

D.K.M COLLEGE FOR WOMEN (AUTONOMOUS) VELLORE-1

M.Sc MICROBIOLOGY SYLLABUS TEMPLATE 2024-2025

S. No	Part	Category	Ins. Hrs/Week	Credit	Title of the paper	Maximum marks		
						CI A	Sem. Exam	Total
SEMESTER I								
1	Part I	Core Paper I	7	5	General Microbiology and Microbial Diversity	25	75	100
2		Core Paper II	7	5	Immunology, Immunomics and Microbial Genetics	25	75	100
3		Core Paper III	6	4	Practical-I	25	75	100
4		Discipline Centric Elective-I	5	3	Forensic Science/ Health Hygiene/ Microalgal Technology	25	75	100
5		Generic Elective - II	5	3	Bioinstrumentation/ Herbal Technology and Cosmetic Microbiology / Essentials of Laboratory Management and Biosafety	25	75	100
			30	20				500
SEMESTER II								
6	Part I	Core Paper IV	6	5	Medical Bacteriology and Mycology	25	75	100
7		Core Paper V	6	5	Medical Virology and Parasitology	25	75	100
8		Core Paper VI	6	4	Practical-II	25	75	100
9		Discipline Centric Elective-III	4	3	Epidemiology/Clinical Diagnostic Microbiology/ Bioremediation (a)	25	75	100
10		Generic Elective – IV	4	3	Bioinformatics/ Nanobiotechnology/Clinical Research and Clinical Trials	25	75	100
11	Part II	Skill Enhancement I	4	2	Vermitechnology	25	75	100
12		Compulsory Paper	2	2	Human rights	25	75	100
13		MOOC course	-	2	Online course	-	-	-
			30	26				600

SEMESTER III								
14	Part I	Core Paper VII	6	5	Soil and Environmental Microbiology	25	75	100
15		Core Paper VIII	6	5	Molecular Biology and Recombinant DNA Technology	25	75	100
16		Core Paper IX	6	4	Practicals III	25	75	100
17		Core Paper X	5	5	Fermentation Technology and Pharmaceutical Microbiology	25	75	100
18		Discipline Centric Elective-V	4	3	Biosafety, Bioethics and IPR/Toxinology/Water Conservation and Water Treatment Technologies	25	75	100
19	Part II	Skill Enhancement II	3	2	Organic Farming and Biofertiliser Technology	25	75	100
20		Internship/ Industrial Activity	-	2	Internship / Industrial Activity	-	-	-
			30	26				500
SEMESTER IV								
21	Part I	Core Paper XI	6	5	Food & Dairy Microbiology	25	75	100
22		Core Paper XII	6	5	Research Methodology & Biostatistics	25	75	100
23		Core Project	10	7	Project with Viva Voce	25	75	100
24		Elective – VI (Industry/ Entrepreneurship) 20% Theory 80% Practical	4	3	Bioenergy/ Marine Microbiology/ Life Science for Competitive Examinations	25	75	100
25	Part II	Skill Enhancement Course/ Professional Competency Skill	4	2	Microbial Quality Control and Testing	25	75	100
26	Part III		-	1	Extension activity	-	-	-
			30	23				500
Total			120	95				

M.SC. MICROBIOLOGY

Programme Educational Objectives (PEOs)

PEO1: Attain Academic and Professional Excellence

Build a strong academic foundation and skill set that will enable success in higher education, competitive examinations, teaching, research, industry, and entrepreneurial ventures.

PEO2: Emerge as Empowered Individuals

Develop into confident, self-reliant, and economically independent women capable of applying scientific knowledge to enhance personal growth, family welfare, and community development.

PEO3: Advance Research and Innovation

Demonstrate the ability to investigate real-world challenges and contribute contextually relevant, research-driven, and innovative solutions across scientific disciplines.

PEO4: Uphold Ethical and Cultural Values

Adhere to high ethical standards, respect cultural diversity, and engage responsibly in scientific practices that contribute to a just and inclusive society.

PEO5: Respond to Societal and National Needs

Utilize scientific understanding to support public health, environmental conservation, and technological advancement, fostering inclusive regional and national progress.

PEO6: Exhibit Leadership and Social Responsibility

Lead scientific and community initiatives with integrity, inspire collaborative action, and actively contribute to positive social transformation at local and global levels.

PEO7: Engage in Lifelong and Global Learning

Pursue continuous personal and professional development while staying abreast of global trends, innovations, and interdisciplinary scientific advancements.

Programme Outcomes (POs)

PO1: Comprehend and Apply Scientific Knowledge

Acquire and apply core knowledge from scientific disciplines to understand natural phenomena, solve complex problems, and support innovation across various domains of life and industry.

PO2: Demonstrate Analytical and Critical Thinking

Develop the ability to think critically and analytically by formulating hypotheses, interpreting experimental results, evaluating scientific literature, and drawing evidence-based conclusions.

PO3: Exhibit Technical and Laboratory Competency

Gain proficiency in laboratory techniques, handling of scientific instruments, and use of software tools, while adhering to safety protocols, accuracy, and reproducibility in experimental work.

PO4: Communicate Effectively

Present scientific concepts and findings clearly and coherently through oral presentations, technical writing, and the use of digital tools, adapting to both academic and professional contexts.

PO5: Uphold Ethical Values and Environmental Consciousness

Integrate ethical principles and environmental awareness into scientific practices, promoting sustainable solutions and a sense of accountability towards society and nature.

PO6: Engage in Lifelong Learning

Cultivate an inquisitive mindset and adaptability to emerging scientific advancements, technologies, and interdisciplinary approaches, thereby remaining relevant and competent throughout life.

PO7: Collaborate and Lead in Scientific and Social Contexts

Participate effectively in collaborative scientific projects and community-based activities, demonstrating leadership, decision-making, and commitment to women's empowerment and societal progress.

□ Programme Specific Outcomes (PSOs) – M.Sc. Microbiology

PSO1: Master Advanced Microbiological Theories and Applications

Acquire in-depth knowledge of microbial biotechnology, molecular biology, medical microbiology, and industrial applications, integrating theoretical and practical insights.

PSO2: Design and Conduct Independent Research

Formulate hypotheses, design experimental protocols, and carry out microbiological research projects with an emphasis on innovation, reproducibility, and ethical integrity.

PSO3: Use Modern Instrumentation and Analytical Tools

Operate advanced laboratory equipment such as spectrophotometers, PCR, electrophoresis units, fermenters, and bioinformatics software for microbial studies.

PSO4: Address Global and Local Challenges Through Microbial Solutions

Apply microbiological expertise to areas such as antimicrobial resistance, vaccine development, environmental remediation, and biotechnology-based entrepreneurship.

PSO5: Exhibit Professional and Leadership Competence

Demonstrate project management, team leadership, and decision-making skills in academic, industrial, and healthcare settings.

PSO6: Contribute to Scientific Literature and Knowledge Dissemination

Engage in scientific writing, peer-reviewed publications, conference participation, and knowledge exchange at regional, national, and international levels.

PSO7: Commit to Lifelong Learning and Ethical Practice

Stay abreast of global trends in microbiology and uphold ethical and environmental standards in all professional and academic endeavors.

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	General Microbiology and Microbial Diversity	Core Course I	Y	Y	-	-	5	7	25	75	100
Course Objectives											
CO1	Acquire knowledge on the principles of different types of microscopes and their applications.										
CO2	Compare and contrast the structure of bacteria and fungi. Illustrate nutritional requirements and growth in bacteria.										
CO3	Exemplify, isolate and cultivate microalgae from diverse environmental sources.										
CO4	Explain various pure culture techniques and discuss sterilization methods.										
CO5	Discuss the importance and conservation of microbial diversity.										
UNIT	Details								No. of Hours	Course Objectives	
I	History and Scope of Microbiology. Microscopy – Principles and applications. Types of Microscopes - Bright field, Dark-field, Phase-contrast, Fluorescence microscope, Transmission electron microscope (TEM) and Scanning electron microscope (SEM). Sample preparation for SEM & TEM. Atomic force, Confocal microscope. Micrometry – Stage, Ocular and its applications.								20	CO1	
II	Bacterial Structure, properties and biosynthesis of cellular components – Cell wall. Actinomycetes and Fungi - Distribution, morphology, classification, reproduction and economic importance. Sporulation. Growth and nutrition - Nutritional requirements, Growth curve, Kinetics of growth, Batch culture, Synchronous growth, Measurement of growth and factors affecting growth.								20	CO2	
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.								15	CO3	
IV	Microbial techniques - 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	
V	Biodiversity - Introduction to microbial biodiversity – Classification and applications of Thermophiles , Alkaliphiles Acidophiles , Barophiles and Halophiles. Methanogenes .								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	Differentiate and appreciate the anatomy of various microbes. Plan the growth of microbes for different environmental conditions.	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	Create aseptic conditions by following good laboratory practices.	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. (10 th Edition). Universities Press (India) Pvt. Ltd.		
2.	Chan E.C.S., Pelczar M. J. Jr. and Krieg N. R. (2010). Microbiology. (5 th Edition). Mc.Graw Hill. Inc, New York.		
3.	Prescott L. M., Harley J. P. and Klein D. A. (2004). Microbiology. (6 th 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 (12 th Edition). Pearson, London, United Kingdom		
2.	Webster J. and Weber R.W.S. (2007). Introduction to Fungi. (3 rd Edition). Cambridge University Press, Cambridge.		
3.	Schaechter M. and Leaderberg J. (2004). The Desk encyclopedia of Microbiology. Elsevier Academic Press, California.		
4.	Ingraham, J.L. and Ingraham, C.A. (2000) Introduction to Microbiology. (2 nd 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. (15 th 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		
									CI A	External	Total
	Immunology Immunomics and Microbial Genetics	Core Course II	Y	Y	-	-	5	7	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.										
UNIT	Details								No. of Hours	Course Objectives	
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 and 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. Antigen processing and presentation to T-lymphocytes.								20	CO1	
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. Physiology of acquired immune response – various phases of HI, CMI – Cell mediated cytotoxicity, DTH response.								20	CO2	
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 Rh System. Diagnostic Immunology - Precipitation reaction, Immunodiffusion methods - SRID, ODD. Immunoelectrophoresis - Rocket and Counter current electrophoresis. Agglutination- Labeled Assay- Immunofluorescence assay, Radio immunoassay, ELISA.								25	CO3	

	Role of cytokines, lymphokines and chemokines. Introduction to Vaccines and Adjuvants - Types of vaccines. Immunomics - Introduction and Applications. Antigen engineering for better immunogenicity and use for vaccine development-multiepitope vaccines. Reverse vaccinology.		
IV	Structure of prokaryotic and eukaryotic genome. Introduction to prokaryotic genomic structure, Eukaryotic Genome - Structure of chromatin, chromosome, centromere, telomere, nucleosome. Modifications-methylation, acetylation, phosphorylation.	13	CO4
V	Gene Transfer Mechanisms- Conjugation and its uses. Transduction, Generalized and Specialized, Transformation– Natural Competence and Transformation. Transposition, Mechanism and Types of Transposition reactions.	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. (5 th Edition). Wiley-Blackwell, New York.
2.	Owen J. A., Punt J., Stranford S. A. and Kuby J. (2013). Immunology, (7 th Edition). W. H. Freeman and Company, New York.
3.	Abbas A. K., Lichtman A. H. and Pillai S. (2021). Cellular and Molecular Immunology. (10 th Edition). Elsevier.
4.	Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4 th Edition). Narosa Publishing House, New Delhi.
5.	Gardner E. J. Simmons M. J. and Snusted D.P. (2006). Principles of Genetics. (8 th Edition). Wiley India Pvt. Ltd.

References Books

1.	Travers J. (1997). Immunobiology - The Immune System in Health and Disease. (3 rd Edition). Current Biology Ltd. New York.
2.	Delves P.J., Martin S., Burton D. R. and Roitt I. M. (2006). Roitt's Essential Immunology. (11 th Edition). Wiley-Blackwell.

3.	Hay F. C. and Westwood O. M. R. (2002). Practical Immunology (4 th Edition). Wiley-Blackwell.
4.	Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5 th Edition). ASM Press.
5.	Russell P.J. (2010). Genetics - A Molecular Approach. (3 rd 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 (8 th 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
	Practical I	Core Course III-Practical I	-	-	Y	-	4	6	25	75	100
Course Objectives											
CO1	Gain knowledge on the fundamentals, handling and applications of microscopy, sterilization methods. Identify microbes by different staining methods.										
CO2	Prepare media for bacterial growth. Discuss plating and growth measurement techniques.										
CO3	Acquire adequate skills to perform blood grouping and serological reactions.										
CO4	Provide fundamental skills in preparation, separation and purification of immunoglobulin.										
CO5	Apply the knowledge of molecular biology skills in clinical diagnosis.										
UNIT	Details								No. of Hours	Course Objectives	
I	<p>Microscopic Techniques: Light microscopy: Hay infusion broth. Wet mount to show different types of microbes, hanging drop.</p> <p>Dark field microscopy – Motility.</p> <p>Washing and cleaning of glass wares: Sterilization methods: moist heat, dry heat, and filtration.</p> <p>Quality control check for each method.</p> <p>Staining techniques - Simple staining, Gram’s staining, Acid fast staining, Spore, Capsule, Flagella.</p>								20	CO1	
II	<p>Media Preparation: Preparation of liquid, solid and semisolid media. Agar deeps, slants, plates. Preparation of basal, enriched, selective and enrichment media.</p> <p>Preparation of Biochemical test media, media to demonstrate enzymatic activities.</p> <p>Microbial Physiology: Purification and maintenance of microbes. Streak plate, pour plate, and slide culture technique. Aseptic transfer.</p> <p>Direct counts – Total cell count, Turbidometry. Viable count - pour plate, spread plate. Bacterial growth curve. Anaerobic culture methods.</p>								20	CO2	
III	<p>Hematological reactions - Blood Grouping – forward and reverse, Rh Typing</p> <p>Identification of various immune cells by morphology – Leishman staining.</p> <p>Agglutination Reactions- Latex Agglutination reactions- RF, ASO.</p> <p>Detection of HBs Ag by ELISA.</p> <p>Precipitation reactions in gels– Ouchterlony double immunodiffusion (ODD) and Mancini’s single radial immunodiffusion (SRID)</p>								20	CO3	

	Immuno-electrophoresis - Rocket immuno electrophoresis and counter current immuno electrophoresis.		
IV	Preparation of lymphocytes from peripheral blood by density gradient centrifugation.	10	CO4
V	Western Blotting – Demonstration. Isolation of genomic DNA from <i>E. coli</i> and analysis by agarose gel electrophoresis Estimation of DNA using colorimeter (Diphenylamine reagent) Separation of proteins by polyacrylamide gel electrophoresis (SDS-PAGE) UV induced mutation and isolation of mutants by replica plating technique. Plasmid DNA isolation from <i>E.coli</i> . RNA isolation from yeast. RNA estimation by Orcinol method.	20	CO5
	Total	60	
Course Outcomes			
Course Outcomes	On completion of this course, students will;		
CO1	Apply microscopic techniques and staining methods in the identification and differentiation of microbes.	PO1, PO6, PO7, PO8, PO9, PO11	
CO2	Apply the knowledge on the sterilization of glass wares and media by different methods and measurement of cell growth.	PO1, PO6, PO7, PO8, PO9, PO11	
CO3	Perform and evaluate immunological reactions to aid diagnosis.	PO5, PO7, PO8, PO9, PO11	
CO4	Assess the level of lymphocytes in a blood sample and purify immunoglobulin employing appropriate techniques.	PO6, PO7, PO8, PO9, PO11	
CO5	Perform DNA extraction and gene transfer mechanisms, analyze and identify by gel electrophoresis	PO6, PO7, PO8, PO9, PO11	
Text Books			
1.	Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand.		
2.	Cappuccino, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6 th Edition). Pearson Education, Publication, New Delhi.		
3.	Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2 nd Edition). -Taylor & Francis.		
4.	Rich R. R., Fleisher T. A., Shearer W. T., Schroeder H, Frew A. J. and Weyand C. M. (2018). Clinical Immunology: Principles and Practice. (5 th Edition). Elsevier.		
5.	Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5 th Edition). ASM Press.		
References Books			
1.	Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14 th Edition). Elsevier, New Delhi.		
2.	Gupta P. S. (2003). Clinical Immunology. Oxford University Press.		
3.	Brown T.A. (2016). Gene Cloning and DNA Analysis. (7 th Edition). John Wiley and Jones, Ltd.		

4.	Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3 rd Edition). John Wileys and Sons Ltd. 2012.
5.	Maloy S. R., Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2 nd Edition). Narosa Publishing Home Pvt Ltd.

Web Resources

1.	http://textbookofbacteriology.net/
2.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/
3.	https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/
4.	[PDF] Lehninger Principles of Biochemistry (8 th 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
	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
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks			
									CIA	External	Total	
	Forensic Science	Elective Course I (Choice -1)	Y	Y	-	-	3	5	25	75	100	
Course Objectives												
CO1	Understand the Scope, need and learn the tools and techniques in forensic science.											
CO2	Comprehend organizational setup of a forensic science laboratory.											
CO3	Identify and Examine body fluids for identification.											
CO4	Extract DNA from blood samples for investigation.											
CO5	Recognize medico legal post mortem procedures and their importance.											
UNIT	Details								No. of Hours	Course Objectives		
I	Forensic Science - Definition, history and development of forensic science. Scope and need of forensic science in present scenario. Branches of forensic science. Tools and techniques of forensic science. Duties of a forensic scientist.								12	CO1		
II	Forensic science laboratories - Organizational setup of a forensic science laboratory. Central and State level laboratories in India. Mobile forensic science laboratory and its functions. Forensic microbiology - Types and identification of microbial organisms of forensic significance.								12	CO2		
III	Forensic serology - Definition, identification and examination of body fluids - Blood, semen, saliva, sweat and urine. Forensic examination and identification of hair and fibre.								12	CO3		
IV	DNA profiling - Introduction, history of DNA typing. Extraction of DNA from blood samples - Organic and Inorganic extraction methods. DNA fingerprinting - RFLP, PCR, STR. DNA testing in disputed paternity.								12	CO4		
V	Forensic toxicology - Introduction and concept of forensic toxicology. Medico legal post mortem and their examination. Poisons - Types of poisons and their mode of action.								12	CO5		
	Total								60			
Course Outcomes	On completion of this course, students will;											
CO1	Identify the scope and need of forensic science in the present scenario.								PO1, PO6, PO7, PO8, PO9			
CO2	Plan for the organizational setup and functioning of forensic science laboratories.								PO1, PO6, PO7, PO8, PO9			
CO3	Analyze the biological samples found at the crime scene.								PO1, PO5, PO7, PO8, PO9			
CO4	Perform extraction and identification of DNA obtained from body fluids.								PO1, PO6, PO7, PO8, PO9			
CO5	Discuss the concept of forensic toxicology.								PO1, PO6, PO7, PO8, PO9			
Text Books												

1.	Nanda B. B. and Tewari R. K. (2001) Forensic Science in India: A Vision for the Twenty First Century. Select Publishers, New Delhi. ISBN- 10:8190113526 / ISBN-13:9788190113526.	
2.	James S. H. and Nordby, J. J. (2015) Forensic Science: An Introduction to Scientific and Investigative Techniques. (5 th Edition). CRC Press. ISBN-10:9781439853832 / ISBN-13:978-1439853832.	
3.	Li R. (2015) Forensic Biology. (2 nd Edition). CRC Press, New York. ISBN-13:978-1-4398-8972-5.	
4.	Sharma B.R (2020) Forensic science in criminal investigation and trials. (6 th Edition)Universal Press.	
5.	Richard Saferstein (2017). Criminalistics- An introduction to Forensic Science. (12 th 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, (3 rd Edition). CRC Press, New York. ISBN-10:1498720196.	
3.	Lincoln, P.J. and Thomson, J. (1998). (2 nd Edition). Forensic DNA Profiling Protocols. Vol. 98. Humana Press. ISBN: 978-0-89603-443-3.	
4.	Val McDermid (2014). Forensics. (2 nd Edition). ISBN 9780802125156.	
5.	Vincent J. DiMaio., Dominick DiMaio. (2001). Forensic Pathology (2 nd 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 (K1)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	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
	Health and Hygiene	Elective Course I (Choice- 2)	Y	Y	-	-	3	5	25	75	100
Course Objectives											
CO1	Acquire knowledge on hygiene and live healthy.										
CO2	Provide insights on health laws for food safety and hygiene.										
CO3	Explain health, physical exercises and their importance.										
CO4	Illustrate mental hygiene and involved in mental hygiene.										
CO5	Describe the various health and health education programmes by the government.										
UNIT	Details								No. of Hours	Course Objectives	
I	Introduction to hygiene and healthful live. Factors affecting health, health habits and practices. Recognizing positive & negative practices in the community. Scientific principles related to health.								12	CO1	
II	Nutrition and Health – Balanced diet, Food surveillance, food Fortification, adulteration and preventive measures. Health laws for food safety. Environmental and housing hygiene. Ventilation and lighting.								12	CO2	
III	Physical health, physical exercises and their importance – Walking, jogging, yoga and meditation, stress relief. International control of health, WHO. Personal hygiene, Sun bathing, Colon Hygiene. Health destroying habits and addictions - Pan, supari, ganja, drinking, smoking, tea and coffee.								12	CO3	
IV	Mental hygiene - factors responsible, developmental tasks, basic needs, emotional stability. Mental hygiene and health in infancy, early childhood, adolescence, adulthood and old age. Mental health occupational hazards.								12	CO4	
V	Health programme and health education – Malaria control, Tuberculosis control, AIDS control programmes and Immunization Programmes. Family planning, Reproductive and Child health programmes (RCH).								12	CO5	
	Total								60		
Course Outcomes											
Course Outcomes	On completion of this course, students will;										
CO1	Identify factors affecting health and health habits.								PO1, PO5, PO10		

CO2	Execute the knowledge of ventilation and lighting. Justify Health laws for food safety and hygiene.	PO5, PO10
CO3	Follow personal hygiene to avoid diseases and Prevent people from health-destroying habits and addictions.	PO5, PO10
CO4	Explore Mental hygiene and maintain emotional stability.	PO5, PO10
CO5	Participate in health education programmes	PO1, PO5, PO10
Text Books		
1.	Bamji M. S., Krishnaswamy K. and Brahmam G. N. V. (2019). Textbook of Human Nutrition. (4 th Edition). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi	
2.	Swaminathan (1995) Food & Nutrition (Vol I) (2 nd Edition). The Bangalore Printing & Publishing Co Ltd., Bangalore.	
3.	Paniker J. C. K. and Ananthanarayan R. (2017). Textbook of Microbiology. (10 th Edition). Universities Press (India) Pvt. Ltd	
4.	Lindsay Dingwall .(2010). Personal Hygiene Care Print ISBN:9781405163071 Online ISBN:9781444318708 DOI:10.1002/9781444318708	
5.	Walter C. C. Pakes(1900). The Science of Hygiene: a Text-book of Laboratory Practice. (London: Methuen and Co.,).	
References Books		
1.	Khader V. (2000) Food, Nutrition and Health, Kalyan Publishers, New Delhi.	
2.	Srilakshmi, B. (2010) Food Science, (5 th Edition) New Age International Ltd., New Delhi.	
3.	Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand.	
4.	Park K. 2007, Park's text book of Preventive and Social Medicine, Banarsidas Bhanot publishers, India.	
5.	Srilakshmi, 2002, Dietetics, New Age Publications, India	
Web Resources		
1.	Health and Hygiene - Personal Hygiene, Community Hygiene and Diseases (vedantu.com)	
2.	Chapter-32.pdf (nios.ac.in)	
3.	Menstrual Health and Hygiene Guide Student Health and Counseling Services (ucdavis.edu)	
4.	https://nap.nationalacademies.org/read/11756/chapter/13	
5.	http://ecoursesonline.iasri.res.in/mod/page/view.php?id=112325	
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	
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				
CO2					S					M				
CO3					S					L				
CO4					S					M				
CO5	L				S					M				

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Microalgal Technology	Elective Course I (Choice -3)	Y	Y	-	-	3	5	25	75	100
Course Objectives											
CO1	Characterize the different groups of algae.										
CO2	Describe the cultivation and harvesting of algae.										
CO3	Identify the commercial applications of various algal products.										
CO4	Apply microalgae for environmental applications.										
CO5	Employ microalgae as alternate fuels.										
UNIT	Details								No. of Hours	Course Objectives	
I	Introduction to Algae - General characteristics. Classification of algae. Salient features of different groups of algae. Distribution - Freshwater, brackish water and marine algae. Identification methods.								12	CO1	
II	Cultivation of freshwater and marine microalgae - Growth media. Isolation and enumeration of microalgae. Laboratory cultivation and maintenance. Outdoor cultivation - Photobioreactors - construction, types and operation; raceway ponds - Heterotrophic and mixotrophic cultivation - Harvesting of microalgae biomass.								12	CO2	
III	Microalgae in food and nutraceutical applications - Algal single cell proteins. Cultivation of <i>Spirulina</i> . Microalgae as aquatic, poultry and cattle feed. Microalgal biofertilizers. Value-added products from microalgae. Pigments - Production of microalgal carotenoids and their uses. Microalgal secondary metabolites - Pharmaceutical and cosmetic applications.								12	CO3	
IV	Microalgae in environmental applications. Phycoremediation - Domestic and industrial waste water treatment. High-rate algal ponds and surface-immobilized systems - Treatment of gaseous wastes by microalgae. Algal blooms, algicides for algal control.								12	CO4	
V	Microalgae as feed stock for production of biofuels - Carbon-neutral fuels. Lipid-rich algal strains - <i>Botryococcus braunii</i> . Drop-in fuels from algae - hydrocarbons and biodiesel, bioethanol, biomethane, biohydrogen and syngas from microalgae biomass.								12	CO5	
	Total								60		

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Acquire knowledge in the field of microalgal technology and their characteristics.	PO1
CO2	Identify the methods of algal cultivation and harvesting.	PO1, PO6
CO3	Recognize and recommend the use of microalgae as food, feed and fodder.	PO7, PO8, PO9
CO4	Promote microalgae in phycoremediation.	PO7, PO9, PO11, PO14
CO5	Compare and critically evaluate recent applied research in these microalgal applications.	PO7, PO8, PO9
Text Books		
1.	Lee R.E. (2008). Phycology. Cambridge University Press.	
2.	Sharma O.P. (2011). Algae. Tata McGraw-Hill Education.	
3.	Shekh A., Schenk P., Sarada R. (2021). Microalgal Biotechnology. Recent Advances, Market Potential and Sustainability. Royal Society of Chemistry.	
4.	Lele. S.S., Jyothi Kishen Kumar (2008). Algal bio process technology. New Age International P(Ltd)	
5.	Das., Mihirkumar. Algal Biotechnology. Daya Publishing House, New Delhi.	
References Books		
1	Andersen R.A. (2005). Algal culturing techniques. Academic Press, Elsevier.	
2	Bux F. (2013). Biotechnological Applications of Microalgae: Biodiesel and Value-added Products. CRC Press.	
3	Singh B., Baudhdh K., Bux, F. (2015). Algae and Environmental Sustainability. Springer.	
4	Das D. (2015). An algal biorefinery: An integrated approach. Springer.	
5	Bux F. and Chisti Y. (2016). Algae Biotechnology: Products and Processes. Springer.	
Web Resources		
1	https://www.classcentral.com/course/algae-10442	
2	https://onlinecourses.nptel.ac.in/noc19_bt16/preview	
3	https://freevidelectures.com/course/4678/nptel-industrial-biotechnology/46	
4	https://nptel.ac.in/courses/103103207	
5.	https://www.sciencedirect.com/topics/earth-and-planetary-sciences/microalgae	
Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	
	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
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Bioinstrumentation	Elective Course II (Choice -1)	Y	Y	-	-	3	5	25	75	100
Course Objectives											
CO1	Explain the principles and working mechanisms of laboratory instruments.										
CO2	Discuss chromatography techniques and molecular biology techniques.										
CO3	Illustrate molecular techniques in biological applications.										
CO4	Acquire knowledge on spectroscopic techniques										
CO5	Demonstrate the use of radio isotopes in various techniques.										
UNIT	Details								No. of Hours	Course Objectives	
I	Basic laboratory Instruments. Aerobic and anaerobic incubator – Biosafety Cabinets - Fume Hood, pH meter, Lyophilizer, Flow cytometry. Centrifugation techniques: Basic principles of centrifugation - Standard sedimentation coefficient - measurement of sedimentation co-efficient; Applications in determination of molecular weight.								12	CO1	
II	General principles of chromatography - Chromatographic Performance parameters; Types- Thin layer chromatography, Paper Chromatography, Adsorption, ion exchange, Gel filtration, affinity. Flash Chromatography and Ultra Performance convergence chromatography. Two dimensional chromatography. Stimulated moving bed chromatography (SEC).								12	CO2	
III	Electrophoresis: General principles - moving boundary electrophoresis - electrophoretic mobility – supportive materials – electro endosmosis – types (horizontal, vertical and two dimensional electrophoresis) - Principle and applications - paper electrophoresis, starch gel electrophoresis, Disc gel, Agarose gel, SDS – PAGE, Immuno electrophoresis. Blotting techniques -Southern, northern and western blotting.								12	CO3	
IV	Spectroscopic techniques: Principle, simple theory of absorption of light by molecules, electromagnetic spectrum, instrumentation and application of UV- visible, Raman, FTIR spectrophotometer, spectrofluorimetry,								12	CO4	

	Atomic Absorption Spectrophotometer, Flame spectrophotometer, NMR, ESR, Emission Flame Photometry and GC-MS. Detection of molecules in living cells - FISH and GISH..		
V	Radioisotopic techniques: Principle and applications of tracer techniques in biology. Radioactive isotopes - radioactive decay; Detection and measurement of radioactivity. Geiger- Muller and Scintillation counters, auto radiography and its applications- 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. (3 rd Edition). Prentice Hall.		
5.	Jayaraman J. (2011). Laboratory Manual in Biochemistry. (2 nd Edition). Wiley Eastn Ltd., New Delhi.		
References Books			
1.	Pavia D. L. (2012) Spectroscopy (4 th Edition). Cengage.		
2.	Skoog A. and West M. (2014). Principles of Instrumental Analysis. (14 th Edition). W.B.Saunders Co., Philadelphia.		
3.	Miller J. M. (2007). Chromatography: Concepts and Contrasts (2 nd Edition) Wiley-Blackwell.		
4.	Gurumani N. (2006). Research Methodology for Biological Sciences. (1 st Edition) MJP Publishers.		
5.	Ponmurugan P. and Gangathara P. B. (2012). Biotechniques. (1 st 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 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		
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
	Herbal Technology and Cosmetic Microbiology	Elective Course II (Choice 2)	Y	Y	-	-	3	5	25	75	100
Course Objectives											
CO1	Impart knowledge of Indian Medicinal Plants and their applications in microbiology.										
CO2	Promote the technical skills involved in preparation of different types of plant extracts.										
CO3	Explain methods to analyze the antimicrobial activity of medicinal plants.										
CO4	Acquire knowledge on cosmetic microbiology and role of microorganisms in cosmetics.										
CO5	Gain insight into pharmacopeial microbial assays and biosafety.										
UNIT	Details								No. of Hours	Course Objectives	
I	Herbs, Herbal medicine - Indian medicinal plants: Scope and Applications of Indian medicinal plants in treating bacterial, fungal and viral diseases. Basic principles involved in Ayurvedha, Sidha, Unani and Homeopathy.								12	CO1	
II	Collection and authentication of selected Indian medicinal plants: <i>Emblica officinalis</i> , <i>Withania somnifera</i> , <i>Phyllanthus amarus</i> , <i>Tinospora cordifolia</i> , <i>Andrographis paniculata</i> , <i>Piper longum</i> , <i>Ocimum sanctum</i> , <i>Azardirchata indica</i> , <i>Terminalia chebula</i> , <i>Allium sativum</i> . Preparation of extracts- Hot and cold methods. Preparation of stock solutions.								12	CO2	
III	Antimicrobial activity of selected Indian medicinal Plants: - In vitro determination of antibacterial and fungal activity of selected whole medicinal plants/ parts – well-diffusion methods. MIC - Macro and micro dilution techniques. Antiviral activity- cell lines- cytotoxicity, cytopathic and non-cytopathic effect.								12	CO3	
IV	History of Cosmetic Microbiology – Need for cosmetic microbiology, Scope of cosmetic microbiology, - Role of microbes in cosmetic preparation. Preservation of cosmetics. Antimicrobial properties of natural cosmetic products – Garlic, neem, turmeric, aloe vera and tulsi. Sanitary practices in cosmetic manufacturing - HACCP protocols in cosmetic microbiology.								12	CO4	
V	Cosmetic microbiology test methods - Antimicrobial preservative efficacy, microbial content testing and biological toxicological testing. Validation methods - bioburden and Pharmacopeial microbial assays. Preservatives of cosmetics - Global regulatory and toxicological aspect of cosmetic preservatives.								12	CO5	
	Total								60		

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Identify the applications of Indian medicinal plants in treating diseases.	PO1, PO5
CO2	Identify and authenticate herbal plants.	PO6, PO7
CO3	Evaluate the antimicrobial activity of medicinal plants.	PO4, PO6, PO9
CO4	Describe the role of microorganisms and their metabolites in the preparation of cosmetics.	PO1, PO5, PO7
CO5	Validate procedures and biosafety measures in the mass production of cosmetics.	PO6, PO7
Text Books		
1.	Ayurvedic Formulary of India. (2011). Part 1, 2 & 3. Pharmacopoeia Commission for Indian Medicine and Homeopathy. ISBN-10:8190648977.	
2.	Panda H. (2004). Handbook on herbal medicines. Asia Pacific Business Press Inc. ISBN:8178330911.	
3.	Mehra P. S. (2019). A Textbook of Pharmaceutical Microbiology. Dreamtech Press. ISBN 13:9789389307344.	
4.	Geis P. A. (2020). Cosmetic microbiology: A Practical Approach. (3 rd 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. (2 nd 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 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		
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge		
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons		
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations		

Mapping with Programme Outcomes

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Essentials of Laboratory Management and Biosafety	Elective Course II (Choice 3)	Y	Y	-	-	3	5	25	75	100
Course Objectives											
CO1	To utilize containment principles to ensure biosafety.										
CO2	To enrich the student role and responsibilities of laboratory hazards and their control.										
CO3	To know the importance of first aid technique for various common lab accidents.										
CO4	To acquire knowledge of biosafety level, risk assessment and maintain proper hygiene in the laboratory.										
CO5	To discuss the biosafety regulations and guidelines and implementation of safety programs.										
UNIT	Details								No. of Hours	Course Objectives	
I	Introduction to the laboratory and laboratory hazards - General laboratory facilities – Occupational safety- Lab accidents - Fires, chemical burns, slips and falls, Animal bites. Cuts from broken glass. Toxic fume inhalation. General laboratory rules, Good laboratory practice (GLP). Laboratory plan.								12	CO1	
II	Common hazards in laboratory: Chemical hazards- Safe handling of chemicals and gases, hazard labels and symbols. Material safety datasheet (MSDS), Chemical handling - Fume hood, Storage of chemicals. Chemical Waste Disposal Guideline. Physical hazards - Physical agent data sheets (PADS), Electric hazards- Electrical shock, Electrical explosions, Electrical burns. Safe work practices. Potential ignition sources in the lab. Stages of Fire. Fire Extinguishers. Fire Response.								12	CO2	
III	Prevention and First aid for laboratory accidents. Personal protective equipment (PPE), Proper attire (Eye/Face Protection, laboratory coats, gloves, respirators. 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	
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								12	CO4	

	biological agents. Hygiene, disinfection, decontamination, sterilization.		
V	Biosafety regulations and guidelines. Centers for disease control and prevention and the National institutes of health. Occupational safety and health administration. Recombinant DNA advisory committee(RDAC), Institutional biosafety committee(IBSC), Review committee on genetic manipulation(RCGM), Genetic engineering approval committee (GEAC). Implementation of biosafety guidelines.	12	CO5
	Total	60	
Course Outcomes			
Course Outcomes	On completion of this course, students will;		
CO1	Employ skills on laboratory safety and avoid laboratory accidents.	PO1, PO2, PO3, PO7, PO11	
CO2	Prevent laboratory hazards by practicing safety strategies.	PO2, PO5, PO7, PO11	
CO3	Practice various first aid procedures during common laboratory accidents.	PO1, PO2, PO3, PO5, PO10, PO11	
CO4	Ensure biosafety strategies in laboratory.	PO2, PO3, PO4, PO7, PO10, PO11	
CO5	Recognize the importance of biosafety guidelines.	PO3, PO4, PO5, PO7, PO10, PO11	
Text Books			
1.	Sateesh M. K. (2013). Bioethics and Biosafety, IK International Pvt Ltd. ISBN : 8190675702.		
2.	Muthuraj M. and Usharani B. (2019). Biosafety in Microbiological Laboratories. (1st Edition). Notion Press. ISBN 10: 1645878856		
3.	Biosafety in Microbiological and Biomedical Laboratories - U.S. Health Department and Human Services. (2016). (5 th Edition). Lulu.com.		
4.	Kanai. L. Mukherjee. (Medical Laboratory Technology(4 th Edition). CBS Publishers.		
5.	Ramakrishnan (2012). Manual of Medical Laboratory Techniques. JP brothers.		
References Books			
1.	World Health Organization, Biosafety programme management. (2010). (4 th Edition). WHO Publications.		
2.	Rashid N. (2013). Manual of Laboratory Safety (Chemical, Radioactive, and Biosafety with Biocides) (1 st 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 (2 nd 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/Online_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
	Medical Bacteriology and Mycology	Core Course IV	Y	Y	-	-	5	6	25	75	100
Course Objectives											
CO1	Acquire Knowledge on collection, transportation and processing of various kinds of clinical specimens.										
CO2	Explain morphology, characteristics and pathogenesis of bacteria.										
CO3	Discuss various factors leading to pathogenesis of bacteria.										
CO4	Acquire knowledge on antifungal agents and their importance.										
CO5	Describe various diagnostic methods available for fungal disease diagnosis.										
UNIT	Details								No. of Hours	Course Objectives	
I	Classification of medically important bacteria, Normal flora of human body, Collection, transport, storage and processing of clinical specimens, Microbiological examination of clinical specimens, antimicrobial susceptibility testing.								20	CO1	
II	Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of <i>Staphylococci</i> , <i>Streptococci</i> , <i>Pneumococci</i> , <i>Neisseriae.</i> , <i>Bacillus</i> , <i>Corynebacteria</i> , <i>Mycobacteria</i> and <i>Clostridium</i> .								20	CO2	
III	Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by Enterobacteriaceae members, <i>Yersinia</i> , <i>Pseudomonas</i> , <i>Vibrio</i> , <i>Helicobacter</i> , <i>Rickettsiae</i> , <i>Chlamydiae</i> , <i>Bordetella</i> , <i>Spirochaetes- Leptospira</i> and <i>Treponema</i> . Nosocomial, zoonotic and opportunistic infections -prevention and control.								20	CO3	
IV	Morphology and taxonomy of fungi. Superficial mycoses - Dermatophytes. Yeast of medical importance - <i>Candida</i> and <i>Cryptococcus</i> . Mycotoxin. Antifungal drugs.								15	CO4	
V	Dimorphic fungi causing - systemic mycoses - <i>Histoplasma</i> , <i>Blastomyces</i> and <i>Coccidioides</i> . Subcutaneous mycoses - <i>Sporothrix</i> . Opportunistic fungi causing secondary infection in immunocompromised individuals. Immunodiagnostic methods in mycology.								15	CO5	
Total								90			

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Collect, transport and process of various kinds of clinical specimens.	PO1,PO5,PO9
CO2	Analyze various bacteria based on morphology and pathogenesis.	PO1,PO5,PO9
CO3	Discuss various treatment methods for bacterial disease.	PO1,PO5,PO9
CO4	Employ various methods detect fungi in clinical samples and apply knowledge on antifungal agents..	PO5,PO9
CO5	Apply various immunodiagnostic method to detect fungal infections.	PO5,PO9
Text Books		
1.	Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (2017).Orient Longman, Hyderabad.	
2.	Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18 th Edition). Churchill Livingstone, London.	
3.	Finegold, S. M. (2000) Diagnostic Microbiology, (10 th Edition). C.V. Mosby Company, St. Louis.	
4.	Alexopoulos C. J., Mims C. W. and Blackwell M. (2007). Introductory Mycology, (4 th Edition). Wiley Publishers.	
5.	Chander J. (2018). Textbook of Medical Mycology. (4 th Edition). Jaypee brothers Medical Publishers.	
References Books		
1.	Salle A. J. (2007). Fundamental Principles of Bacteriology. (4 th Edition). Tata McGraw-Hill Publications.	
2.	Collee J.C. Duguid J.P. Foraser, A.C, Marimon B.P, (1996). <u>Mackie & McCartney Practical Medical Microbiology</u> . 14 th edn, Churchill Livingston.	
3.	Cheesbrough M. (2006). <u>District Laboratory Practice in Tropical countries.- Part 22ndedn</u> .Cambridge University Press.	
4.	Topley and Wilson's. (1998). <u>Principles of Bacteriology</u> .9 th edn. Edward Arnold, London.	
5.	Murray P.R., Rosenthal K.S. and Michael A. (2013). <u>Medical Microbiology</u> . Pfaller. 7 th edn. Elsevier, Mosby Saunders.	
Web Resources		
1.	http://textbookofbacteriology.net/nd	
2.	https://microbiologysociety.org/members-outreach-resources/links.html	
3.	https://www.pathelective.com/micro-resources	
4.	http://mycology.cornell.edu/fteach.html	
5.	https://www.adelaide.edu.au/mycology/	

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks
Methods of Assessment		
Recall (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				S				M					
CO2	M				S				M					
CO3	M				S				M					
CO4					S				M					
CO5					S				M					

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Medical Virology and Parasitology	Core Course V Theory	Y	Y	-	-	5	6	25	75	100
Course Objectives											
CO1	Describe the replication strategy and cultivation methods of viruses.										
CO2	Acquire knowledge about oncogenic virus and human viral infections.										
CO3	Develop diagnostic skills, in the identification of virus infections.										
CO4	Impart knowledge about parasitic infections.										
CO5	Develop diagnostic skills, in the identification of parasitic infections.										
UNIT	Details								No. of Hours	Course Objectives	
I	General properties of viruses - Structure and Classification - viroids, prions, satellite RNAs and virusoids. Cultivation 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	
II	Virus Entry, Host Defenses Against Viral Infections, Epidemiology, pathogenic mechanisms, Pathogenesis, laboratory diagnosis, treatment for the following viruses: DNA Viruses- Pox , Herpes , Adeno , Papova and Hepadna , RNA Viruses- Picorna, Orthomyxo, Paramyxo, Rhabdo, Rota, HIV and other Hepatitis viruses, Arbo – Dengue virus, Ebola virus, Emerging and reemerging viral infections								20	CO2	
III	Bacterial viruses - ΦX 174, M13, MU, T4, lambda, Pi; Structural organization, life cycle and phage production. Lysogenic cycle. Diagnosis of viral infections. Antiviral agents and viral vaccines.								15	CO3	
IV	Introduction to Medical Parasitology – Classification, host-parasite relationships. Epidemiology, life cycle, pathogenic mechanisms, laboratory diagnosis, treatment for the following: Protozoa causing human infections – <i>Entamoeba</i> , <i>Giardia</i> , <i>Trichomonas</i> , <i>Balantidium</i> . <i>Toxoplasma</i> , <i>Cryptosporidium</i> , <i>Leishmania</i> , and <i>Trypanasoma</i> .								15	CO4	
V	Classification, life cycle, pathogenicity, laboratory diagnosis and treatment for parasites – Helminthes - Cestodes – <i>Taenia Solium</i> , <i>T. Saginata</i> , <i>T. Echinococcus</i> . Trematodes – <i>Fasciola Hepatica</i> , <i>Fasciolopsis Buski</i> , <i>Paragonimus</i> , <i>Schistosomes</i> . Nematodes - <i>Ascaris</i> , <i>Ankylostoma</i> , <i>Trichuris</i> , <i>Trichinella</i> , <i>Enterobius</i> ,								20	CO5	

	<i>Strongyloides</i> and <i>Wuchereria</i> . Other parasites causing infections in immune compromised hosts and AIDS.		
	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. (10 th Edition). Universities Press (India) Pvt. Ltd.		
2.	Dubey, R.C. and Maheshwari D.K. (2010). A Text Book of Microbiology. S. Chand & Co.		
3.	Rajan S. (2007). Medical Microbiology. MJP publisher.		
4.	Paniker J. (2006). Text Book of Parasitology. Jay Pee Brothers, New Delhi.		
5.	Arora, D. R. and Arora B. B. (2020). Medical Parasitology. (5 th Edition). CBS Publishers & Distributors Pvt. Ltd. New Delhi.		
Reference Books			
1.	Carter J. (2001). Virology: Principles and Applications (1 st Edition). Wiley Publications.		
2..	Willey J., Sandman K. and Wood D. Prescott's Microbiology. (11 th Edition). McGraw Hill Book.		
3.	Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19 th Edition). Lange Medical Publications, U.S.A.		
4.	Finegold S.M. (2000). Diagnostic Microbiology. (10 th Edition). C.V. Mosby Company, St. Louis.		
5.	Levanthal R. and Cheadle R. S. (2012). Medical Parasitology. (6 th 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 (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
Analyses (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Practical II	Core Course VI-Practical I II	-	-	Y	-	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	Diagnose parasitic										
CO4	To gain knowledge about industrially important microbes.										
CO5	Screen and utilize microorganisms for effective industrial production of metabolites.										
UNIT	Details							No. of Hours	Course Objectives		
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. Antimicrobial sensitivity testing - Kirby Bauer method and Stokes method. Minimum inhibitory concentration (MIC) test. Minimum bactericidal concentration (MBC) test.							20	CO1		
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 - <i>Mucor</i> , <i>Rhizopus</i> , <i>Aspergillus</i> , <i>Penicillium</i> . 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	CO2		
III	Examination of parasites in clinical specimens - Ova/cysts in faeces. Concentration: methods – Flootation methods-simple Saturated salt solution method – Zinc sulphate methods - Sedimentation methods- Formal ether method. Blood smear examination for malarial parasites. Leishman's stain.							20	CO3		

	Identification of common arthropods of medical importance - spotters of <i>Anopheles</i> , <i>Aedes</i> , Ticks and mites.		
IV	Good Laboratory Practices in Industrial Microbiology laboratory. Study of Bioreactor and its essential parts. Culturing and Characterization of microorganisms used in Dairy and Pharmaceutical industry. Screening for Enzyme producers (amylase /protease). Optimization of parameters for Amylase production. Screening for Organic acid producers (acetic acid/lactic acid). Screening for Antibiotic producers.	15	CO4
V	Immobilization of microbial cells and enzyme and its assessment. Microbiological assays of fermentation products – MIC-MBC. Microbiological assay of antibiotics by cup plate method and other methods.	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 bacteria, fungus and parasites from the clinical samples by staining and biochemical tests.	PO7, PO8, PO9
CO3	Promote diagnostic skills; interpret laboratory tests in the diagnosis of infectious diseases.	PO7, PO8, PO9, PO10
CO4	Perform antibiotic sensitivity tests and compare with the standard tests.	PO7, PO8, PO9, PO10
CO5	Screening of industrially important microbes for metabolite production.	PO7, PO8, PO9

Text Books

1.	Cullimore D. R. (2010). Practical Atlas for Bacterial Identification, 2 nd Edition. Publisher-Taylor and Francis.
2.	Abbott A.C. (2010). The Principles of Bacteriology. Nabu Press.
3.	Parija S. C. (2012). Textbook of Practical Microbiology. Ahuja Publishing House.
4.	Cappuccino, J. and Sherman, N. (2002) Microbiology: A Laboratory Manual, (6 th Edition). Pearson Education, Publication, New Delhi.
5.	Morag C. and Timbury M.C. (1994). Medical Virology. 4 th 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. (14 th 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 22 nd Edition. Cambridge University Press.
5.	Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7 th 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 Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (K1)	Simple definitions, MCQ, Recall steps, Concept definitions
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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
	Epidemiology	Elective Course III (Choice 1)	Y	Y	-	-	3	4	25	75	100
Course Objectives											
CO1	Describe the role of epidemiology in public health.										
CO2	Explain about epidemiology tools and disease surveillance methods.										
CO3	Analyze various communicable and non-communicable diseases in India.										
CO4	Discuss on mechanism of antimicrobial resistance.										
CO5	Outline on National health programmes that have been designed to address the issues.										
UNIT	Details								No. of Hours	Course Objectives	
I	Fundamentals of epidemiology - Definitions of epidemiology – Epidemiology of infectious diseases in Public Health. Natural history of disease - Historical aspects of epidemiology. Common risk factors - Epidemiologic Triad - Agent factors, host factors and environmental factors. Transmission basics - Chain of infection, portal of entry. Modes of transmission -Direct and indirect. Stages of infectious diseases. Agents and vectors of communicable diseases of public health importance and dynamics of disease transmission. Epidemiology of Zoonosis - Control of zoonosis.								12	CO1	
II	Tools of Epidemiology - Measures of Disease - Prevalence, incidence. Index case. Risk rates. Descriptive Epidemiology - Cohort studies, measuring infectivity, survey methodology including census procedures. Surveillance strategies - Disease surveillance, geographical indication system, outbreak investigation in public health and contact investigation.								12	CO2	
III	Epidemiological aspects of diseases of national importance - Background to communicable and non-communicable diseases. Emerging disease threats - Severe Acute Respiratory Syndrome (SARS), Covid-19, Ebola, MDR-TB, Malaria, Mucor mycosis, Avian flu. Dengue, Swine Flu, Chikungunya. Epidemiology, prevention, and control of non-communicable diseases - Asthma, Coronary heart disease, Malignancy, diabetes mellitus, respiratory diseases, eye diseases, Dental disorders. Emerging and Re-emerging Diseases.								12	CO3	
IV	Mechanisms of Antimicrobial resistance - Multidrug Efflux pumps, Extended Spectrum β -lactamases (ESBL). Hospital acquired infections - Factors, infection sites, mechanisms, Role of Multidrug resistant pathogens. Role of <i>Pseudomonas</i> , <i>Acinetobacter</i> , <i>Clostridium difficile</i> , HBV, HCV, Rotavirus, <i>Cryptosporidium</i> and <i>Aspergillus</i> in Nosocomial infections. Prevention and management of nosocomial infections.								12	CO4	
V	National Programmes related to Communicable and Non-Communicable diseases - National Malaria Eradication Programme, Revised National Tuberculosis Control								12	CO5	

	Programme, Vector Borne Disease Control Programme, National AIDS Control Programme, National Cancer Control Programme and National Diabetes Control Programme.		
	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., (3 rd Edition). CDC.		
2.	Gerstman B. (2013). Epidemiology Kept Simple: An Introduction to Classic and Modern Epidemiology. (3 rd Edition). Wiley Blackwell.		
3.	Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18 th Edition). Churchill Livingstone, London.		
4.	Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19 th Edition). Lange Medical Publications, U.S.A.		
5.	Dimmok N. J. and Primrose S. B. (1994). <u>Introduction to Modern Virology</u> .5 th edn. Blackwell Scientific Publishers.		
References Books			
1.	Bhopal R. S. (2016). Concepts of Epidemiology - An Integrated Introduction to the Ideas, Theories, Principles and Methods of Epidemiology. (3 rd Edition). Oxford University Press, New York.		
2.	Celentano D. D. and Szklo M. (2018). Gordis Epidemiology. (6 th Edition). Elseiver, USA.		
3.	Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2 nd Edition). Cambridge University Press.		
4.	Ryan K. J. and Ray C. G. (2004). Sherris Medical Microbiology. (4 th Edition), McGraw Hill, New York.		
5.	Topley W.W. C., Wilson, G. S., Parker M. T. and Collier L. H. (1998). Principles of Bacteriology. (9 th 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/		

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Clinical and Diagnostic Microbiology	Elective Course III (Choice 2)	Y	Y	-	-	3	4	25	75	100
Course Objectives											
CO1	Describe appropriate safety protocol and laboratory techniques for handling specimens and biomedical waste management.										
CO2	Develop working knowledge of techniques used to identify infectious agents in the clinical microbiology lab.										
CO3	Elucidate various diagnostic procedures in microbiology.										
CO4	Acquire knowledge on different methods employed to check antibiotic sensitivity.										
CO5	Gain knowledge on hospital acquired infections and their control measures.										
UNIT	Details								No. of Hours	Course Objectives	
I	Microbiology Laboratory Safety Practices -General Safety Guidelines, Handling of Biological Hazards, Infectious health care waste disposal - Biomedical waste management, Emerging and Re-emerging infections.								12	CO1	
II	Diagnostic procedures - General concept of Clinical specimen collection, transport, storage and general processing in Microbiology laboratory - Specimen acceptance and rejection criteria.								12	CO2	
III	Diagnosis of microbial diseases - Microbiological, immunological and molecular diagnosis of microbial diseases. Automation in Microbial diagnosis.								12	CO3	
IV	Antibiotic sensitivity tests - Disc diffusion - Stokes and Kirby Bauer methods- Dilution - MBC/MIC - Quality control for antibiotics and standard strains.								12	CO4	
V	Nosocomial infections – common types, sources, reservoir and mode of transmission, pathogenesis and control measures. Hospital Infection Control Committee (HICC) – Functions.								12	CO5	
	Total								60		

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Apply Laboratory safety procedures and hospital waste disposal strategies.	PO5, PO6, PO7
CO2	Collect various clinical specimens, handle, preserve and process safely.	PO6, PO7
CO3	Identify the causative agents of diseases by conventional and molecular methods following standard protocols.	PO6, PO7, PO9, PO11
CO4	Assess the antimicrobial susceptibility pattern of pathogens.	PO7, PO9
CO5	Trace the sources of nosocomial infection and recommend control measures.	PO5, PO7
TEXT BOOKS		
1.	Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14 th Edition). Elsevier, New Delhi. ISBN-10:0443047219 / ISBN-13-978-0443047213.	
2.	Tille P. M. (2021). Bailey and Scott's Diagnostic Microbiology. (15 th Edition). Elsevier. ISBN:9780323681056.	
3.	Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19 th Edition). Lange Medical Publications, U.S.A.	
4.	Mukherjee K.L. (2000). Medical Laboratory Technology. Vol. 1-3. (2 nd Edition). Tata McGraw-Hill Education. ISBN-10:0074632604.	
5.	Sood R. (2009). Medical Laboratory Technology – Methods and Interpretations. (6 th Edition). 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 Tenover F.C. (2003). Manual of Clinical Microbiology. (8 th Edition). American Society for Microbiology, Washington, DC. ISBN:1-555810255-4.	
2.	Bennett J. E., Dolin R. and Blaser M. J. (2019). Principles and Practice of Infectious Diseases. (9 th Edition). Elsevier. EBook ISBN:9780323550277. Hardcover ISBN:9780323482554.	
3.	Ridgway G. L., Stokes E. J. and Wren M. W. D. (1987). Clinical Microbiology 7 th Edition. Hodder Arnold Publication. ISBN-10:0340554231 / ISBN-13:9780340554234.	
4.	Koneman E.W., Allen S. D., Schreckenber P. C. and Winn W. C. (2020). Koneman's Color Atlas and Textbook of Diagnostic Microbiology. (7 th Edition). Jones & Bartlett Learning. ISBN:1284322378 9781284322378.	
5.	Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2 nd 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 (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

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Bioremediation	Elective Course III (Choice 3)	Y	Y	-	-	3	4	25	75	100
Course Objectives											
CO1	Describe the nature and importance of bioremediation and use in real world applications.										
CO2	Describe the typical composition of waste water and application of efficient technologies for water treatment.										
CO3	Explain the fundamentals of treatment technologies and the considerations for its design and implementation in treatment plants.										
CO4	Explain the potential of microbes in ore extraction and acquaint students with methods of reducing health risks caused by xenobiotics.										
CO5	Familiarize the role of plants and their associated microbes in remediation and management of environmental pollution.										
UNIT	Details								No. of Hours	Course Objectives	
I	Bioremediation - process and organisms involved. Bioaugmentation - Ex-situ and in-situ processes; Intrinsic and engineered bioremediation. Major pollutants and associated risks; organic pollutant degradation. Microbial aspects and metabolic aspects. Factors affecting the process. Recent developments and significance.								12	CO1	
II	Microbes involved in aerobic and anaerobic processes in nature. Water treatment, BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal. Secondary waste water treatments- use of membrane bioreactor.								12	CO2	
III	Composting of solid wastes, anaerobic digestion - methane production and important factors involved, Pros and cons of anaerobic process, sulphur, iron and nitrate reduction, hydrocarbon degradation, degradation of nitroaromatic compounds. Bioremediation of dyes, bioremediation in paper and pulp industries.								12	CO3	
IV	Microbial leaching of ores - process, microorganisms involved and metal recovery with special reference to copper and iron. Biotransformation of heavy metals and xenobiotics. Petroleum biodegradation - reductive and oxidative. Dechlorination. Biodegradable of plastics and super bug.								12	CO4	
V	Phytoremediation of heavy metals in soil - Basic principles of phytoremediation - Uptake and transport, Accumulation and sequestration. Phytoextraction. Phytodegradation. Phytovolatilization. Rhizodegradation. Phytostabilization – Organic and synthetic amendments in multi metal contaminated mine sites. Role of Arbuscular mycorrhizal fungi and plant growth promoting rhizobacteria in phytoremediation.								12	CO5	
Total								60			

Course Outcomes		
Course Outcomes		
CO1	Differentiate Ex-situ bioremediation and In-situ bioremediation. Assess the roles of organisms in bioremediation.	PO1, PO2, PO4, PO5
CO2	Distinguish microbial processes necessary for the design and optimization of biological processing unit operations.	PO1, PO4, PO5, PO11
CO3	Identify, formulate and design engineered solutions to environmental problems.	PO5, PO7, PO8, PO11
CO4	Explore microbes in degradation of toxic wastes and playing role on biological mechanisms.	PO5, PO6, PO7, PO8, PO9
CO5	Establish the mechanisms of Arbuscular mycorrhizal fungi and Plant growth promoting <i>Rhizobacteria</i> in phytoremediation.	PO1, PO5, PO6, PO7, PO8
Text Books		
1.	Bhatia H.S. (2018). A Text book on Environmental Pollution and Control. (2 nd Edition). Galgotia Publications.	
2.	Chatterjee A. K. (2011). Introduction to Environmental Biotechnology. (3 rd Edition). Printice-Hall, India.	
3.	Pichtel, J. (2014). Waste Management Practices: Municipal, Hazardous, and Industrial, 2 nd edition, CRC Press.	
4.	Liu, D.H.F and Liptak, B.G (2005). Hazardous Wastes and Solid Wastes, Lewis Publishers.	
5.	Rajendran, P. & Gunasekaran, P. (2006). Microbial Bioremediation. 1 st 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. (1 st 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 (1 st 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. 1 st 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	
	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	
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
	Bioinformatics	Elective Course IV Theory (Choice 1)	Y	Y	-	-	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.										
UNIT	Details								No. of Hours	Course Objectives	
I	Biological Data Mining – Exploration of Data Mining Tools. Cluster Analysis Methods. Data Visualization. Biological Data Management. Biological Algorithms – Biological Primary and Derived Databases.								12	CO1	
II	Phylogenetic Tree Construction - Concept of Dendrograms. Evolutionary Trees - Distance Based Tree Reconstruction - Ultrametric trees and Ultrametric distances – Reconstructing Trees from Additive Matrices - Evolutionary Trees and Hierarchical Clustering - Character Based Tree Reconstruction - Maximum Parsimony Method, Maximum likelihood method - Reliability of Trees – Substitution matrices – Evolutionary models.								12	CO2	
III	Computational Protein Structure prediction – Secondary structure – Homology modelling- Fold recognition and ab initio 3D structure prediction – Structure comparison and alignment – Prediction of function from structure.								12	CO3	
IV	Prediction of Properties of Ligand Compounds – 3D Autocorrelation –Prediction of the Toxicity of Compounds								12	CO4	
V	Molecular Docking- Flexible - Rigid docking- Target- Ligand preparation- Solvent accessibility- Surface volume calculation, Active site prediction- Docking algorithms- Genetic, 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.								12	CO5	
	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. (4 th 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) (4 th Edition). Prentice-Hall of India Pvt.Ltd.	
4.	Attwood, T.K. and Parry-Smith, D.J. (1999). Introduction to Bioinformatics. Addison Wesley Longman Limited, England.	
5.	Mount D.W., (2013).Bioinformatics sequence and genome analysis, 2 nd edn.CBS Publishers, New Delhi.	
References Books		
1.	Baxevanis A. D. and Ouellette F. (2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. (2nd Edition). John Wiley and Sons.	
2.	Bosu O. and Kaur S. (2007). Bioinformatics - Database, Tools, and Algorithms. Oxford University Press.	
3.	David W. M. (2001). Bioinformatics Sequence and Genome Analysis (2 nd Edition). CBS Publishers and Distributors(Pvt.)Ltd.	
4.	Xiong J, (2011). <u>Essential bioinformatics</u> , First south Indian Edition, Cambridge University Press.	
5.	Harshawardhan P.Bal, (2006). <u>Bioinformatics Principles and Applications</u> , 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	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M			M		M			M	M			M	
CO2							S		S	S			S	
CO3						S			S	S				
CO4				S		S	S		S				S	
CO5				S	S	S	S		S	S			S	

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Nanobiotechnology	Elective Course IV (Choice 2)	Y	Y	-	-	3	4	25	75	100
Course Objectives											
CO1	Analyze nanomaterials based on the understanding of nanobiotechnology.										
CO2	Discuss the methods of fabrication of nanomaterials.										
CO3	Gain Knowledge on characterization of nanomaterials.										
CO4	Discover nanomaterials for targeted drug delivery.										
CO5	Explain nanomaterials in nanomedicine and environmental pollution.										
UNIT	Details								No. of Hours	Course Objectives	
I	Introduction to nanobiotechnology, Nano size-changing phenomena at nano scale, Classification of nanomaterials based on their dimensions (0D, 1D, 2D and 3D materials) and based on realization of their applications (The First, second, third and fourth generation materials), Class of nanomaterials and their applications. Need for nanomaterials and the risks associated with the materials.								12	CO1	
II	Fabrication of Nanomaterials-Top-down and Bottom-up approaches, Solid phase synthesis-milling, Liquid phase synthesis-Sol-gel synthesis, colloidal synthesis, micro emulsion method, hydrothermal synthesis and solvo thermal synthesis, Vapour/Gas phase synthesis-Inert gas condensation, flame pyrolysis, Laser ablation and plasma synthesis techniques. Microbial synthesis of nanoparticles.								12	CO2	
III	Characterization of nanoparticles – Based on particle size/morphology- 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.								12	CO3	
IV	Nanomaterial based Drug delivery and therapeutics-surface modified nano particles, MEMS/NEMS based devices, peptide/DNA coupled nanoparticles, lipid and inorganic nano particles for drug delivery, Metal/metaloxide nano particles as antibacterial, antifungal and antiviral agents. Toxicity of nanoparticles and Toxicity Evaluation.								12	CO4	
V	Nanomaterials in diagnosis-Imaging, nanosensors in detection of pathogens. Treatment of surface water, ground water and waste water contaminated by toxic metal ions, organic and inorganic solutes and microorganisms.								12	CO5	

		Total	60
Course Outcomes			
Course Outcomes	On completion of this course, students will;		
CO1	Employ knowledge in the field of nanobiotechnology for development.		PO1, PO9
CO2	Identify various applications of nanomaterials in the field of medicine and environment.		PO1, PO9
CO3	Examine the prospects and significance of nanobiotechnology.		PO1, PO6, PO11
CO4	Identify recent advances in this area and create a career or pursue research in the field.		PO1, PO5, PO7, PO9
CO5	Design non-toxic nanoparticles for targeted drug delivery.		PO1, PO5, PO7, PO9, PO11
Text Books			
1.	Brydson R. M., Hammond, C. (2005). Generic Methodologies for Nanotechnology: Characterization. In Nanoscale Science and Technology. John Wiley & Sons, Ltd.		
2.	Leggett G. J., Jones R. A. L. (2005). Bionanotechnology. In Nanoscale Science and Technology. John Wiley & Sons, Ltd.		
3.	Mohan Kumar G. (2016). Nanotechnology: Nanomaterials and nanodevices. Narosa Publishing House.		
4.	Goodsell D. S. (2004). Bionanotechnology. John Wiley & Sons, Inc.		
5.	Pradeep T. (2007). Nano: The Essentials-Understanding nanoscience and nanotechnology. Tata McGraw-Hill.		
References Books			
1.	Nouailhat A. (2008). An Introduction to Nanoscience and Nanotechnology, Wiley.		
2.	Sharon M. and Maheshwar (2012). Bio-Nanotechnology: Concepts and Applications. New Delhi. Ane books Pvt Ltd.		
3.	Niemeyer C.M. and Mirkin C. A. (2005). Nanobiotechnology. Wiley Interscience.		
4.	Rehm, B. (2006). Microbial Bionanotechnology: Biological Self-Assembly Systems and Biopolymer-Based Nanostructures. Horizon Scientific Press.		
5..	Reisner, D.E. (2009). Bionanotechnology: Global Prospects. CRC Press		
Web Resources			
1.	https://www.gale.com/nanotechnology		
2.	https://www.understandingnano.com/resources.html		
3.	http://dbtnanobiotech.com/index2.php		
4.	http://www.istl.org/11-winter/internet1.html		
5.	https://www.cdc.gov/niosh/topics/nanotech/default.html		

Methods of Evaluation			
Internal Evaluation	Continuous Internal Assessment Tests		25 Marks
	Assignments		
	Seminars		
	Attendance and Class Participation		
External Evaluation	End Semester Examination		75 Marks
	Total		100 Marks
Methods of Assessment			
Recall (K1)	Simple definitions, MCQ, Recall steps, Concept definitions		
Understand/Comprehended (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					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
	Clinical Research and Clinical Trials	Elective Course IV (Choice 3)	Y	Y	-	-	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.										
UNIT	Details								No. of Hours	Course Objectives	
I	Introduction to Clinical Research: Clinical Research: An Overview, Different types of Clinical Research. Clinical Pharmacology: Pharmacokinetics, Pharmacodynamics, Pharmacoepidemiology, Bioavailability, Bioequivalence, Terminologies and definition in Clinical Research. Drug Development Process: Drug Discovery Pipeline, Drug Discovery Process. Preclinical trail, Human Pharmacology (Phase-I), Therapeutic Exploratory trail (Phase-II), Therapeutic Confirmatory Trail (Phase-III) and Post marketing surveillance (Phase-IV).								12	CO1	
II	Ethical Considerations and Guideline in Clinical Research: Historical guidelines in Clinical Research-Nuremberg code, Declaration of Helsinki, Belmont report. International Conference on Harmonization (ICH)-Brief history of ICH, Structure of ICH & ICH Harmonization Process, Guidelines for Good Clinical Practice. Regulation in Clinical Research- Drug and cosmetic act, FDA, Schedule-Y- Ethics Committee and their responsibilities. Clinical Research Regulatory Submission & approval Process- IND, NDA and ANDA submission Procedure. DCGI submission procedure. Other Regulatory authorities- EMEA, MHRA, PhRMA.								12	CO2	
III	Clinical Trial Management: Key Stakeholders in Clinical Research, Ethics Committees and Institutional Review Board, Responsibilities of Sponsor. Responsibilities of Investigator, Protocol in Clinical Research Clinical Trial Design, Project Planning Project Managements - Informed Consent, Investigator's Brochure (IB), Selection of an Investigator and Site, Patient screening, Inclusion and exclusion criteria, Randomization, Blinding. Essential Documents in clinical research -IB, ICF, PIS, TMF, ISF, CDA & CTA.								12	CO3	
IV	Quality Assurance, Quality Control & Clinical Monitoring: Defining the terminology-Quality, Quality system, Quality Assurance & Quality Control-QA audit plan. 21 CFR Part 11, Site Auditing, Sponsor Compliance and Auditing, SOP For								12	CO4	

	Clinical Research-CRF Review & Source Data Verification, Drug Safety Reporting Corrective and preventative action process.		
V	Business Development in the Clinical Research Industry: Introduction & Stages of Business Development-Start-up Phase, Growth Phase, Maturity Phase, Decline Phase. Outsourcing in Clinical Research, Reasons for outsourcing to contract research organizations, The India Advantage, Scope and Future of CRO, List of Clinical Research Organizations in India, List of IT companies offering services in Clinical Research. Role of business development manager.	12	CO5
	Total	60	

Course Outcomes

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

Text Books

1.	Gallin J. I., Ognibene F. P. and Johnson L. L. (2007). Principles and Practice of Clinical Research. (4 th Edition). Elsevier, 2007. ISBN-10: 0128499052
2.	Friedman L. M., Furberg C. D. and Demets D. (1998). Fundamentals of Clinical Trials, Vol: XVIII. (3 rd 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. (4 th Edition). Jaypee Medical. ISBN-13: 978-1608318049.
4.	Reed, G. (2004). Prescott and Dunn's Industrial Microbiology, 4 th edn, CBS publication and distributors.
5.	Himanshu B. Text book of Clinical Research, Pee Vee books.

References Books

1.	Friedman L.M., Fuberge C.D., DeMets D. and Reboussen, D.M. (2015). Fundamentals of Clinical Trials, Springer.
2.	Browner W. S., (2012). Publishing and Presenting Clinical Research. (3 rd Edition). Lippincott Williams and Wilkins.
3.	Rondel R. K., Varley S. A. and Webb C. F. (2008). Clinical Data Management. (2 nd Edition). Wiley.
4.	Peppler, H.J. and Pearl Man, D. (1979). Fermentation Technology, Vol 1 & 2, 2 nd 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. 2 nd Edition, CRC press, Taylor and Francis Group.
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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 Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (K1)	Simple definitions, MCQ, Recall steps, Concept definitions
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Mapping with Programme Outcomes

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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Vermitechnology	Skill Enhancement Course 1	Y	-	-	-	2	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.										
UNIT	Details								No. of Hours	Course Objectives	
I	Definition and history of vermiculture. Role of earthworm in sustainable agriculture, organic farming, solid waste management. Earthworm activities. Choosing the right worm. Useful species of earthworms. Local species of earthworm. Exotic species of earthworms. Factors affecting distribution of earthworms in soil.								6	CO1	
II	Earthworm biology and rearing. Classification of earthworm. Morphology or anatomy of earthworm. Life cycle of Eudrilidae and Lumbricidae. Collection of local earthworms. Rearing of earthworms.								6	CO2	
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. Methods of vermicomposting- a) windrows system; b) wedge system; c) container system-pits, tanks & cement rings; commercial model; beds or bins-top fed type, stacked type, d) Continuous flow system.								6	CO3	
IV	Vermicomposting - Trouble Shooting- Pests and Diseases. Separation techniques- Light Separation-Sideways Separation- Vertical Separation-Gradual transfer. Harvesting Earthworms- manual method- migration method. Packing & Nutritional analysis of vermicompost.								6	CO4	
V	Applications of Vermiculture - Vermiculture Bio-technology, use of vermi castings in organic farming/horticulture, as feed/bait for capture/culture fisheries; forest regeneration. Application quantity of vermicompost in Agricultural fields- crops, fruits, vegetables & flowers. By-products and value-added products- Verm wash- vermicompost tea-vermi meal-enriched vermicompost-pelleted vermicompost.								6	CO5	
	Total								30		
Course Outcomes											

Course Outcomes	On completion of this course, students will;	
CO1	Compare and contrast the uses of vermicompost to the soil.	PO1, PO4, PO5, PO9,
CO2	Recommend different species of earthworms after acquiring knowledge on its biology.	PO1, PO4, PO6, PO9
CO3	Design the vermicomposting process.	PO1, PO4, PO6, PO7, PO8
CO4	Assess the Best Practices of Vermicomposting	PO6,PO7, PO8,PO9,
CO5	Recommend the applications of vermicompost to different soils and for different crops.	PO1, PO4, PO5,PO6, PO7
Text Books		
1	Ismail S. A. (2005). The Earthworm Book, Second Revised Edition. Other India Press, Goa, India.	
2	Rathoure A. K., Bharati P. K. and Ray J. (2020). Vermitechnology, Farm and Fertilizer. Vermitechnology, Farm and Fertilizer Discovery Publishing House Pvt Ltd.	
3	Christy M. V. 2008. Vermitechnology, (1 st Edition), MJP Publishers.	
4	The complete technology book on Vermiculture and Vermicompost with manufacturing Process, machinery equipment details and Plant Layout. AB Press.	
5	Keshav Singh (2014). A Textbook of vermicompost: Vermiwash and Biopesticide.	
References Books		
1	Roy D. (2018). Handbook of Vermitechnology. Lambert Academic Publishing.	
2	Kumar A. (2005). Verms and Vermitechnology, A.P.H. Publishing Corporation, New Delhi.	
3	Lekshmy M. S., Santhi R. (2012). Vermitechnology, Sara Publications, New Delhi, India.	
4	Edwards CA, Arancon NQ ShermanRL. (2011) Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management 1st edn.CRC Press.	
5	Ismail, S.A. (1997). Vermicology-The Biology of Earthworm.1st edn. Orient longman.	
Web Resources		
1.	https://en.wikipedia.org/wiki/Vermicompost	
2.	http://stjosephs.edu.in/upload/papers/9567411a78c63d4ccfbbe85e6aa22840.pdf	
3.	https://www.kngac.ac.in/elearning-portal/ec/admin/contents/4_18K4ZEL02_2021012803204629.pdf	
4.	https://composting.ces.ncsu.edu/vermicomposting-2/	
5.	https://rodaleinstitute.org/science/articles/vermicomposting-for-beginners/	
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	
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	S				S					
CO2	S			M		S			S					
CO3	S			S		S	S	S						
CO4						S	S	S	S					
CO5	S			M	S	M	S							

SEMESTER III

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Soil and Environmental Microbiology	Core Course VII	Y	Y	-	-	5	6	25	75	100
Course Objectives											
CO1	Explain the role of microorganisms in soil fertility.										
CO2	Discuss the benefits of interactions among soil microbes and acquire awareness about microbes as biofertilizers and biocontrol agents.										
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.										
UNIT	Details								No. of Hours	Course Objectives	
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. Biological Nitrogen fixation-Phytopathology and Disease cycle of Plant pathogens - Tikka and Citrus canker, Types of disease symptoms, Plantibodies, Phenolics, Phytoalexins								20	CO1	
II	Microbial Interactions - Mutualism, Commensalism, Amensalism, Synergism, Competition, Rhizosphere- Rhizosphere effect, Mycorrhizae – Types, Endophytes, PGPR- Plant growth promoting bacteria– symbiotic (<i>Bradyrhizobium</i> , <i>Rhizobium</i> , <i>Frankia</i>), Non-Symbiotic (<i>Azospirillum</i> , <i>Azotobacter</i> , Mycorrhizae, MHBs, Phosphate solubilizers, algae), PGPRs. Biofertilizers and Biocontrol agents – Types, benefits and application. Bt crops, golden rice.								20	CO2	
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. Treatment and safety of drinking (potable) water, methods to detect potability of water samples. Space microbiology - Microbiological research in space environment.								15	CO3	
IV	Industrial effluent treatment, primary, secondary, tertiary, and advanced treatment process. Utilization of Solid Waste as Food, Feed and Fuel- Composting, Vermicomposting, Bio manure and Biogas production. E waste management.								15	CO4	

V	Degradation of organic matter - lignin, cellulose, hemicellulose, pectin, common pesticides- herbicides (2,4-D) and pesticides (DDT), heavy metals. Biodegradation of Xenobiotics - Recalcitrant TNTs, PCBs and Synthetic polymers. Biodegradation of Hydrocarbons. Biodeterioration of Textiles and Leather	20	CO5
	Total	90	
Course Outcomes			
Course Outcomes	On completion of this course, students will;		
CO1	Depict diversity and significance of soil microbes and predict the role of microbes in biological nitrogen fixation.		PO1
CO2	Utilize the knowledge of microbial interactions, with beneficial application of biofertilizers for sustainable agriculture and benefits of biopesticides.		PO1, PO7, PO8
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.	Subba Rao. N. S. (2017). Soil Microbiology. (5 th Edition). MedTech Publishers.		
2.	Daniel. C. J. (2006). Environmental Aspects of Microbiology. (2 nd Edition). Bright Sun Publications.		
3.	Rangaswami. G. and Mahadevan. A. (2006). Diseases of Crop Plants in India. (4 th Edition). Prentice–Hall of India Pvt. Ltd.		
4.	Sharma P. D. (2010). Microbiology and Plant pathology. (2 nd Edition). Rastogi Publications.		
5.	Subba Rao. N.S. (2005). Soil microorganisms and Plant Growth. (4 th Edition). Oxford and IBH Publishing Pvt. Ltd.		
References Books			
1.	Pepper I. L., Gerba C. P. and Gentry T. J. (2014). Environmental Microbiology (1 st Edition). Academic Press, Elsevier.		
2.	Bitton, G. (2011). Wastewater Microbiology. (4 th Edition). Wiley-Blackwell.		
3.	Bridgewater L. (2012). Standard Methods for the Examination of Water and Wastewater. American Public Health Association.		
4.	Shrivastava A.K. (2003). Environment Auditing. A. P. H. Publishing Corporation.		
5.	Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan.		
Web Resources			
1.	https://academic.oup.com/femsec/article/93/5/fix044/3098413		
2.	http://www.fao.org/3/t0551e/t0551e05.htm		

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Molecular Biology and Recombinant DNA Technology	Core Course VIII Theory	4	2	-	-	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.										
UNIT	Details									No. of Hrs	Course Objectives
I	DNA replication – modes and enzymes involved. Detailed mechanism of semi-conservative replication. Structure of m-RNA, r-RNA and t-RNA. Ribosomes. Genetic Code and Wobble hypothesis, Translation in prokaryotes and eukaryotes, post translational modifications.									20	CO1
II	Gene regulation and expression – Lac operon, arabinose and tryptophan operons. 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
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) - Phage Vectors (M13 and Lambda), cosmids, phagemids and BACs - Eukaryotic vectors - Yeast vectors – Animal and plant vectors – expression vectors. Shuttle vectors - Expression of foreign genes in bacteria, animal, plant, algae and fungi – merits and demerits.									20	CO3
IV	Genomic DNA and cDNA library - Construction and Screening. restriction fragment length polymorphism (RFLP) - Polymerase chain reaction (PCR) – Principles, types and their applications. DNA sequencing - Primer walking, Sanger’s method. Protein engineering and its applications .									15	CO4

V	Plant biotechnology - constituents and concepts of sterilization - preparation, isolation and selection of explant. Suspension cell culture, callus culture, protoplast isolation, culture & fusion. 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. Applications of Genetic Engineering - transgenic animals, Monoclonal Antibodies in Therapy- Human Gene Therapy - Germline and Somatic Cell Therapy - Ex-vivo Gene Therapy. In-vivo Gene 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. (4 th Edition). Narosa Publishing House, New Delhi.
2.	Snusted D.P. and Simmons M. J. (2019). Principles of Genetics. (7 th 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. (3 rd Edition). John Wileys and Sons Ltd.
4.	Primrose S.B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics. (7 th Edition). Blackwell Publishing.
5.	Maloy S. R. Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2 nd Edition). Narosa Publishing House Pvt. Ltd.

References Books

1.	Brown T. A. (2016). Gene Cloning and DNA Analysis- An Introduction. (7 th Edition). John Wiley and Sons, Ltd.
2.	Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5 th Edition). ASM Press.
3.	Russell P.J. (2010). Genetics - A Molecular Approach. (3 rd 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. (3 rd 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 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
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
	Practical III	Core Course IX Practicals	-	-	Y	-	4	6	25	75	100
Course Objectives											
CO1	Illustrate the significance of artificial transformation and mutations.										
CO2	Discuss blotting techniques and PCR.										
CO3	Analyze and estimate water quality and potability										
CO4	Prepare Biofertilizers, vermicompost and test their efficiency										
CO5	Familiarize with common plant infections										
UNIT	Details								No. of Hours	Course Objectives	
I	Detection of Antibiotic resistant mutants Identification of mutants by replica plating method								20	CO1	
II	Amplification of DNA by PCR - Demonstration Western blotting - Demonstration Southern blotting – Demonstration								15	CO2	
III	Microbiological analysis of water Total Heterotrophic Count B) Test for indicative organisms 1) MPN 2) Membrane Filtration Physical, chemical, assessment of water Physical - Color, pH, Chemical - DO, BOD, COD Enumeration of bacteria and fungi from air – Air sampler Isolation of free-living nitrogen fixers from soil and <i>Rhizobium</i> from root nodules of leguminous plants. Isolation and enumeration of phosphate-solubilizing bacteria from soil								15	CO3	
IV	Estimation of soil enzymes- urease and phosphatase Study of phylloplane microflora by leaf impression method Isolation of cellulose degrading bacteria Preparation of a vermicompost - Demonstration Isolation of VAM fungi from soil Cultivation of edible mushroom from solid waste - Demonstration Cultivation of <i>Azolla</i> - Demonstration								20	CO4	
V	Visual examination, observation, and identification of some common plant infections. Collection of 5 herbarium specimens of infected leaves.								20	CO5	
	Total								90		

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Utilize various molecular techniques for gene manipulation and detection of mutants.	PO4, PO6, PO7, PO9, PO11
CO2	Undertake novel research with techniques like PCR and blotting analysis.	PO4, PO6, PO7, PO10, PO11
CO3	Assess the microbial quality of water and air and relate the results to standards.	PO1, PO4, PO5, PO7, PO8
CO4	Synthesize biofertilizers and vermicompost. Cultivate mushrooms using solid waste.	PO1, PO4, PO5, PO7, PO8
CO5	Identify various plant pathogens	PO5, PO10
Text Books		
1.	Russell P. J. (2019). Genetics – A Molecular Approach (3 rd Edition). Pearson Education, Inc.	
2.	Glick B. R. and Patten C. L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA (5 th 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. (5 th 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. (3 rd Edition). American Society for Microbiology.	
References Books		
1.	Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. (7 th Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press.	
2.	Brown T.A. (2016). Gene Cloning and DNA Analysis. (7 th Edition). John Wiley and Jones, Ltd.	
3.	Dale J. W., Schantz M. V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3 rd Edition). John Wileys and Sons Ltd.	
4.	Pepper I., Gerba C. and Brendecke J. (2004). Environmental Microbiology - A Laboratory Manual. (2 nd Edition). Academic Press, Elsevier.	
5.	Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). Manual of Environmental Microbiology. (4 th Edition). Wiley.	
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 Participation	

External Evaluation	End Semester Examination	60 Marks
	Total	100 Marks
Methods of Assessment		
Recall (K1)	Simple definitions, MCQ, Recall steps, Concept definitions	
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview	
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain	
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge	
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons	
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations	

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1				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
	Fermentation technology and Pharmaceutical Microbiology	Industry Module	Y	Y	-	-	5	5	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.										
UNIT	Details								No. of Hours	Course Objectives	
I	Bioprocesses. 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. Types of fermentation - Batch, continuous, surface, submerged, aerobic and anaerobic.								12	CO1	
II	Fermenter – Design, types and construction, Instrumentation and control. Heat production. Aeration and agitation. Gas exchange and mass transfer. Computer Applications in fermentation technology. Fermentation Economics.								12	CO2	
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	
IV	Overview of pharmaceutical microbiology - Ecology of microorganisms - Atmosphere, water, skin, respiratory flora of workers, raw materials, packaging, building equipment and their control measures. Contamination and Spoilage of Pharmaceutical products - sterile injectable and non-injectable, ophthalmologic preparation, implants.								12	CO4	
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								12	CO5	

	pharmaceuticals – In-Process, Final-Product Control and sterility tests. Regulatory aspects - BIS (IS), ISI, ISO, WHO and US certification.		
	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. (2 nd Edition). Laxmi Publications, New Delhi.		
2.	Casida L. E. J. R. (2019). Industrial Microbiology. New Age International Publishers.		
3.	Sathyanarayana U. (2005). Biotechnology. (1 st Edition). Books and Allied (P) Ltd.		
4.	Reed G. (2004). Prescott and Dunn's Industrial Microbiology. (4 th 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. (3 rd Edition). Pergamon Press. NY.		
2.	Handa S. S. and Kapoor V. K. (2022). Pharmacognosy, (4 th Edition). Vallabh Prakashan Publishers, New Delhi.		
3.	Kokate C. K., Durohit A. P. and Gokhale S. R. Pharmacognosy. (2002). (12 th Edition). Nirali Prakasham Publishers, Pune.		
4.	Hugo W. B. and Russell A. D. (2004). Pharmaceutical Microbiology. (7 th Edition). Blackwell Scientific Publication, Oxford.		
5.	Wallis, T.E. (2005). Text book of Pharmacognosy. (5 th 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/penicillin.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 (K1)	Simple definitions, MCQ, Recall steps, Concept definitions	
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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	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
	Biosafety, Bioethics and IPR	Elective Course V (Choice 1)	Y	Y	-	-	3	4	25	75	100
Course Objectives											
CO1	Create a research environment. Encourage investigation, analysis and study the bioethical principles, values, concepts, and social and juridical implications in the areas of science, biotechnology and medicine.										
CO2	Discuss about various aspects of biosafety regulations, IPR and bioethics concerns arising from the commercialization of biotechnological products.										
CO3	Familiarize fundamental aspects of Intellectual property Rights in the development and management of innovative projects in industries.										
CO4	Acquire knowledge about bioethics, biodiversity and Genetically modified foods and food crops										
CO5	Provide students with an understanding of bioethics in research associated with medicine										

UNIT	Details	No.of Hours	Course Objectives
I	Intellectual Property Rights: Different forms of Intellectual Property Rights Patent Terminology - Patents, trademarks, copyrights, industrial designs, geographical indications, trade secrets, non-disclosure agreements. International organizations and IPR - Overview of WTO, TRIPS, WIPO, GATT, International conventions, Trade agreements,	12	CO1
II	Process involved in patenting - process of filing, PCT application, pre-grant & post-grant opposition, PCT, patent search methods, Country-wise patent searches (USPTO, EPO, India etc.), patent mapping.	12	CO2
III	Patentability of biotechnology invention - Patentability of biotechnology inventions in India, territorial nature of patents - from territorial to global patent regime, feasibility of a uniform global patent system, merits and demerits of uniform patent law, implications of setting up a uniform world patent system.	12	CO3
IV	Introduction to bioethics - need of bioethics, applications and issues related to bioethics, social and cultural issues. Bioethics and biodiversity - convention on protecting biodiversity. Bioethics & GMO's - issues and concerns pertaining to genetically modified foods and food crops, organisms.	12	CO4
V	Bioethics in medicine - gene therapy, organ transplantation, xeno transplantation, ethics in patient care, informed consent. bioethics and cloning - permissions and procedures	12	CO5

	in animal cloning, human cloning, risks and hopes. Bioethics in research: stem cell research, human genome project, use of animals in research.		
	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	Apply bioethics 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. (1 st Edition). Notion Press. ISBN-101645878856	
2.	Satheesh M. K. (2009). Bioethics and Biosafety. (1 st Edition). J. K International Publishing House Pvt. Ltd: Delhi. ISBN: 9788190675703	
3.	Goel D. and Parashar S. (2013). IPR, Biosafety and Bioethics. (1 st Edition). Pearson education: Chennai. ISBN-13: 978-8131774700	
4.	Raj Mohan joshi. Biosafety and Bioethics. Wiley Publications.	
5.	Sibi. GIIntellectual, Property Rights, Bioethics, Biosafety and Entrepreneurship 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.	

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		
	Toxicology	Elective Course V (Choice 2)	Y	Y	-	-	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 diseases												
CO3	Strengthen the evidence for a causal link between the exposure of hazardous agent and the development of diseases												
CO4	Illustrate various techniques to isolate and characterize the toxin												
CO5	Examine, interpret and discuss the certainty of toxic substances, proposing the deep understanding of medicinal and industrial applications												
UNIT	Details								No. of Hours	Course Objectives			
I	General Introduction - Definition of toxins, different categories of toxins and venoms, recent trends in venom and toxin research.								12	CO1			
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			
III	Plant toxins & Toxins from snake venom - Natural toxins in plants, Plant toxic proteins, impact of plant toxin on human, natural toxins in food, plants, allelopathy. Toxins from snake venom Snakes and Biological significance of their venoms, composition of snake venom, evolution of venom, 3D structure of some important venom constituents and their mechanism of action (phospholipase A2, cardiotoxin, neurotoxin) three-finger toxins, anti-venom and medicinal plants in treatment of snakebite patients.								12	CO3			
IV	Tools for isolation and characterization of toxins - Multidimensional chromatographic techniques (gel-filtration, ion-exchange reverse-phase HPLC, SDS-PAGE, 2-dimensional gel electrophoresis), toxin mass fingerprinting, N-								12	CO4			

	terminal peptide sequencing, analysis of protein data by using proteomics software.		
V	Medicinal and industrial applications of venoms and toxins. Use of toxin in neurobiology and muscular research, anticancer drug, diagnosis of haemostatic disorders, antibacterial agents, bioinsecticides and other industrial applications.	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 microbial toxins.	PO2, PO4, PO6, PO10	
CO3	Explicate the mode of actions and their biological significance.	PO1, PO2, PO4	
CO4	Evaluate the toxicity level with the help of advanced techniques.	PO6, PO7. PO9.PO11	
CO5	Elucidate the various natures of application of toxic substances.	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. (7 th Edition). Cambridge University Press India Pvt.Ltd. ISBN 1-4051-3544-1.
4.	Pholtan Rajeev S.R. (2021)Pictorial handbookfor toxinology. Rudra Publications.
5.	Cora Lancaster. (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. (2 nd Edition). 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.researchgate.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 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
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
	Water Conservation and Water Treatment Technologies	Elective Course V (Choice 3)	Y	Y	-	-	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										
UNIT	Details								No. of Hours	Course Objectives	
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	
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 Bhujal Yojana, Adoption of Composite Water Management Index (CWMI), Water conservation resource management, Rain Water Harvesting.								12	CO2	
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	
IV	Water Treatment Technologies; Sedimentation, Filtration, Coagulation and flocculation, Water softening and adsorption processes, Membrane filtration, Microfiltration, Ultrafiltration and Nanofiltration, Water disinfection,								12	CO4	

	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.		
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., Tzanakakis N. Paranychianakis V. and Angelakis A. N. (2020). Water Supply and Water Scarcity. MDPI, ISBN 978-3-03943-306-3 (Hbk). ISBN 978-3-03943-3070.
2.	Pannirselvam M., Shu Li.,Griffin G., Philip L., Natarajan A. and Hussain S. (2019). Water Scarcity and Ways to Reduce the Impact. ISBN: 978-3-319-75199-3.
3.	Tiwari A., Kumar A., Singh A., Singh T.N., Suozzi E., Matta G. and Russo S. (2022). Water Scarcity, Contamination and Management. Elsevier. ISBN: 9780323853781.
4.	Daniel, C.J. (1996). Environmental Aspects of Microbiology, 1 st edn. Bright Sun Publications.
5.	Maier RM, Pepper IL, Gerba CP (2008). Environmental Microbiology, 2 nd 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.	Ahuja S. (2013). Monitoring Water Quality-Pollution Assessment, Analysis, and Remediation. Elsevier. Book ISBN: 9780444594044. Hardcover ISBN: 9780444593955.
4.	Saeid Eslamian ., Faezeh Eslamian ., (2021) Water harvesting and conservation – Basic Concepts and fundamentals, Wiley Publications.
5.	Buckley RG. (2016) Environmental Microbiology 1 st 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 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
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
	Organic Farming and Biofertilizer Technology	Skill Enhancement Course II	Y	-	-	-	2	3	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										
UNIT	Details								No. of Hours	Course Objectives	
I	Organic farming – Definition, relevance. Biological nutrient management - Organic manures, vermicompost, green manure, organic residue. Integrated pest and weed management - Use of biocontrol agents, bio pesticides etc. Organic and Conventional farming. Organic and Chemical farming – Comparison.								6	CO1	
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	
III	Biofertilizers - Introduction, types, advantages and future perspective. Introduction, status and scope. Structure and characteristic features of bacterial biofertilizers- <i>Azospirillum</i> , <i>Azotobacter</i> , <i>Bacillus</i> , <i>Pseudomonas</i> , <i>Rhizobium</i> and <i>Frankia</i> .								6	CO3	
IV	Cyanobacterial biofertilizers- Anabaena, Nostoc and fungal biofertilizers- AM mycorrhiza and ectomycorrhiza. Nitrogen fixation -Free living and symbiotic nitrogen fixation.								6	CO4	

	Mechanism of phosphate solubilization and phosphate mobilization, potassium solubilization.		
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, seedlings, tubers. Biofertilizers - Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers.	6	CO5
	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, PO8, 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. (4 th Edition). Med Tech publisher.		
4.	Subba Rao N. S. (2002). Soil Microbiology. Soil Microorganisms and Plant Growth. (4 th 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. (1 st 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) (1 st 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-wIV2ZZLBR1ozQj9EAAAYAiAAEgJW2_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

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Food and Dairy Microbiology	Core Course X Theory	Y	Y	-	-	5	6	25	75	100
Course Objectives											
CO1	Discuss microorganisms involved in food spoilage.										
CO2	Illustrate bacterial and nonbacterial food borne infections important in public health.										
CO3	Familiarize various national and international aspects of food safety and quality assurance.										
CO4	Elaborate on microbiology of milk, preservation techniques and production of dairy products.										
CO5	Explain Dairy plant hygiene, quality control and waste disposal.										
UNIT	Details								No. of Hours	Course Objectives	
I	Microorganisms of food- Scope of food Microbiology. Contamination and spoilage of food –vegetables, fruits, poultry, fish, eggs, meat, meat products and canned foods. Food Preservation - Temperature (low and high), drying, radiation and chemicals.								18	CO1	
II	Food microbiology and public health. Food hazards. Food infections - <i>Bacillus cereus</i> , <i>Vibrio parahaemolyticus</i> , <i>Escherichia coli</i> , <i>Salmonella</i> , <i>Shigella</i> , <i>Yersinia enterocolitica</i> , <i>Listeria monocytogenes</i> and <i>Campylobacter jejuni</i> . Nonbacterial food borne illness - Helminthes, nematodes, protozoa, toxigenic fungi and food borne virus.								18	CO2	
III	Quality assurance of food - International aspects of Quality and safety assessment of foods. Microbiological quality standards for food. Government regulatory practices and policies - FDA, HACCP, BIS (IS), FSSAI-2014. Food adulteration and common food additives.								18	CO3	
IV	Introduction to Dairy microbiology –Microorganisms associated with milk. Microbial metabolites and their role in spoilages-souring, curdling, gassiness, ropiness, proteolysis, lipolysis, abnormal flavour and colour. Antimicrobial systems in raw milk. Microbiological grading of raw milk. Milk borne diseases and their control. Bacteriological aspects of milk processing – Thermization, pasteurization, boiling, sterilization, UHT, bactofugation, and membrane filtration.								18	CO4	

V	Composition and chemistry of cream, butter, ghee, ice-cream, cheese, kefir, koumiss, rennin, condensed and dried milks, infant food. Spoilage of ghee and use of antioxidants. Chemistry of milk fermentation. Chemistry of rennin coagulation of milk and changes occurring during ripening of cheese, physico-chemical changes in the manufacture and storage of milk powder, lactose, crystallization and its significance. Dairy plant hygiene and sanitation. Disposal of dairy waste. Microbiological standards for Milk and Milk products- PFA BIS, Codex/ ISO standards.	18	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	Familiarize various national and international aspects of food safety and quality assurance.	PO4, PO7, PO8	
CO4	Prepare dairy products and perform quality checks.	PO7, PO8	
CO5	Apply microbiological standards to milk and milk products.	PO7, PO8	
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. (6 th Edition). McGraw Hill Education.		
3.	Jay J. M., Loessner M. J. and Golden D.A. (2006). Modern Food Microbiology. (7 th Edition). Springer.		
4.	Doyle M. P., Buchanan R. L. (2012). Food Microbiology: Fundamentals and Frontiers. (4 th Edition). American Society for Microbiology Press.		
5.	Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5 th Edition). CRC Press.		
References Books			
1.	Robinson R. K. (2000). Dairy Microbiology 3 rd edn, Elsevier Applied Science, London.		
2.	Adams M.R, and Moss M.D, (2005). Food Microbiology 4 th edn, New Age International Pvt. Ltd., Publishers.First edition.		
3.	Banwarst. G.J. (2003). Basic Food Microbiology 2 nd edn, CBS Publishers and distributors.		
4.	Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7 th edn. Edward Arnold: London.		

5.	5. Vijaya R K, (2004). Food Microbiology 1 st edn. MJP Publishers, Chennai.
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Web Resources

1.	https://www.fssai.gov.in
2.	https://www.who.int/news-room/fact-sheets/detail/food-safety
3.	https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

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
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
	Research Methodology and Biostatistics	Core Course XI Theory	Y	Y	-	-	5	6	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.										
UNIT	Details								No. of Hours	Course Objectives	
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	
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	
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.								15	CO3	
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),								20	CO4	
V	Probability and distributions - Introduction to probability theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems) .								15	CO5	
	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). Introduction to 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		
	Continuous Internal Assessment Tests	25 Marks

Internal Evaluation	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
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					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
	Bioenergy	Elective Course VI (Choice 1)	Y	Y	-	-	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.										
UNIT	Details								No. of Hours	Course Objectives	
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	
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 (<i>Cryptococcus</i> , <i>Cunninghamella</i> , <i>Mortierella</i>).								12	CO2	
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	
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	
V	Biohydrogen– Production from bacteria and algae. Commercialized microalgae (<i>Spirulina</i> , <i>Dunaliella</i> , <i>Hematococcus</i> and <i>Chlorella</i>) 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. (1 st Edition). Academic Press Editor.
2.	Brown R. C. (2003). Biorenewable Resources: Engineering New Products from Agriculture. (1 st Edition). Wiley Blackwell Publishing.
3.	Jawaid M., Hakeem K. R. and Rashid U. (2014). Biomass and Bioenergy: Processing and Properties. (1 st Edition). Springer Cham.
4.	Caye M. Drapcho, Tery H. Walker (Biofuels Engineering Process Technology. McGraw Hill.
5.	Teri. Bio energy Powering the Future. Pearson Longman Publications.

References Books

1.	Konur O. (2018). Bioenergy and Biofuels. (1 st Edition). CRC Press.
2.	Lee J. W. (2012). Advanced Biofuels and Bioproducts. (13 th Edition), Springer.
3.	Khanal S. (2008). Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. (8 th 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 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
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
	Marine Microbiology	Elective Course VI (Choice 2)	Y	Y	-	-	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.										
UNIT	Details								No. of Hours	Course Objectives	
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	
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	
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	
IV	Marine Microbial Diseases: Aqua culture pathogens & Water borne pathogens - <i>Aeromonas</i> , <i>Vibrio</i> , <i>Salmonella</i> , <i>Pseudomonas</i> , <i>Leptospira</i> , <i>Corynebacteria</i> and viral diseases. Rapid diagnosis of contamination in sea foods and aquaculture products.								12	CO4	
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. (3 rd 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. (5 th 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. (2 nd 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. (3 rd 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 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
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					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
	Life Sciences for Competitive Examinations	Elective Course VI (Choice 3)	Y	Y	-	-	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.										
UNIT	Details								No. of Hours	Course Objectives	
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	
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	
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	
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	
V	Evolution and Behaviour- Evolution - Theories- Darwin's, Lamarck's, Oparin Haldane. Paleontological, Embryological and Molecular evidences. Hardy Weinberg's Law. Speciation;								12	CO5	

	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. (5 th Edition). W.H. Freeman and Company.	
2.	Chapman J. L. (1998). Ecology: Principles and Applications. (2 nd Edition). Cambridge University Press.	
3.	Krishnamurthy V. K. (2003). Textbook of Biodiversity. Science Publishers.	
4.	Rogers A. L. (2011). Evidence of Evolution. University of Chicago Press. Chicago.	
5.	Stites D.P., Abba I. Terr, Parslow T.G. (1997). <u>Medical Immunology</u> . 9 th Edn, <i>Prentice</i> -Hall Inc.	
References Books		
1.	Pontarotti P. (2018). Origin and Evolution of biodiversity. (1 st Edition). Springer.	
2.	Verma P. S. and Agarwal V. K. (2004). Cell biology, Genetics, Molecular Biology, Evolution and Ecology. (2 nd Edition). S Chand publication.	
3.	Lewin R. and Foley R. (2004). Principles of Human Evolution. (2 nd Edition). Black well Publishing Company.	
4.	Boyer R.F. (2002) <u>Modern Experimental Biochemistry</u> 3 rd Edition. Pearson Education.	
5.	Wilson K., Walker J., Clokie S and Hofmann A. (2018) <u>Wilson and Walker? Principles and Techniques of Biochemistry and Molecular Biology</u> 8 th 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 (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
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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			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
	Project with Viva voce		-	-	Y	-	7	10	25	75	100

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)	-	25 Marks
Viva	-	15 Marks
Project Report	-	60 Marks

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Microbial Quality Control and Testing	Skill Enhancement Course III	Y	-	-	-	2	4	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 of water 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.										

UNIT	Details	No. of Hours	Course Objectives
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
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
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
IV	Microflora of air - Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries	6	CO4

	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.		
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 harvesting and 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. (2 nd Edition). Royal Society of Chemistry.		
3.	Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand.		
4.	Cappuccino, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6 th Edition). Pearson Education, Publication, New Delhi.		
5.	Rosamund M. Baird., Norman A. (2019). Handbook of Microbiological quality control in Pharmaceuticals and Medical Devices. CRC Press.		
References Books			
1.	Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2 nd Edition). - Taylor & Francis.		
2.	Sundararaj T. (2003). Microbiology Laboratory Manual. (2 nd Edition). Published by A. Sundararaj		
3.	Hoges N. A., Denyer S P. and Baird R.M. (2003). Handbook of microbiological quality control. Microbial Quality Assurance in Pharmaceutcals, cosmetics & Toiletries. by Sally F. Bloomfield		

4.	Amitava Mitra. Fundamentals of Quality control and Improvement. (3 rd 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

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

CO5				S	L		M	M						
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