Describe the application and uses of various emerging water treatment technologies

	Details	No.of Hours	Course Objectives
UNIT I	Water Scarcity; Major Causes of Water Scarcity, Types of Water Scarcity, Water Footprint- Effects of Water Scarcity Across the Globe-, Water Scarcity in India; Effects of Water Scarcity in India-Social and Political Effects and Economic Risks of Water Scarcity in India.	12	CO1
UNIT II	Multi-pronged approach to Prevent Water Scarcity; Aquifer Recharging, Water reuse and Zero-Liquid Discharge Technology, Coastal Reservoir, Desalination Plants-Measures for Preventing Water Scarcity in India - Jal Shakti Abhiyan Campaign, Atal BhujalYojana, Adoption of Composite Water Management Index (CWMI), Water conservation resource management, Rain Water Harvesting.	12	CO2
UNIT III	Water Quality and Pollution; Impurities in the water, Characteristics of different water sources Vulnerability of the water sources to contamination, Water quality criteria - Quality of surface waters, flowing waters, impounded waters, Groundwater, Water quality standards, Microbiological quality of drinking Water, Chemical quality of drinking water.	12	CO3
UNIT IV	Water Treatment Technologies; Sedimentation, Filtration, Coagulation and flocculation, Water softening and adsorption processes, Membrane filtration, Microfiltration, Ultrafiltration and Nanofiltration,Water disinfection, Activated carbon filtration, Household Water Treatment and Safe Storage (HWTS). Methods for household water treatment Safe water storage, Household water treatment and safe storage decision tree, Assessing the impact of HWTS, Government policies for HWTS.	12	CO4

UNIT V	New and Emerging Drinking Water Treatment Technologies; Nanotechnology, Acoustic nanotube technology, Photocatalytic water purification technology, Aquaporin Inside™ technology, Automatic Variable Filtration (AVF) technology, Sun Spring System, Desalination.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Appraise issues of water scarcity, stress, and conflict on global population.	PO1, PO2, PO4, PO5, PO10
CO2	Apprehend the multiple approaches against water scarcity and to understand various government schemes for water conservation.	PO1, PO2, PO5, PO10, PO14
CO3	Relate the connection between water quality and public health.	PO4, PO6, PO10
CO4	Design and execute standard strategy for successful HWTS implementation.	PO4, PO5, PO6, PO9
CO5	Cogitate the purpose, principles, operation, and limitation of various modern water treatment technologies.	PO5, PO7, PO8, PO9, PO10, PO11

Text Books

1. Vasileios A., TzanakakisN.Paranychianakis V. and Angelakis A. N. (2020). Water Supply and Water Scarcity. MDPI, ISBN 978-3-03943-306-3 (Hbk). ISBN 978-3-03943-3070.
2. Pannirselvam M., ShuLi.,Griffin G., Philip L., Natarajan A. and Hussain S. (2019). Water Scarcity and Ways to Reduce the Impact. ISBN: 978-3-319-75199-3.
3. Tiwari A., Kumar A., Singh A., Singh T.N., Suozzi E., Matta G. and Russo S. (2022). Water Scarcity, Contamination and Management. Elsevier. ISBN: 9780323853781.
4. Daniel, C.J. (1996). Environmental Aspects of Microbiology, 1st edn. Bright Sun Publications.
5. Maier RM, Pepper IL, Gerba CP (2008). Environmental Microbiology, 2nd edn. Academic Press

References Books

1. Fujita K. and Mizushima T. (2021). Sustainable Development in India-Groundwater Irrigation, Energy Use, and Food Production. ISBN 9780367460976.
2. Gupta R. (2008). Water Crisis in India. Atlantic Publishers. ISBN: 9788126909582, 9788126909582.
3. AhujaS. (2013). Monitoring Water Quality-Pollution Assessment, Analysis, and Remediation. Elsevier. Book ISBN: 9780444594044. Hardcover ISBN: 9780444593955.
4. SaeidEslamian ., FaezehEslamian ., (2021) Water harvesting and conservation – Basic Concepts and fundamentals, Wiley Publications.
5. Buckley RG. (2016) Environmental Microbiology 1st edn. CBS Publishing.

Web Resources	
1.	https://link.springer.com/book/10.1007/978-1-59745-278-6
2.	https://apps.who.int/iris/handle/10665/206916?show=full
3.	https://www.acs.org/content/acs/en/policy/publicpolicies/sustainability/water-statement.html
4.	https://www.toftigers.org/best-practice/water-conservation-and-treatment/
5.	https://doh.wa.gov/community-and-environment/wastewater-management/site-sewage-systems-oss

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 3S1	**Organic Farming and Biofertilizer Technology**	**Skill Enhancement Course II**	-	T	-	-	2	2	25	75	100

Course Objectives	
CO1	Impart knowledge on the importance, types and advantages of organic farming thereby creating awareness on conserving environment and natural resources, encouraging sustainable agriculture.
CO2	Familiarize with the basic concepts of farm development and relate the development of organic farming in their countries to meet global trends.
CO3	Explain the various types of biofertilizer and the scope in its production.
CO4	Discuss about biofertilizer production and its field application, promoting economy.
CO5	Develop the skill to analyze the quality of packaging, storage, assess the shelf life and bioefficacy of biofertilizers

	Details	**No. of Hours**	**Course Objectives**
UNIT I	Organic farming – Definition, relevance. Biological nutrient management- Organic manures, vermicompost, green manure, organic residue,biofertilizer soil amendments. Integrated pest and weed management - Use of biocontrol agents, bio pesticides etc. Organic and Conventional farming. Organic and Chemical farming – Comparison.	6	CO1
UNIT II	Certification and Schemes - Certification and Schemes. Organic certification in brief. Integrated farming system-definition, goal, components. Factors affecting ecological balance. Land degradation. Soil health management. Models of IFS for rainfed and irrigated conditions and different categories of farmers. Government schemes - NPOF, NPOF, NHM, HMNEH, NPMSH&F and RKVY.	6	CO2
UNIT III	Biofertilizers - Introduction, types, advantages and future perspective. Introduction, status and scope. Structure and characteristic features of bacterial biofertilizers- *Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium* and *Frankia*.	6	CO3
UNIT IV	Cyanobacterial biofertilizers- Anabaena, Nostoc, *Hapalosiphon*and fungal biofertilizers- AM mycorrhiza and ectomycorhiza. Nitrogen fixation -Free living and symbiotic nitrogen fixation. Mechanism of phosphate solubilizationand phosphate mobilization, potassium solubilization.	6	CO4
UNIT V	Production technology - Strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid bio-fertilizers. FCO specifications and quality control of biofertilizers. Application technology for seeds,	6	CO5

	seedlings, tubers.Biofertilizers -Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers.		
	Total	**30**	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Produce biofertilizers and distinguish between organic and conventional farming.	PO1, PO3, PO4, PO5, PO6, PO7, P08, PO9, PO10, PO11, PO12, PO14
CO2	Plan a Complete Farm Business including marketing, operation and financial outline.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8
CO3	Practice the application of microbial bio-fertilizers in large scales, thereby increasing soil fertility.	PO4, PO5, PO6
CO4	Develop integrated farming for sustainable agriculture.	PO6, PO9, PO10
CO5	Promote the quality of packaging, storage, increase shelf life, accelerate the bio efficacy of bio fertilizers as per BIS standards	PO5, PO7, PO8, PO11, PO13, PO14

Text Books	
1.	Sharma A. K. (2001). Hand book of Organic Farming.Agrobios.
2.	Gaur A. C. (2006). Hand book of Organic Farming and Biofertilizers.Ambika Book Agency.
3.	Subba Rao N.S. (2017). Bio-fertilizers in Agriculture and Forestry. (4th Edition). Med Tech publisher.
4.	Subba Rao N. S. (2002). Soil Microbiology. Soil Microorganisms and Plant Growth. (4th Edition). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
5.	Sathe T.V. (2004). Vermiculture and Organic Farming. Daya Publishers.
References Books	
1.	Rakshit A. and Singh H. B. (2015). ABC of Organic Farming. (1st Edition). Jain Brothers.
2.	Dubey R. C. (2008). A Textbook of Biotechnology. S. Chand & Co., New Delhi.
3.	Bansal M. (2019). Basics of Organic Farming. CBS Publisher.
4.	Bhoopander G., Ram Prasad., (2019) Biofertilizer for sustainable agriculture and Environment, Springer
5.	Niir Board., (2012) (1st Edition) Biofertiliser and organic farming
Web Resources	
1.	https://agritech.tnau.ac.in/org_farm/orgfarm_introduction.html
2.	https://www.fao.org/organicag/oa-faq/oa-faq6/en/
3.	https://www.india.gov.in/topics/agriculture/organic-farming
4.	https://agriculture.nagaland.gov.in/bio-fertilizer/

5.	https://www.ccd.ngo/sustainable-agriculture.html?gclid=EAIaIQobChMI5a-KndCo-wIV2ZZLBR1ozQj9EAAYAiAAEgJW2_D_BwE

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Test	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

CO /PO	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	S	S	S	S	S	S		S
CO2	S	S	S	M	M	M	S	M						
CO3				S	S	S								
CO4						M			S	S				
CO5					M		S	S			S		M	S

SECOND YEAR
FOURTH SEMESTER

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI4C1	**Food and Environmental Microbiology**	**Core Course XI**	**-**	**T**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives	
CO1	Discuss microorganisms involved in food spoilage.
CO2	Illustrate bacterial and nonbacterial food borne infections important in public health. Familiarize various national and international aspects of food safety and quality assurance.
CO3	Create awareness. about components of environment, environmental pollution, and detection methods.
CO4	Acquire in depth knowledge about solid and liquid waste treatments.
CO5	Develop knowledge about organic matter degradation, bioremediation, and the environment risk assessment.

	Details	**No. of Hours**	**Course Objectives**
UNIT I	Microorganisms of food- Scope of food Microbiology. Contamination and spoilage of food –vegetables, fruits, poultry, fish, eggs, meat and milk products and canned foods. Food Preservation - Temperature (low and high), drying, radiation and chemicals.	18	CO1
UNIT II	Food microbiology and public health. Food hazards. Food Bacterial infections. Nonbacterial food borne illness - Helminthes, nematodes, protozoa, toxigenic fungi and food borne virus.Microbiological quality standards for food. Government regulatory practices and policies - FDA, HACCP, BIS (IS), FSSAI-2014. Food adulteration and common food additives.	18	CO2
UNIT III	Components of Environment: Hydrosphere, lithosphere, atmosphere, and biosphere – definitions with examples; Energy flow in the ecosystem- Carbon, Nitrogen, Sulfur and Phosphorous cycles. Physical factors affecting distribution of microorganisms in various environments. Predisposing factors for Environmental diseases – infectious (water and air borne) and pollution related, spread and control of these diseases. Treatment and safety of drinking (potable) water, methods to detect potability of water samples. Space microbiology - Microbiological research in space environment.	15	CO3

UNIT IV	Waste management – Solid waste - Types - management - Factors affecting solid waste generation rates. Industrial effluent treatment, primary, secondary, tertiary, and advanced treatment process. Quality assessment of decontaminated matters and other biological effluents. Biological reference standards. Utilization of Solid Waste as Food, Feed and Fuel- Composting, Vermicomposting, Bio manure and Biogas production. E waste management.	15	CO4
UNIT V	Degradation of organic matter - lignin, cellulose, hemicellulose, pectin, common pesticides- herbicides (2,4-D) and pesticides (DDT), heavy metals. Biodegradation of Xenobiotics - Recalcitrant Halocarbons, Recalcitrant TNTs, PCBs and Synthetic polymers. Biodegradation of Hydrocarbons. Biodeterioration of Textiles and Leather. Pollution Control Bodies and Environmental laws in India. Environmental impact assessment, EIA guidelines, US Environment protection Agency norms.	20	CO5
	Total	90	

Course Outcomes

Course Outcomes		
CO1	Utilize the knowledge on process of food contamination and spoilage to preserve food.	PO7, PO8, PO9
CO2	Use the knowledge on food borne disease to protect public health.	PO5, PO7, PO8, PO9
CO3	Explain the different types of microorganisms in water. Identify the causes of water pollution and the methods for quality assessment of water and control of water borne diseases.	PO1, PO5, PO6, PO7, PO8
CO4	Apply knowledge about waste treatments and microbial decomposition and bio-remediation process in environmental cleanup.	PO1, PO5
CO5	Plan a clear approach on environmental issues. Control pollution and explain protection laws to public.	PO1, PO5

Text Books

1.	Adams M. R. and Moss M. O. (1996). Food Microbiology, New Age International (P) Limited Publishers, New Delhi.
2.	Frazier W.C., Westhoff. D. C. and Vanitha K.N. (2013). Food Microbiology. (6th Edition). McGraw Hill Education.
3.	Jay J. M., Loessner M. J. and Golden D.A. (2006). Modern Food Microbiology. (7th Edition). Springer.
4.	Shrivastava A.K. (2003). Environment Auditing. A. P. H. Publishing Corporation.
5.	Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan.

	References Books
1.	Robinson R. K. (2000). Dairy Microbiology3rdEdn, Elsevier Applied Science, London.
2.	Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7thEdn. Edward Arnold: London.
3.	Banwarst. G.J. (2003). Basic Food Microbiology 2ndEdn, CBS Publishers and distributors.
4.	Bitton, G. (2011). Wastewater Microbiology. (4th Edition). Wiley-Blackwell.
5.	Bridgewater L. (2012). Standard Methods for the Examination of Water and Wastewater. American Public Health Association.
	Web Resources
1.	https://www.fssai.gov.in
2.	https://www.who.int/news-room/fact-sheets/detail/food-safety
3.	https://egyankosh.ac.in

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI4P1	**Practical IV – Applied Microbiology**	**Core Practical IV**	**-**	**-**	**P**	**-**	**4**	**6**	**25**	**75**	**100**

Course Objectives	
CO1	Enumerate bacteria in milk for quality analysis.
CO2	Analyze methods for microbes from spoiled food .
CO3	Gain knowledge on microbes present in water.
CO4	Identification and characterization of nitrogen fixers.
CO5	Gain knowledge on biofertilizerproduction.and field application.

	Details	**No. of Hours**	**Course Objectives**
UNIT I	Breed count, Direct microscopic count and Standard plate count of Milk, Methylene blue reductase test, Resazurin test and alkaline phosphatase test of milk.	20	CO1
UNIT II	Isolation of bacteria, fungi and yeast from spoiled and canned food. Production and detection of aflatoxins from spoiled food.	20	CO2
UNIT III	Microbial Analysis of water –MPN, Membrane filtration. Chemical - BOD.	10	CO3
UNIT IV	Enumeration of bacteria and fungi from air – Air sampler Isolation of free-living nitrogen fixers from soil and *Rhizobium* from root nodules of leguminous plants. Isolation and enumeration of phosphate-solubilizing bacteria from soil	20	CO4
UNIT V	Preparation of Biofertilizers and testing the efficiency of prepared biofertilizers, R:S ratio of soil microbes Study of phylloplane microflora by leaf impression method Isolation of cellulose degrading bacteria Isolation of plant pathogen –*Alternaria, Curvularia*, Cultivation of mushroom from solid waste	20	CO5
	Total	90	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Check the quality of milk	PO7, PO10
CO2	Identify bacteria and fungi in spoiled food	PO5, PO7, PO10
CO3	Analyze potability of water	PO5, PO10

CO4	Check the microbial population in air.	PO5, PO10
CO5	Prepare, apply and check the efficiency of biofertilizers.	PO5, PO10
Text Books		
1.	Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5th Edition). CRC Press.	
2.	Garg N., Garg K. and Mukerji K. G. (2013). I K. International Pvt. Ltd.	
3.	Pepper I., Gerba C. and Brendecke J. (2004). Environmental Microbiology - A Laboratory Manual. (2nd Edition). Academic Press, Elsevier.	
4.	Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). Manual of Environmental Microbiology. (4th Edition). Wiley.	
5.	Adams M.R, and Moss M.D, (2005). Food Microbiology 4th Edition, New Age International Pvt. Ltd., Publishers.First edition.	
	References Books.	
1.	Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7th Edition Edward Arnold: London.	
2.	Vijaya R K, (2004). Food Microbiology 1st Edition. MJP Publishers, Chennai.	
3.	Banwarst. G.J. (2003). Basic Food Microbiology 2nd Edition, CBS Publishers and distributors.	
4.	James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual. (5th Edition). The Benjamin publishing company. New York.	
5.	Hurst, C.J., Crawford R.L., Garland J.L., Lipson D.A., Mills A.L. and Stetzenbach L.D. (2007). Manual of Environmental Microbiology. (3rd Edition). American Society for Microbiology.	
Web Resources		
1.	https://www.fssai.gov.in	
2.	https://www.who.int/news-room/fact-sheets/detail/food-safety	
3.	https://academic.oup.com/bioscience/article/65/8/758/240222	
4.	https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5	
5.	https://vlab.amrita.edu/index.php?sub=3&brch=272	
Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	40 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
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

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI4 C2	**Research Methodology and Biostatistics**	**Core Course XII**	**-**	**T**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives	
CO1	Discuss the methods and techniques of data collection.
CO2	Explain sampling methods, write research reports and articles.
CO3	Discuss the basic concepts of Biostatistics.
CO4	Describe statistical software for analysis.
CO5	Explain the tests of significance.

	Details	**No.of Hours**	**Course Objectives**
UNIT I	Introduction to Research Methodology - Meaning and importance. Statement, Constraints. Review of literature - Review and synopsis presentation. Types of research, Research tools. Methods and techniques of data collection - types of data, methods of primary data collection (observation/ experimentation/ questionnaire/ interviewing/ case/pilot study, methods), methods of secondary data collection.	20	CO1
UNIT II	Sampling and sampling distributions. Sampling frame, importance of probability sampling, sampling - simple random, systematic, stratified random and cluster. Variables - nominal, ordinal, discontinuous, continuous, derived. Research process, designs and Report writing - types of research reports, guidelines for writing an article and report, report format, appendices, Ethical issues related to publishing, Plagiarism and Self-Plagiarism.	20	CO2
UNIT III	Introduction to Biostatistics - Basic concepts, Measurement and measurement scales, Sampling and data collection, Data presentation. Measures of central tendency: Mean, Median, Mode. Measures of variability - Standard deviation, standard error, range, mean deviation and coefficient of variation. Frequency table of single discrete variable, bubble spot, computation of mean, variance and standard Deviations, t test, correlation coefficient.	15	CO3
UNIT IV	Correlation and regression - Positive, negative, calculation of Karl-Pearsons co-efficient of correlation. Linear regression and multiple linear regression, ANOVA, one and two way classification. Calculation of an unknown variable using regression equation. Tests of significance - Tests of significance: Small sample test (Chi-square t test, F test), large sample test (Z test) and standard error.	20	CO4
UNIT V	Probability and distributions - Introduction to probability	15	CO5

	theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems) Computer oriented statistical techniques. RSM: methods for process optimization set up CCD, Box Behnken, optimal RSM design, regression models FDS curves, surface contours, multi linear constraints and categoric factors to optimal design.		
	Total	90	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Collect and present data suitable to the research design.	PO1, PO4, PO9, PO10
CO2	Write research manuscripts and articles for journals.	PO1, PO2, PO3, PO4, PO5, PO6, PO9, PO10, PO13
CO3	Recommend the utilization of biostatistics tools for analysis of biological data.	PO5, PO6, PO9, PO10, PO13
CO4	Prove and justify hypothesis for a particular research.	PO3, PO4, PO9, PO10
CO5	Apply software tools for interpretation of biological data.	PO4, PO9, PO10, PO13

Text Books	
1.	Sharma K.R. (2002) Research methodology. National Publishing House, New Delhi.
2.	Daniel W.W. (2005). Biostatistics; A foundation for analysis in the health sciences. (7^{th} Edition). Jhon Wiley & sons Inc, New York.
3.	Rao P. S. S. and Richard J. (2006). Introductionto Biostatistics & Research methods. Prentice-Hall, New Delhi.
4.	Veerakumari L. (2015) Bioinstrumentation 1^{st}edn. MJP Publishers.
5.	Ahuja V.K. (2017) Laws Relating to Intellectual Property Rights. Lexis Nexis.

References Books	
1.	Zar J. H. (2006). Biostatistical Analysis. (4^{th} Edition). Pearson Education Inc. New Jersey.
2.	Beins B. C. and McCarthy M.A. (2011). Research Methods and Statistics.Pearson Education Inc. New Jersey.
3.	Adams K. A. and Lawrence E. M. K. (2014). Research Methods, Statistics, and Applications.SAGE Publications, Inc., New Delhi.
4.	Anderson J.B. and Poole M. (2011). Assignment and Thesis Writing. 4^{th}edn. Wiley India Private Limited.
5.	Kothari C.R. and Garg G (2004) Research Methodology: Methods and Techniques. 2^{nd} Edition. New Age International Publishers

Web Resources	
1.	https://www.studocu.com/en-ca/document/mount-royal-university/quantitative-

	research-methods-and-data-analysis/lecture-notes-all-lectures/344093
2.	https://www.khanacademy.org/math/statistics-probability/sampling-distributions-library
3.	https://testbook.com/learn/maths-mean-median-mode/
4.	https://rcub.ac.in/econtent/ug/bcom/sem4/Business%20Statistics%20Unit%204%20Correlation%20and%20Regression.pdf
5.	https://www.cse.iitk.ac.in/users/piyush/courses/pml_fall17/material/probabilty_tutorial.pdf

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 4PR	Project with Viva voce		-	-	4	-	6	10	50	150	200

OBJECTIVES OF THE COURSE

To impart advanced practical knowledge to conduct a research project. To plan and design statistically, retrieve relevant literature, organize and conduct, process the data, photograph relevant observations, evaluate by statistical programmes. Present the project in any regional/national conference/seminar during the second year of the course and submit for final semester examinations. The work has to be conducted in department under the guidance of the project supervisor. Interdisciplinary collaborations from external departments / institutions can be organized only for essential areas of the project. Industrial visit has been included along with the project work as a report (minimum of 10 pages) possibly with geo-tagged photographs. The method of valuation of the project and Industrial visit report submitted by the candidate is outlined as follows:

Internal (2 out of 3 presentations)	-	50 Marks
Viva	-	50Marks
Project Report	-	100 Marks

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 4E1	**Bioenergy**	**Elective Course VI A**	**-**	**T**	**P**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives	
CO1	Acquire knowledge on bioenergy utilizing organic wastes for energy recovery.
CO2	Discuss methods and strategies of exploiting microbes for the production technology of biodiesel.
CO3	Describe resources and techniques for the production and estimation of eco-friendly biofuels and the extent of their use potentially.
CO4	Gain knowledge for executing biogas plant in communities.
CO5	Explain possibility of using microbes for the production of bio-hydrogen as a source of future fuel.

	Details	**No. of Hours**	**Course Objectives**
UNIT I	Bioenergy– Biomass Energy Resources. Biomass conversion methods. Microbes as bioresources for bioenergy products (Bacteria, fungi, yeast and microalgae) -Bioprospecting of microbial strains for biofuel production.	12	CO1
UNIT II	Biodiesel − Microbes and Biodiesel. Production and feed stock. Techniques of lipid extraction and conversion to biodiesel. Biodiesel quality and its assessment. Strategies of genetic engineering of organisms for biodiesel production. Biodiesel production from single cell organisms (*Cryptococcus, Cunninghamella, Mortierella*).	12	CO2
UNIT III	Alcoholic Fuels from microorganisms: Biochemical conversion to ethanol: Biomass pre-treatment, Starch to sucrose conversion and Sucrose to ethanol fermentation. Role of enzymes and their applications in ethanol production. Distillation and Quantification of ethanol. Production and Estimation of biobutanol, biomethanol, biopropanol and bioglycerol.	12	CO3
UNIT IV	Biogas - Microbes and Biogas production, Biogas plants – types – design – construction– Biogas Bottling Technology and Development in India, Biogas appliances – burner, luminaries and power generation – effect on engine performance. Application of Biogas slurry in agriculture**.**	12	CO4
UNIT V	Biohydrogen– Production from bacteria and algae. Commercialized microalgae (*Spirulina, Dunaliella, Hematococcus*and *Chlorella*) and their production. Economics of microalgae production. Cultivation of seaweeds. Microbial fuel cells.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Evaluate the various aspects of biomass production and their implementation.	PO1, PO5, PO6
CO2	Design and construct a biodiesel plant.	PO5, PO7, PO8, PO11,
CO3	Carry out the process of fermentation for bio – alcohol fuels.	PO1, PO4, PO5, PO7,
CO4	Identify the nature of biogas as a biofuel and their technologies and applications.	PO5, PO7, PO8, PO11.
CO5	Design, execute and extract biohydrogen from algae.	PO4, PO5, PO7, PO8.

Text Books	
1.	Dahiya A. (2014). Bioenergy- Biomass to Biofuel. (1st Edition). Academic Press Editor.
2.	Brown R. C. (2003). Biorenewable Resources: Engineering New Products from Agriculture. (1st Edition). Wiley Blackwell Publishing.
3.	Jawaid M., Hakeem K. R. and Rashid U. (2014). Biomass and Bioenergy: Processing and Properties. (1st Edition). Springer Cham.
4.	Caye M. Drapcho, Tery H. Walker (Biofuels EngineeringProcess Technology. McGraw Hill.
5.	Teri. Bio energy Powering the Future. Pearson Longman Publications.
References Books	
1.	Konur O. (2018). Bioenergy and Biofuels. (1st Edition). CRC Press.
2.	LeeJ. W.(2012). Advanced Biofuels and Bioproducts. (13th Edition), Springer.
3.	Khanal S. (2008). Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. (8th Edition). Wiley-Blackwell Publishing.
4.	Pradeep Chaturvedi.(1995). Bioenergy Resources. Concept Publishing Company.
5.	Lee S. (2018).Biofuel and Bioenergy. Taylor and Francis
Web Resources	
1.	https://www.elsevier.com Biofuels and Bioenergy
2.	https://www.sciencedirect.com › book › bioenergy
3.	https://www.un.org/en/climatechange/what-is-renewable-energy?gclid=EAIaIQobChMIqriN2Nao-wIV2HwrCh2pfA5mEAAYASAAEgI-p_D_BwE
4.	https://www.energy.gov/eere/bioenergy/bioenergy-basics
5.	https://www.iea.org/fuels-and-technologies/bioenergy

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

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 4E2	**Marine Microbiology**	**Elective Course VI B**	**-**	**T**	**P**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives	
CO1	Gain fundamental knowledge of marine environment and the microbial communities inhabiting the oceans.
CO2	Discuss the metabolic diversity of marine microorganisms and their interrelationships.
CO3	Explain the survival of microorganisms in extreme environments.
CO4	Illustrate pathogens and contaminants in sea foods.
CO5	Describe the applications of marine biotechnological products and their future role in a rapidly changing planet.

	Details	**No. of Hours**	**Course Objectives**
UNIT I	Marine microbial environment - Benthic & littoral zone, salt pan, mangroves and estuarine microbes, microbial loop. Marine microbial communities – Bacteria, fungi, protozoa. Microbial interactions – Endosymbionts and Ectosymbionts.	12	CO1
UNIT II	Dynamics of Marine Microbes - Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming – Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization – phosphorus cycle. Decomposition of organic matter. Bioleaching and biodeterioration of natural and synthetic materials.	12	CO2
UNIT III	Marine extremophiles: Mechanism of survival at extreme environments – Adaptive mechanisms in thermophilic, alkalophilic, osmophilic, barophilic, psychrophilic hyperthermophilic and halophilic microorganisms – Importance in biotechnology.	12	CO3
UNIT IV	Marine Microbial Diseases:Aqua culture pathogens & Water borne pathogens -*Aeromonas, Vibrio,Salmonella, Pseudomonas, Leptospira, Corynebacteria*and viral diseases.Rapid diagnosis of contamination in sea foods and aquaculture products.	12	CO4
UNIT V	Applications of Marine Microbial Biotechnology: Production and applications of marine microbial products – Enzymes, Antibiotics, Organic acids, Toxins, Biosurfactants and Pigments. Sea food preservation methods. Probiotic bacteria and their importance in aquaculture.	12	CO5
	Total	60	

Course Outcomes	
Course Outcomes	On completion of this course, students will;

CO1	Apply the knowledge on marine microbial communities and their interactions.	PO1, PO9
CO2	Illustrate the role of marine microorganisms in biogeochemical cycles.	PO5, PO7
CO3	Categorize the extreme environments in the oceans and the survival mechanisms adapted by the microorganisms living in these environments.	PO7, PO9
CO4	Identify the diseases affecting marine organisms and its diagnosis.	PO5, PO7
CO5	Evaluate the marine microorganisms as a resource for novel microbial products.	PO7, PO8, PO9
Text Books		
1.	Munn C. B. (2019). Marine Microbiology: Ecology and Applications. (3rd Edition). CRC Press. ISBN:9780367183561.	
2.	Bhakuni, D.S. and Rawat D.S. (2005). Bioactive Marine Natural Products. Anamaya Publishers, New Delhi. ISBN:1-4020-3472-5.	
3.	Brock T. D. (2011). Thermophilic Microorganisms and Life at High Temperatures. Springer. ISBN-13:978-1461262862 / ISBN-10:1461262860.	
4.	Nybakken, J.W. (2001). Marine Biology. (5th Edition). Benjamin Cummings. ISBN:0321030761 9780321030764.	
5.	Veena. (Understanding marine biology. Discovery Publishing.	
References Books		
1.	Maier R.M., Pepper I.L. and Gerba C.P. (2006). Environmental Microbiology. (2nd Edition). Academic Press. ISBN:978-0-12-370519-8.	
2.	Belkin S. and Colwell R.R. (2005). Oceans and Health: Pathogens in the Marine Environment. Springer. ISBN:978-0-387-23708-4.	
3.	Scheper T. (2009). Advances in Biochemical Engineering/Biotechnology-Marine Biotechnology. Springer. ISBN:978-3-540-69356-7. E-ISBN:978-3-540-69357-4.	
4.	Gasol J. M. and Kirchman D. L. (Eds.). (2018). Microbial Ecology of the Oceans. (3rd Edition). Wiley-Blackwell. ISBN:978-1-119-10718-7.	
5.	Kim S. K. (2019). Essentials of Marine Biotechnology. Springer.	
Web Resources		
1.	https://link.springer.com/content/pdf/bfm%3A978-0-387-23709-1%2F1	
2.	https://www.researchgate.net/publication/285931262_Bioactive_Marine_Natural_Products	
3.	http://link.springer.com/content/pdf/bfm%3A978-3-642-03470-1%2F1.pdf	
4.	https://link.springer.com/book/10.1007/b102184	
5.	https://www.wiley.com/en-bs/Microbial+Ecology+of+the+Oceans%2C+3rd+Edition-p-9781119107187	
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
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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	M								M					
CO2					M		S							
CO3							M		S					
CO4					M		S							
CO5							S	S	M					

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 4E3	Life Science for Competitive Examinations	Elective Course VI C	-	T	P	-	3	4	25	75	100

Course Objectives	
CO1	Impart knowledge on structure, metabolism and function of biomolecules.
CO2	Understand the importance of inheritance biology.
CO3	Discuss in-depth about the different types of ecosystems and their importance.
CO4	Outline the major drivers in biodiversity and various conservation approaches.
CO5	Introduce basic concepts of evolution and biological clock.

	Details	No. of Hours	Course Objectives
UNIT I	Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins. Structure of atoms, molecules and chemical bonds.Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.).Bioenergetics.	12	CO1
UNIT II	Cellular Organisation,Cell division and cell cycle,Membrane structure and function,Organization of genes and chromosomes,Structural organization and function of intracellular organelles,DNA replication, repair and recombination,Protein synthesis and processing.	12	CO2
UNIT III	Inheritance Biology,Mendelian principles- Dominance, segregation, independent assortment,Linkage and Gene mapping, Karyotyping,Extrachromosomal inheritance - Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. Human genetics-Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.	12	CO3
UNIT IV	Ecology-Habitat and Niche,biotic and abiotic interactions, Biome- biogeographical zones of India.Ecological Succession,Population Ecology- Characteristics of a population; population growth curves,Environmental pollution-global environmental change, Biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.Biodiversity Management approaches. Indian case studies on Conservation/Management strategy (Project Tiger, Biosphere Reserves).	12	CO4
UNIT V	Evolution and Behaviour- Evolution - Theories- Darwin's, Lamarck's, Oparin Haldane. Paleontological,	12	CO5

	Embryological and Molecular evidences. Hardy Weinberg's Law. Speciation; Allopatricity and Sympatricity. Adaptive radiation and Convergent evolution; Sexual selection; Co-evolution. Altruism, Biological clocks, Migration and Parental care. Molecular Evolution- Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny.		
	Total	60	
Course Outcomes			
Course Outcomes	On completion of this course, students will;		
CO1	Define, classify and assess the structure, biological functions and interactions of Biomolecules.	PO4, PO6, PO9	
CO2	Validate the knowledge of collective and progressive notions of cellular organization.	PO4, PO6, PO9	
CO3	Assess and describe the importance of inheritance biology.	PO4, PO6, PO9	
CO4	Establish acquaintance and understanding of ecology & Biodiversity in a broader sense.	PO4, PO6, PO9	
CO5	Understand the processes of evolution, relate with natural selection, adaptation and speciation.	PO4, PO6, PO9	
Text Books			
1.	Nelson D. L. and Cox M. M. (2008). Lehningers Principles of Biochemistry. (5th Edition). W.H. Freeman and Company.		
2.	Chapman J.L. (1998).Ecology: Principles and Applications. (2nd Edition). Cambridge University Press.		
3.	Krishnamurthy V.K. (2003). Textbook of Biodiversity. Science Publishers.		
4.	Rogers A.L. (2011). Evidence of Evolution. University of Chicago Press. Chicago.		
5.	StitesD.P.,AbbaI.Terr, Parslow T.G.(1997). Medical Immunology. 9thEdn, Prentice-Hall Inc.		
References Books			
1.	Pontarotti P. (2018). Origin and Evolution of biodiversity. (1st Edition). Springer.		
2.	Verma P.S. and Agarwal V.K. (2004). Cell biology, Genetics, Molecular Biology, Evolution and Ecology. (2nd Edition). S Chand publication.		
3.	Lewin R. and Foley R. (2004). Principles of Human Evolution. (2nd Edition). Black well Publishing Company.		
4.	Boyer R.F. (2002) Modern Experimental Biochemistry 3rd Edition. Pearson Education.		
5.	Wilson K., Walker J., Clokie S and Hofmann A. (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8th Edition Cambridge University Press.		
Web Resources			
1.	https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_		

2.	https://www.livescience.com/474-controversy-evolution-works.html.
3.	https://www.examrace.com/Study-Material/Life-Sciences/
4.	https://www.kopykitab.com/Methods-In-Biology-Life-Science-Study-Material-For-CSIR-NET-Exam-by-Panel-Of-Experts
5	https://www.erforum.net/2017/01/life-science-biology-handwritten-notes-for-competitive-exams.html

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23MMI 4S1	**Microbial Quality Control and Testing**	**Skill Enhancement Course III**	**-**	**T**	**-**	**-**	**2**	**2**	**25**	**75**	**100**

Course Objectives

CO1	Explain various microbiological quality standards for food, water and air regulatory practices and policies.
CO2	Discuss collection, processing and preservation ofwater samples from industries in different areas.
CO3	Enumeration and isolation of microorganism from the water samples.
CO4	Enumeration and isolation of microorganism from the air samples.
CO5	Gain knowledge on sterility testing of different components in industries and quality control techniques.

	Details	No. of Hours	Course Objectives
UNIT I	Concepts of quality control techniques - quality assurance, Total Quality Management (TQM) Continuous Quality Improvement (CQI) Quality Assurance (QA) pre analytical and post analytical techniques, ATCC, MTCC, microbial based assay.	6	CO1
UNIT II	Waste water microbiology – types and sources of contamination, prevention of water borne diseases. Water management, water harvesting, water recycling. Characteristics of waste water from industries - Sugar factory, Pulp & Paper mill, Distillery, Textile, Engineering, Food Industry, Domestic waste. Waste water treatment plant types and quality control. Water pollution causes and remedies.	6	CO2
UNIT III	Microflora of water. Microbiological analysis of water sample. Microbiological analysis of water sample collection, drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests Control of microbes in water: Water borne pathogens, water borne diseases. Control of water borne pathogens- Precipitation, chemical disinfection, filtration, high temperature, UV light.	6	CO3
UNIT IV	Microflora of air - Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in	6	CO4

	food and pharma industries and operation theatres. Collection of air samples and analysis. Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, isolation and Identification. Control Measures of Bioaerosols - UV light, HEPA filters, desiccation, Incineration.		
UNIT V	Quality control in food - Food X ray inspection, PPE Equipment, IoT sensors, preventive quality control and reality quality control. Quality control of pharma products. Quality assurance framework, assessment of pharmaceutical quality, determinants of pharmaceutical quality, practical approaches to quality assurance.	6	CO5
	Total	30	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Apply knowledge in quality analysis techniques suitable for industries.	PO4, PO5, PO7, PO8
CO2	Perform water managements, water harvestingand treat sewage, water pollutions and remedies.	PO4, PO5, PO7, PO8
CO3	Detect portability of water. Test water quality.	PO4, PO5, PO7, PO8
CO4	Impart knowledge on bioaerosols, impact and prevention	PO4, PO5, PO7, PO8
CO5	Apply quality control techniques for food and pharma products	PO4, PO5, PO7, PO8

Text Books

1. Aneja R.P., Mathur B.N., Chandan R.C. and Banerjee, A.K. (2002). Experiments in Microbiology.
2. Adams M. R. and Moss M. O. (2006). Food Microbiology. (2nd Edition). Royal Society of Chemistry.
3. Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand.
4. Cappuccimo, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6th Edition). Pearson Education, Publication, New Delhi.
5. Rosamund M. Baird., Norman A. (2019). Handbook of Microbiologicalquality control in Pharmaceuticals and Medical Devices. CRC Press.

References Books

1. Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2nd Edition). - Taylor &Francis.
2. Sundararaj T. (2003). Microbiology Laboratory Manual. (2nd Edition). Published by A. Sundararaj
3. Hoges N. A., Denyer S P. and Baird R.M. (2003). Handbook of microbiological quality control. Microbial Quality Assurance in Pharmaceutcals, cosmetics & Toiletries. by Sally F. Bloomfield
4. AmitavaMitra. Fundamentals of Quality control and Improvement. (3rd Edition). Wiley Publications

5.	David Roesti, Marcel Goverde (2019). Pharmaceutical Microbiological Quality Assurance and control: Practical guide for non- sterile Manufacturing. Wiley Publishers.
Web Resources	
1.	https://www.researchgate.net › publication › 320730681
2.	https://www.fssai.gov.in
3.	https://mofpi.nic.in/Schemes/implementation-haccp-iso-22000-iso-9000-ghp-gmp-etc
4.	https://www.who.int/news-room/fact-sheets/detail/food-safety
5.	https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

Methods of Evaluation		
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Mapping with Programme Outcomes

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CO1				M	L		S	S						
CO2				M	L		M	M						
CO3				S	L		S	S						
CO4				S	L		S	S						
CO5				S	L		M	M						