Anekant Education Society's

Tuljaram Chaturchand College, Of Arts, Science & Commerce, Baramati

(Autonomous Institute)

Syllabus (CBCS) for M.Sc. Microbiology

w.e.f. June 2019

Anekant Education Society's
Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

Autonomous

Course Structure for M.Sc. -II: Microbiology (2019 Pattern)

Semester	Paper Code	Title of Paper	No. of Credits
III	MICRO5301	Immunology	4
	MICRO5302	Molecular Biology I	4
	MICRO5303	Industrial Waste Water Treatment	4
	MICRO5304	Biophysical Techniques	4
	MICRO5305	Practical Course: Practical course based on Immunology, Pharmaceutical Microbiology and Industrial waste water treatment	4
	MICRO5306	Practical Course: Practical course based on Molecular Biology (I and II) and Microbial Technology	4
	CC029	Certificate Course: Research Methodology	2
	SD23	Skill Development: Spectroscopic Techniques	2
IV	MICRO5401	Pharmaceutical Microbiology	4
	MICRO5402	Molecular Biology II	4
	MICRO5403	Microbial Technology	4
	MICRO5404	Medical Microbiology	4
	MICRO5405	Dissertation I	4
	MICRO5406	Dissertation II	4
	SD24	Skill Development: Chromatographic Techniques	2

SYLLABUS (CBCS) FOR M.Sc. II Microbiology
(w. e. from June, 2020)
Academic Year 2020-2021

Class : M. Sc. II (Semester- III)
Paper Code : MICRO5301
Paper : I
Title of Paper : Immunology
Credit : 4
No. of lectures : 60

Course Objectives:

1. Define cancer and describe the key hallmarks of cancer cells.
2. Explain the role of mutations in the initiation and progression of cancer.
3. Identify the different types of cancer and their prevalence
4. Explain the distinction between the innate and adaptive immune responses.
5. Illustrate how immune cells recognize and respond to cancer cells
6. Analyze strategies to modulate the tumor microenvironment for therapeutic purposes

Course Outcome:

CO1. Explain the mechanisms of immune response regulation to prevent autoimmunity and excessive immune reactions.
CO2. Understand the roles of regulatory T cells and cytokines in immune regulation.
CO3. Describe the role of the immune system in recognizing and eliminating cancer cells.
CO4. Understand immunotherapeutic approaches for cancer treatment
CO5. Develop critical thinking skills to analyze immunological data and solve problems related to immune responses.
CO6. Effectively communicate immunological concepts through written and/or oral presentations

UNIT 1: Cell surface molecules and receptors (15L)

- Structure and function of: G-protein coupled receptors, Toll-like receptors, Cytokine receptors, T Cell receptor, B Cell Receptor, TCR-CD3 complex.
- Organization of Cytokine receptors and T Cell receptor
- Adhesion molecules in immune activation (adhesion, Selectin, Mucin)
- Signal transduction pathways: JAK/STAT and Ras/MAP Kinase Pathways.

UNIT 2: Regulation of Immune response (15L)

- Negative regulation - Immunological tolerance, Mechanisms of tolerance induction (related experimentation using transgenic animals),
- T cell mediated suppression of immune response.
- Regulation of immune responses by : antigen, antigen-antibody complexes, Network theory and its experimental evidence Cytokine mediated cross regulation of TH subsets (TH1-TH2)
- Immunomodulation: BRMs for therapy
- Regulation of complement system (classical and alternative)

UNIT 3: Experimental Immunology (15L)

- In vitro systems Quantification of cytokines (ELISPOT assay), functional assays for phagocytes and cytokines (cytotoxicity and growth assays)
- In vivo systems – Experimental animals in immunology research (Inbred animal strains, Knockout mice, transgenic animals, Knock in technology), Animal models for autoimmunity and AIDS.

UNIT 4: Tumor Immunology (15L)

- Cellular transformations during neoplastic growth.
- Classification of tumors based on histological, physiological, biochemical and immunological properties, Tumors of lymphoid system (lymphoma, myeloma, Hodgkin's disease).
- Escape mechanisms of tumor from host defense.
- Host immune response to tumor – Effector mechanisms, Immuno-surveillance theory
- Diagnosis of tumors – biochemical and immunological tumor markers
- Approaches in cancer immunotherapy: Immune adjuvant and tumor vaccine therapy.

Text / Reference Books:

- Akihiko Yoshimura, Tetsuji Naka and Masato Kubo, (2007), SOCS proteins, cytokine si gnaling and immune regulation, Nature Reviews, Immunology, 7:454-465 .
- Austyn J. M. and Wood K. J. (1993) Principles of Molecular and Cellular Immunology, Oxford University Press,
- Barret James D. (1983) Text Book of Immunology 4th edition, C. V. Mosby & Co. Lon don.
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- Gangal Sudha and Sontakke Shubhangi (2013), Textbook of Basic and Clinical Immunol ogy Paperback, University Press, India
- Kindt, Osborne, Goldsby, (2006), Kuby Immunology, 6th Ed., W. H. Freeman & Co.
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- Bhushan Patwardhan, Sham Diwanay and Manish Gautam. (2006). Botanical Immunom odulators and Chemoprotectants in Cancer Therapy.
- In Drug discovery and development Volume I: Drug Discovery. Ed. Chorghade Mukund S., (2006), WileyInterscience, John Wiley and Sons Inc. USA. 405-424.
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- House Robert V., (1998), Therapeutic Manipulation of Cytokines, Biotechnology and Sa fety Assessment, 2nd Ed., Taylor & Francis, 81-105.
- Masters John R. W., (2000), Animal Cell Culture A Practical Approach, 3rd Ed., Oxford University Press.
- Mather Jennie P. and Penelope E. Roberts, (1998), Introduction to Cell and Tissue Culture Theory and Technique, Plenum Press, New York.

- Roitt Evan, Brostoff J. Male D. (1993) Immunology 6th Ed., Mosby & Co. London.
- Talwar G. P. (1983) Handbook of Immunology, Vikas Publishing Pvt. Ltd. New Delhi.
- William E., Md. Paul, (2003), Fundamental Immunology, 5th Ed, Lippincott Williams & Wilkins Publishers
- Ann M. Leen, Cliona M. Rooney and Aaron E. Foster, (2007), Improving T Cell Therapy for Cancer, Ann. Rev. Immunol. 25:243–65.
- Chatterji C. C. (1992) Human Physiology Vol. 1 &2, Medical Allied Agency, Calcutta.
- Guyton A. C. and Hall J. E. (1996) Text Book of Medical Physiology, Goel Book Agency, Bangalore.
- Malati T. (2007), Tumor Markers: An Overview, Indian Journal of Clinical Biochemistry, 22(2):17-31
- Rev., 435|2:605-611Bendelac Albert, Paul B. Savage, and Luc Teyton, (2007), The Biolo gy of NKT Cells Ann. Rev. Immunol. 25:297–336
- Sham Diwanay, Manish Gautam and Bhushan Patwardhan. (2004). Cytoprotection and I munomodulation in Cancer Therapy. Current Medicinal Chemistry Anti-Cancer Agents, 4: 479-490

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	2									
CO 2	2									
CO 3				3						
CO 4					2					
CO 5		2							2	
CO 6			2			2			2	

Justification for the mapping

PO1: Disciplinary Knowledge:

CO1: Understanding the mechanisms of immune response regulation to prevent autoimmunity and excessive immune reactions contributes to disciplinary knowledge in immunology.

CO2: Grasping the roles of regulatory T cells and cytokines in immune regulation enhances disciplinary knowledge in the field of immunology**.**

PO2: Critical Thinking and Problem Solving:

CO5: Developing critical thinking skills to analyze immunological data and solve problems related to immune responses directly aligns with critical thinking and problem-solving abilities.

PO3: Social Competence:

CO6: Effectively communicating immunological concepts through written and/or oral presentations demonstrates social competence by facilitating the dissemination of knowledge within the scientific community.

PO4: Research-Related Skill:
CO3: Describing the role of the immune system in recognizing and eliminating cancer cells highlights research-related skills, as it involves understanding the complex interplay between the immune system and cancer**.**

PO5: Transdisciplinary Knowledge:
CO4: Understanding immunotherapeutic approaches for cancer treatment involves knowledge that spans across immunology and oncology, contributing to transdisciplinary knowledge.

PO6: Personal and Professional Competence:
CO7: Emphasizing effective citizenship and ethics in the context of immune responses contributes to personal and professional competence, ensuring responsible and ethical use of immunological knowledge**.**

PO7: Effective Citizenship and Ethics:
CO7: Understanding the ethical considerations in immune response regulation and cancer treatment aligns with effective citizenship and ethics, emphasizing responsible conduct in research and clinical practice.

PO9:Self-Directed and Lifelong Learning:
CO5: Developing critical thinking skills
CO8:** Effectively communicating immunological concepts contribute to fostering self-directed and lifelong learning by encouraging students to continuously update their knowledge and communication skills in the ever-evolving field of immunology

SYLLABUS (CBCS) FOR M.Sc. II Microbiology
(w. e. from June, 2020)
Academic Year 2020-2021

Class	: M. Sc. II (Semester- III)
Paper Code	: MICRO5302
Paper	: II
Title of Paper	: Molecular Biology I
Credit	: 4
No. of lectures	: 60

Course objective:

1. Understanding Operons and Regulatory Mechanisms
2. Understanding the function and significance of riboswitches in gene regulation and understand the role of sigma factors in response to phage infections in different bacterial hosts.
3. Molecular Understanding of mRNA, rRNA, and tRNA Processing
4. Understanding Non-coding RNAs and RNA Interference
5. To demonstrate proficiency in various molecular techniques such as gel assays, ChIP, probe designing, DNA and protein detection methods, footprinting assays, and hybridization techniques.
6. To explain the applications and significance of genome analysis tools like knockout mice, phage display, RFLP, DNA fingerprinting, and methods for measuring transcription rates and RNA interactions.
7. To demonstrate proficiency in PCR and its modifications as well as understanding the principles and applications of DNA microarray technology.
8. Understand and explain the role of molecular diagnostic tools, particularly PCR-based methods and microarrays, in the detection and diagnosis of diseases, with a focus on cancer diagnostics.

Course outcome:

CO1. Students will demonstrate an in-depth understanding of operons and the various regulatory mechanisms governing gene expression in prokaryotic and eukaryotic systems.

CO2. Students will comprehend the function and significance of riboswitches in gene regulation and the role of sigma factors in response to phage infections across different bacterial hosts.

CO3. Students will gain a comprehensive understanding of the molecular processes involved in mRNA, rRNA, and tRNA processing, including splicing, modifications, and maturation.

CO4. Students will comprehend the roles and mechanisms of non-coding RNAs, including their involvement in RNA interference pathways and gene silencing.

CO5. Students will demonstrate proficiency in executing various molecular techniques, including gel assays, ChIP, probe designing, DNA and protein detection methods, footprinting assays, and hybridization techniques.

CO6. Students will be able to apply and elucidate the significance of genome analysis tools such as knockout mice, phage display, RFLP, DNA fingerprinting, and methods for measuring transcription rates and RNA interactions in molecular research.

CO7. Students will understand and explain the role of molecular diagnostic tools, particularly PCR-based methods and microarrays, in the detection and diagnosis of diseases, focusing on their applications in cancer diagnostics.

UNIT 1: Fine Control of Prokaryotic and Eukaryotic transcription (15L)

- Lactose operon: repressor-operator interactions, mechanism of repression, Positive control of lac operon-Mechanism of CAP action, catabolite repression.
- The Arabinose operon: Ara operon repression loop, evidence for repression loop, auto regulation of araC.
- The trp operon:- control of trp operon by attenuation, defeating attenuation.
- Riboswitches
- Sigma factor Switching:- Phage infection- T4,T7 infection in *E. coli,* SPO1 infection in *B. subtilis*.

UNIT 2: RNA processing (15L)

- mRNA processing: splicing, capping, polyadenylation.
- Coordination of mRNA processing.
- rRNA processing
- tRNA processing
- Non coding RNAs and their production
- RNA interference
- SiRNA, micro-RNA role in gene silencing,

UNIT 3: Tools in molecular biology (15L)

Activity gel assay, ChIP,, Designing probe, Detection of DNA binding protiens, DMS foot printing, DNA helicase assay, Epitope tagging, Sequence tagged sites, Filter binding assay, Protein foot printing, Knockout mice, phage display, Expressed sequence tags, Yeast two and three hybrid assay, RFLP, Finding the replicon, DNA finger printing, Measuring transcription rates, Finding RNA sequences that interact with each other.

UNIT 4: Techniques in Molecular biology and diagnostic applications (15L)

- PCR and its modifications, nested PCR, Hot start
- PCR, RT –PCR and Real time PCR (Q –PCR)
- DNA microarray
- Applications of PCR and microarray.
- Molecular diagnostic tools in detection of cancer.

Text / Reference Books:

- Functions and Mechanics of RNA editing, J. M. Goot, Ann. Rew. Gent., 2000, **30**, 419-53.
- http://highered.mcgrawhill.com/sites/0072943696/student_view0/chapter3/animation__dna_replication__quiz_1_.html
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- James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) *Molecular Biology of the Gene,* 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.
- Lewin's Genes XI, (2014) Jones and Bartelett Publishers Inc.
- Mechanism of subcellular mRNA localization, 2002, CSH, **108**, 533-44.

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- Molecular Biology of the Cell, Bruce Albert et. al. , 6th Edn., Garland Sciences.
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- Recent progress in structure, Biology and tRNA processing and modification. Mol. Cell., **19(2)**, 2005, 157-66
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- Concepts of Genetics, W.S. Klug and M.R. Cummings, (2005) Pearson education
- Functions and Mechanics of RNA editing, J. M. Goot, Ann. Rev. Gent, 2000, **30**, 419-53.
- Mechanism of subcellular mRNA localization, 2002, CSH, **108**, 533-44.
- Micro RNAs in cell proliferation, Cell death and tumorogenesis, B. J. of Cancer, 2006, 94.
- Recent progress in structure, Biology and tRNA processing and modification. Mol. Cell., **19(2)**, 2005, 157-66
- http://onlinelibrary.wiley.com/doi/10.1576/toag.12.1.037.27556/pdf
- http://www.annualreviews.org/doi/abs/10.1146/annurevbiochem-052610-091920
- http://www.nature.com/nrg/journal/v13/n7/full/nrg3230.html
- http://www.nature.com/nrg/journal/v14/n8/full/nrg3535.html
- http://www.nature.com/scitable/topicpage/the-role-ofmethylation-in-gene-expression-1070
- http://www.ncbi.nlm.nih.gov/pubmed/20920744
- Recent progress in structure, Biology and tRNA processing and modification. Mol. Cell., **19(2)**, 2005, 157-66
- Micro RNAs in cell proliferation, Cell death and tumorogenesis, B. J. of Cancer, 2006, 94.
- Recent progress in structure, Biology and tRNA processing and modification. Mol. Cell., **19(2)**, 2005, 157-66
- S.B Primrose and R M Twyman 2006 7th edition. Blackwell publishing
- Weaver R., (2007) *Molecular Biology*, 4th Edition, McGrew Hill Science.

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3								
CO 2	3					2			
CO 3				3					
CO 4				3					
CO 5		2							
CO 6				3					
CO 7					2	2			

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Strong (3) relation - Understanding operons and gene regulatory mechanisms directly contributes to disciplinary knowledge in molecular genetics.

CO2: Strong (3) relation - Knowledge of riboswitches, sigma factors, and phage responses significantly adds to disciplinary knowledge in gene regulation.

PO2: Critical Thinking and Problem Solving

CO5: Moderate (2) relation - Employing molecular techniques requires problem-solving skills for experimental design and data interpretation.

PO4: Research-related Skills and Scientific Temper

CO3: Strong (3) relation - Understanding molecular processes and modifications of mRNA, rRNA, and tRNA is essential for research skills in molecular biology.

CO4: Strong (3) relation - Understanding non-coding RNAs and their impact on gene silencing directly contributes to research-related skills.

CO6: Strong (3) relation - Application of genome analysis tools enhance research skills and scientific temper in molecular biology research.

PO5: Trans-disciplinary Knowledge

CO7: Moderate (2) relation - Molecular diagnostic tools' understanding partially contributes to trans-disciplinary knowledge in medical applications.

PO6: Personal and Professional Competence

CO2: Moderate (2) relation - Understanding molecular responses to infections develops professional competence in molecular biology.

CO7: Moderate (2) relation - Knowledge of molecular diagnostic tools develops professional competence in medical applications.

SYLLABUS (CBCS) FOR M.Sc. II Microbiology
(w. e. from June, 2020)
Academic Year 2020-2021

Class : M. Sc. II (Semester- III)
Paper Code : MICRO5303
Paper : III
Title of Paper : Industrial waste water treatment
Credit : 4
No. of lectures : 60

Course Objective:

1. Capable of comprehending the significance of treating industrial wastewater for safeguarding the environment and public health.
2. Comprehend the origins and varieties of industrial wastewater.
3. Identify primary contaminants typically present in industrial wastewater.
4. Grasp the principles behind constructing and running physical treatment facilities.
5. Introduce the basics of biological treatment, encompassing aerobic and anaerobic methodologies.
6. Comprehend the function of microorganisms in breaking down organic substances.
7. Investigate the principles of sustainability applied in wastewater treatment, focusing on energy conservation and reducing carbon emissions.

Course Outcome:

CO1. Provide definitions for fundamental terms and concepts associated with treating industrial wastewater.
CO2. Outline the importance of industrial wastewater treatment in safeguarding the environment.
CO3. Capable of identifying elementary wastewater measures, including pH, turbidity, and suspended solids.
CO4. Analyze wastewater characterization information to gauge pollution levels and create treatment approaches.
CO5. Elucidate the fundamental principles governing physical treatment methods.
CO6. Develop an initial design for a physical treatment setup tailored to a particular industrial wastewater.
CO7. Evaluate and interpret data derived from a biological treatment setup, encompassing COD and BOD elimination efficiency.

UNIT 1: Principles of Wastewater Treatment (15L)

- The need for Wastewater Treatment
- Measuring Pollution Load of wastewaters
- Methods for estimating parameters used for determining treatment efficacy
- Layout of typical wastewater treatment plants

UNIT 2: Pre-treatment & Primary treatment process (Unit Processes) (15L)

- Flow equalization
- Screening
- Flocculation
- Flotation
- Granular medium filtration

UNIT 3: Secondary and Tertiary Treatment process (Unit Processes) (15L)

- Biological Processes (Aerobic)
- Biological Processes (Anaerobic)
- Biological processes (Combined)
- Sedimentation and clarification
- Disinfection
- Adsorption

Advanced, Combined and Innovative wastewater treatment processes

- Submerged Aerobic Fixed Film reactors (SAFF)
- Membrane bioreactors (MBRs)
- Mixed Bed Bioreactors (MBBRs)

UNIT 4: Current industrial wastewater treatment processes (15L)

- Dairies
- Food processing
- Dyeing industry / Dye-house effluents
- Paper manufacture

Text / Reference Books:

- Biotechnology for Water and Wastewater Treatment. Dr. Satya Prakash. Navyug Pub lishers & Distributors, New Delhi. 2009.
- Industrial Water Pollution Control. 3rd Edition. W. WesleyEckenfelder Jr. McGraw H ill. 2000.
- Standard Methods for the Examination of Water & Wastewater. 21st Edition. 2005 APHA.AWWA.WEF
- Wastewater Engineering, Treatment, Disposal and Reuse. 3rd Ed., Metcalf and Eddy (Eds). Tata Mac Graw Hill Publishing Co. Ltd. New Delhi
- Tchobanoglous G. and F. L. Burton. (1991).
- Disposal and Reuse. 3rd Ed., Metcalf and Eddy (Eds). Tata Mac Graw Hill Publishing Co. Ltd. New Delhi
- Biological Wastewater Treatment. Vol. 5. Activated Sludge and Aerobic Biofilm Reactors. Marcos von Sperling. IWA Publishing. London, New York. © 2007 IWA Publishing
- Industrial Wastewater Treatment. A. D. Patwardhan. © Prentice –Hall of India Pvt. Ltd., New Delhi. 2008. ISBN 978-81-203-3350-5.

Mapping of Program Outcomes with Course Outcomes

Weightage:1=weak or low relation,2=moderate or partial relation,3=strong or direct relation

Course Outcomes	**Programme Outcomes(POs)**								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3						2		
CO2	3							1	
CO3	3		2		2	2			1

CO4	2	2		3	2	1		3	2
CO5	2	3	2	3	1	3	3		1
CO6	3	2	2	2		2			2
CO7	2	3	3			2		2	2

Justification for the mapping

PO1: Disciplinary Knowledge

The course outcomes CO1 to CO7 enrich disciplinary knowledge by exploring terms and concepts associated with industrial wastewater treatment, emphasizing the significance of such treatment for environmental protection, and elucidating basic wastewater parameters.

PO2: Critical Thinking and Problem Solving

CO4, CO5, CO6, and CO7 nurture critical thinking and problem-solving abilities by tasking students with interpreting wastewater characterization data to evaluate pollution levels and devise treatment strategies. CO6, involving the design of an initial physical treatment system, and CO7, requiring analysis and interpretation of biological treatment system data like COD and BOD removal efficiency, cultivate analytical and solution-driven thinking.

PO3: Social Competence

CO3, CO5, CO6, and CO7 encourage social competence through collaborative interdisciplinary work addressing environmental concerns. This collaborative experience enhances communication, teamwork, and cooperation, enabling students to engage diverse stakeholders and contribute responsibly to water treatment solutions.

PO4: Research-related Skills and Scientific Temper

CO4, CO5, and CO6 impart research-related skills by familiarizing students with sampling, isolation, and analysis techniques, preparing them for scientific research. Emphasis on critically evaluating data from a biological treatment system, including COD and BOD removal efficiency, fosters a scientific temper.

PO5: Trans-disciplinary Knowledge

CO3, CO4, and CO5 promote trans-disciplinary knowledge by integrating principles from microbiology, environmental science, chemistry, and engineering to address intricate environmental challenges. This integrative approach equips students with versatile skills applicable across diverse scientific and engineering fields.

PO6: Personal and Professional Competence

CO3, CO4, CO5, CO6, and CO7 enhance personal and professional competence by providing knowledge and practical skills crucial for careers in research, environmental monitoring, and water treatment. They instill a sense of responsibility for environmental stewardship and contribute to professional growth in scientific and environmental fields.

PO7: Effective Citizenship and Ethics

CO1 and CO5 foster effective citizenship and ethical behavior by stressing responsible environmental stewardship and ethical conduct in research and water management practices.

They equip students with the knowledge and values necessary to make informed decisions regarding environmental conservation and sustainable water use.

PO8: Environment and Sustainability

CO2, CO4, and CO7 address environmental and sustainability concerns by exploring the role of microorganisms in ecosystem balance and assessing the impact of human activities on water quality. They equip students with knowledge and tools to develop sustainable solutions for environmental challenges, including pollution control, wastewater treatment, and resource preservation.

PO9: Self-directed and Life-long Learning

CO3, CO4, CO5, CO6, and CO7 foster self-directed and lifelong learning by encouraging students to explore cutting-edge research, adapt to evolving environmental challenges, and stay updated with advancements in microbiological techniques and technology. This approach cultivates curiosity, adaptability, and motivation for continual learning to address dynamic wastewater treatment issues.

SYLLABUS (CBCS) FOR M.Sc. II Microbiology
(w. e. from June, 2020)
Academic Year 2020-2021

Class : M. Sc.II (Semester- III)
Paper Code : MICRO5304
Paper : IV
Title of Paper : Biophysical Techniques
Credit : 4
No. of lectures : 60

Course Objectives:

1. To acquire knowledge in various biophysics techniques.
2. To acquire knowledge in various methods for determining molecular structures
3. To learn principle and working of biophysical techniques.
4. To acquire knowledge about various ionization methods.
5. To learn the chromatography as well as spectroscopy techniques.
6. To determines the physical and chemical properties of atoms or molecules.
7. To enables the study of physiochemical, electronic and structural properties of molecules.

Course Outcome:

CO1. Students will gain the ability to understand molecular structure determination
CO2. Student will grasp the fundamental concept of biology, chemistry and physics, understanding how these disciplines interconnect with biology systems.
CO3. Students will effectively operate in the laboratory while adhering to safe practices.
CO4. Students will critically assess primary literature within the field.
CO5. Students will effectively utilize databases, computational tools, and other online resources.
CO6. Students will exhibit awareness of issues in the practice of science.
CO7. Shows a strong grasp of biophysical concept.

UNIT 1: Mass spectroscopy (15L)

Principles of operation, Ionization, Ion fragmentation, Mass Analyzers, GC-MS, MALDI-TOF

UNIT 2: X-ray crystallography (15L)

Purification of proteins, Crystallization of proteins.
Instrumentation, acquisition of the diffraction pattern, basic principles of x-ray diffraction, Crystal Structures (Bravais Lattices), Crystal planes and Miller Indices, Fourier Transform and Inverse Fourier, Direct Lattice and Reciprocal lattice, Ewald sphere, Electron density Maps, Phase determination, Phase Refinement, Validation.

UNIT 3: NMR spectroscopy (15L)

Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin coupling, Nuclear Overhauser Effect Spectroscopy, Correlation Spectroscopy, Approach to structure determination by 2D-NMR

UNIT 4: Tools of Bioinformatics (15L)

General Introduction of Biological Databases, Introduction to Sequences, Sequence alignment, Local and global alignment, pair wise sequence alignment, Multiple sequence Alignment, Dynamic Programming, Homology Modelling, 3-D protein Model. Examples of related tools (FASTA, BLAST, BLAT), databases (GENBANK, PDB, OMIM) and software (RASMOL, Ligand Explorer).

Text / Reference Books:

- Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology*, 6th Ed. Cambridge University Press, New York.
- Pattabhi, V. and Gautham, N. (2002) *Biophysics.* Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
- Rolf Ekman, Jerzy Silberring, Ann Westman-Brinkmalm, Agnieszka Kraj (2009) *Mass spectrometry : instrumentation,interpretation, and applications*, John Wiley & Sons, Inc.,Canada.
- Irwin H. Segel (1976) *Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry*, 2nd Edition. John Wiley & Sons.
- Nölting, B. (2006) *Methods in modern biophysics.* Second Edition. Springer, Germany.
- Cavanagh John *et.al.* (1995) *Proteins NMR Spectroscopy:Principles and Practice*, Academic Press.
- Cotterill, R. M. J. (2002) *Biophysics: An Introduction.* John Wiley & Sons, England.
- Keeler, J. (2002) *Understanding NMR Spectroscopy*. John Wiley & Sons, England.
- Mount, D. W. (2001) *Bioinformatics: sequence and genome analysis.* Cold Spring Harbor Laboratory Press, New York.
- David M Webster (2000) *Protein Structure Prediction-Methods and Protocols*, Methods In Molecular Biology Vol 143 Humana Press.
- Narayanan, P. (2000) Essentials of Biophysics. New Age International Publication, New Delhi.

Mapping of Program Outcomes with Course Outcomes

Weightage:1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1				2					2
CO2	3				3	2			
CO3									
CO4		2							
CO5				3	3				
CO6	3		2						

Justification for the mapping

PO1: Disciplinary Knowledge

CO2: Disciplinary knowledge of the fundamental concepts of biology, chemistry and physics, aided by biophysics, is crucial for a comprehensive understanding of living systems.
CO6: Biophysics serves as the bridge that integrates principles from these core disciplines, providing insight into the physical mechanisms underlying biological phenomena.

PO2: Critical Thinking and Problem Solving

CO3: Evaluate and refine experimental designs to ensure they address challenges that may arise during biophysical experiments, such as technical issues or unexpected results.
CO4: Students will critically evaluate primary literature in the dicipline develop and use computer modelling methods to see and manipulate the shapes and structures, crucial information needed to develop new drug targets, or understand how proteins mutate and cause tumors to grow.

PO3: Social competence

CO6: Social competence ensures an understanding of ethical consideration in scientific practices. This awareness with integrity, transparency, and adherence to ethical standards.

PO4:Research related skills and scientific temper.

CO1: Research-related skills are crucial for designing experiments that aim to determine molecular structure. Ascientific temper drives the selection of appropriate methods, precision in execution, and through data analysis for accurate result.
CO5: Research related tools, and online resources to gather, analyze, and interpret information. Proficiency in database management systems, data mining, and statistical analysis is crucial for effective research.

PO5: Trans-disciplinary Knowledge

CO2: Transdiciplinary knowledgeof biophysical techniques integrated understandingn of varoius scientific disciplines, combining biology and physics to study biological processes at a molecular and cellular level.
CO5: The techniques such as spectroscopy, microscopy and imaging to explore the physical properties of biological molecules.

PO6: Personal and Professional Competence

CO2: Students will demonstrate the proficiency in analytical techniques, mathematical modeling and computational methods is crucial for interpreting complex biophysical data and conducting meaningful research.

PO9: Self-directed and Life-long Learning

CO1: Techniques for molecular structure determination, such as X- ray crystallograghy, NMR spectroscopy etc require specialized skills.

SYLLABUS (CBCS) FOR M.Sc. II Microbiology
(w. e. from June, 2020)
Academic Year 2020-2021

Class	: M. Sc.II (Semester- III)
Paper Code	: MICRO5305
Paper	: V
Title of Paper	: Practical Course: Practical course based on Immunology, Pharmaceutical Microbiology and Industrial waste water treatment
Credit	: 4
No. of lectures	: 60

Course Objectives

1. Gain foundational knowledge on antigens and antibodies.
2. Investigate the processes involved in the binding of antigens and antibodies.
3. Introduce various laboratory techniques employed for the examination of antigen-antibody interactions, including ELISA, Western blotting, and immunofluorescence.
4. Explore the practical implications of comprehending antigen-antibody interactions in the fields of diagnostics and therapeutics.
5. Foster critical thinking abilities for the analysis of intricate scenarios related to antigen-antibody interactions.
6. Outline the origins and classifications of industrial wastewater.
7. Recognize prevalent pollutants commonly encountered in industrial wastewater

Course Outcome

CO1. Students should be capable of determining fundamental wastewater parameters, including pH, turbidity, and suspended solids.
CO2. Analyze data on wastewater characterization to evaluate levels of pollution and formulate treatment strategies.
CO3. Evaluate and interpret data obtained from a biological treatment system, specifically focusing on the efficiency of COD and BOD removal.
CO4. Explore the factors that impact the rate of single diffusion and understand their contributions to the overall process.
CO5. Examine practical instances where single diffusion plays a pivotal role, such as in biological membranes, chemical reactions, or materials science.
CO6. Assess experimental methodologies employed in the study of single diffusion critically and interpret the outcomes of experiments

A. Antigen-Antibody Interactions

1. Precipitation reactions of antigen-antibody: Single radial immunediffusion, double immunodifusion, Immunoelectrophoresis and rocket immuneelectrophoresis
2. Agglutination techniques: Titer determination of isoantibodies to human blood group antigens

B. Biophysics

Ramchandran plot

C. Detection and isolation of anti-infectives from plant

1. Extraction of bioactive principles from plant and activity fractionation
2. Estimation of its antimicrobial activity using standard guidelines (CLSI)

D. Industrial waste water treatment

1. Estimation of pollution load of a natural sample (e.g. river water / industrial waste water)

2. Setting up a laboratory experiment to assess degradability of synthetic waste water

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	2	2								
CO 2										
CO 3				2						
CO 4					3					
CO 5					2					
CO 6		2								

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Students should be capable of determining fundamental wastewater parameters, including pH, turbidity, and suspended solids. Justification: This outcome involves the acquisition and application of specific knowledge related to wastewater parameters, reflecting disciplinary expertise in environmental science and engineering**.**

PO2: Critical Thinking and Problem Solving

CO2: Analyze data on wastewater characterization to evaluate levels of pollution and formulate treatment strategies. Justification: Analyzing data and formulating treatment strategies require critical thinking skills to assess complex information and develop effective solutions to address pollution levels.

CO6: Assess experimental methodologies employed in the study of single diffusion critically and interpret the outcomes of experiments. Justification: Critical assessment of experimental methodologies and interpretation of outcomes are essential critical thinking skills applied in a research context

PO4: Research-related Skill

CO3: Evaluate and interpret data obtained from a biological treatment system, specifically focusing on the efficiency of COD and BOD removal. Justification: This outcome involves the ability to assess and interpret data from a biological treatment system, reflecting research-related skills in data analysis and interpretation**.**

PO5: Transdisciplinary Knowledge

CO4: Explore the factors that impact the rate of single diffusion and understand their contributions to the overall process. Justification: Exploring factors impacting diffusion involves understanding principles from multiple disciplines such as chemistry, physics, and engineering, reflecting a transdisciplinary approach.

CO5: Examine practical instances where single diffusion plays a pivotal role, such as in biological membranes, chemical reactions, or materials science. Justification: This outcome requires applying knowledge of single diffusion across different practical instances, showcasing transdisciplinary understanding in biology, chemistry, and materials science**.**

SYLLABUS (CBCS) FOR M.Sc. II Microbiology
(w. e. from June, 2020)
Academic Year 2020-2021

Class	: M. Sc.II (Semester- III)
Paper Code	: MICRO5306
Paper	: VI
Title of Paper	: Practical Course: Practical course based on Molecular Biology (I and II) and Microbial Technology
Credit	: 4
No. of lectures	: 60

Course objective:

1. Understanding the impact of varying gel concentrations on the efficiency and stability of immobilized cells or enzymes in bioconversions.
2. Investigating the influence of different cell or enzyme concentrations on the rate and yield of bioconversion processes.
3. Understanding Biosorption Mechanisms: Comprehending the mechanisms involved in biosorption, particularly the uptake of dyes or metals, using deceased biomass.
4. Optimizing Production Conditions: Developing the ability to optimize laboratory-scale production conditions, particularly focusing on media composition, for enhancing exopolysaccharide or bioemulsifier yield.
5. Gaining expertise in techniques and methodologies involved in characterizing bacterial isolates at the molecular level, such as genetic profiling and identification.
6. Understanding the process of gene annotation, including identifying and analyzing gene sequences to determine their functions, regulatory elements, and possible roles in biological systems.

Course outcome:

After completing this course Students should able to:

CO1. Develop the capability to evaluate and explain the effects of different gel concentrations on the effectiveness and stability of immobilized cells or enzymes in bioconversion processes.

CO2. Acquire the ability to analyze and interpret the influence of various cell concentrations on the speed and output of bioconversion reactions, leading to informed decision-making in process optimization.

CO3. Acquire the ability to analyze and interpret the influence of various enzyme concentrations on the speed and output of bioconversion reactions, leading to informed decision-making in process optimization.

CO4. Attain a comprehensive understanding of the underlying mechanisms involved in biosorption, particularly elucidating the uptake of dyes or metals by utilizing deceased biomass as an absorbent material.

CO5. Develop proficiency in optimizing laboratory-scale production conditions, specifically focusing on manipulating media composition to maximize the yield of exopolysaccharides or bioemulsifiers.

CO6. Gain expertise in employing various techniques and methodologies for characterizing bacterial isolates at a molecular level, including genetic profiling and accurate identification.

Develop the ability to comprehend and apply the process of gene annotation, including the identification, analysis, and determination of functions, regulatory elements, and potential roles of gene sequences within biological systems.

A. Bioconversion

Bioconversions using immobilized systems (cells / enzyme) Parameter testing

a. Effect of gel concentration

b. Effect of cell / enzyme concentration

B. Biosorption

Biosorption of dyes or metals using dead biomass

C. Laboratory scale production

Laboratory scale production and media optimization for exopolysaccharide / bioemulsifier production.

D. Molecular Biology

1. Molecular Characterization of bacterial isolates
2. Gene annotation

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3							2
CO 2	3	3							2
CO 3							2	2	3
CO 4				3					2
CO 5				2					3
CO 6					2				2
CO 7						3			3

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Demonstrates a robust connection (Strong - 3) between critical analysis of gel concentrations in bioconversions and disciplinary knowledge by comprehending their direct impact on process efficiency and stability.

CO2: Illustrates a significant relationship (Strong - 3) between interpreting varying cell concentrations in bioconversion and disciplinary knowledge by elucidating optimal conditions for higher yields.

PO2: Critical Thinking and Problem Solving

CO1: Reflects a compelling association (Strong - 3) as critical analysis of gel concentrations require problem-solving skills to understand their effects on bioconversion.

CO2: Highlights a substantial correlation (Strong - 3) as interpreting varying cell concentrations demands critical thinking to optimize bioconversion processes.

PO4: Research-related Skills and Scientific Temper

CO4: Demonstrates a direct connection (Strong - 3) as proficiency in Plackett-Burman design aligns explicitly with research-related skills.
CO5: Indicates a moderate link (Moderate - 2) as skills in isolating plasmid DNA contribute partially to research-related skills.

PO5: Trans-disciplinary Knowledge
CO6: Suggests a partial relationship (Moderate - 2) as understanding DNA transformation contributes partly to trans-disciplinary knowledge, spanning across molecular biology and genetic engineering.

PO6: Personal and Professional Competence
CO7: Illustrates a direct and significant association (Strong - 3) as analyzing gene sequences involves advanced bioinformatics skills, directly enhancing personal and professional competence.

PO7: Effective Citizenship and Ethics
CO3: Indicates a moderate relationship (Moderate - 2) as understanding biosorption mechanisms contributes partially to environmental awareness, indirectly relating to effective citizenship and ethics.

PO8: Environment and Sustainability
CO3: Suggests a moderate connection (Moderate - 2) as biosorption mechanisms, primarily environmental, partially contribute to understanding sustainability practices.

PO9: Self-directed and Life-long Learning
All COs exhibit varying degrees of connection (moderate to strong) with PO9, emphasizing the continuous learning, skill development, and need for staying updated in the field.

SYLLABUS (CBCS) FOR M.Sc. II Microbiology
(w. e. from June, 2020)
Academic Year 2020-2021

Class : M. Sc. II (Semester- III)
Paper Code : CC029
Title of Paper : Certificate Course – Research Methodology
Credit : 2
No. of lectures : 30

Course objective:

1. Comprehend the underlying philosophical principles and paradigms that form the basis of research methodologies.
2. Acquire familiarity with various types of research publications, their structures, and content.
3. Develop skills in effectively using online referencing tools for citation and bibliography creation.
4. Understand the concept of plagiarism and methods to avoid it in academic and research writing.
5. Gain an introduction and basic understanding of statistical software, particularly focusing on R software.
6. Learn the principles and techniques involved in constructing titles and composing concise yet informative abstracts for research papers or proposed projects.
7. Acquire skills in crafting different sections of a research paper, including materials and methods, results, discussion, conclusion, etc., adhering to academic writing conventions.
8. Develop the ability to construct comprehensive and well-structured research proposals.
9. Gain proficiency in composing and structuring project reports, incorporating findings, analysis, and conclusions from research projects.

Course outcome:

CO1. Students will demonstrate an understanding of the philosophical principles and paradigms underpinning various research methodologies.
CO2. Students will be able to recognize and differentiate between various types of research publications, comprehending their structures and content.
CO3. Students will develop proficiency in using online referencing tools to create accurate citations and bibliographies.
CO4. Students will understand the concept of plagiarism and adopt strategies to prevent its occurrence in academic and research writing.
CO5. Students will gain an introductory understanding of statistical software, specifically focusing on R software.
CO6. Students will acquire skills in constructing effective titles and composing informative yet concise abstracts for research papers or proposed projects.
CO7. Students will demonstrate the ability to craft diverse sections of a research paper, including materials and methods, results, discussion, conclusion, etc., adhering to academic writing norms.

UNIT 1: Introduction to Research (15L)

- Philosophical foundation of research
- Understanding research publications
- Online Referencing Tools
- Plagiarism
- Statistical Software (R software)

UNIT 2: Scientific writing (15L)

- Construction of title and Preparation of abstract for a research paper/ proposed project
- Writing of materials and methods, results, discussion, conclusion etc
- Writing of research proposals
- Writing a project report

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3								2
CO 2	2								
CO 3				2					
CO 4		3					3		
CO 5					1				
CO 6		2							
CO 7				2					

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Strong (3) relation - Understanding philosophical principles in research aligns directly with disciplinary knowledge.

CO2: Moderate (2) relation - Recognizing and differentiating between research publication types partially contributes to disciplinary knowledge.

PO2: Critical Thinking and Problem Solving

CO4: Strong (3) relation - Understanding and preventing plagiarism aligns directly with critical thinking and problem-solving skills.

CO6: Moderate (2) relation - Constructing titles and abstracts involves partial critical thinking.

PO4: Research-related Skills and Scientific Temper

CO3: Moderate (2) relation - Developing proficiency in using online referencing tools partially aligns with research-related skills.

CO7: Moderate (2) relation - crafting research paper sections contribute partially to research-related skills.

PO5: Trans-disciplinary Knowledge
CO5: Weak (1) relation - An introductory understanding of statistical software has minimal relevance to trans-disciplinary knowledge.

PO7: Effective Citizenship and Ethics
CO4: Strong (3) relation - Understanding and preventing plagiarism aligns directly with ethical conduct in research.

PO9: Self-directed and Life-long Learning
CO1: Moderate (2) relation - Comprehension of research methodologies partially contribute to self-directed and lifelong learning.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology (2019 Pattern)
(w. e. from June, 2019)
Academic Year 2019-2020

Class : M. Sc. II (Semester- III)
Paper Code : SD23
Title of Paper : Skill Development: Spectroscopic Techniques
Credit : 2
No. of lectures : 30

Course Objective:

1. Understand the basic principles of UV-Visible spectroscopy, including the electromagnetic spectrum, molecular transitions, and the Beer-Lambert Law.
2. Familiarize students with the components of UV-Visible spectrophotometers, their functions, and the operational procedures.
3. Gain practical skills in setting up, calibrating, and operating UV-Visible spectrophotometers.
4. Learn techniques for quantitative analysis using UV-Visible spectroscopy, including the construction of calibration curves and determination of unknown concentrations.
5. Explore various applications of UV-Visible spectroscopy in chemistry, such as analyzing concentration, determining reaction kinetics, and identifying chemical species.
6. Develop the ability to interpret UV-Visible spectra and correlate spectral features with molecular structures and electronic transitions.
7. Understand the components of an AAS instrument, such as the light source, monochromator, and detector, and the role each plays in the analysis process.
8. Learn sample preparation techniques suitable for AAS, and gain proficiency in introducing samples into the AAS instrument.
9. Develop skills in quantitative analysis using AAS, including calibration procedures, standard addition methods, and the determination of elemental concentrations in samples.

Course Outcome:

CO1. Understand the Principles: Students will be able to explain the fundamental principles of UV-Visible spectroscopy, including the interaction of electromagnetic radiation with matter, molecular transitions, and the Beer-Lambert Law.
CO2. Gain proficiency in operating UV-Visible spectrophotometers, understanding the components, and calibrating the instrument for accurate measurements.
CO3. Develop the ability to perform quantitative analysis using UV-Visible spectroscopy, including the determination of concentration and molar absorptivity.
CO4. Interpret UV-Visible spectra to identify functional groups, electronic transitions, and chemical properties of various compounds.
CO5. Acquire skills in developing experimental methods for specific applications using UV-Visible spectroscopy, such as kinetics studies, reaction monitoring, and quality control.
CO6. Learn to troubleshoot common issues associated with UV-Visible spectrophotometers and understand routine maintenance procedures to ensure reliable and accurate results.

CO7. Understand the fundamental principles of Atomic Absorption Spectroscopy, including the theory of atomic absorption, energy levels, and the role of hollow cathode lamps.

CO8. Gain proficiency in operating AAS instruments, handling sample introduction systems, and optimizing instrumental parameters for different elements.

A. UV-Visible spectroscopy- Principle, Instrumentation. FTIR and its advantages, Principle, Instrumentation, Absorption band

B. Atomic Absorption Spectroscopy (AAS) and its advantages, Hands-on training

Text / Reference Books:

- Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology*, 6th Ed. Cambridge University Press, New York.
- Pattabhi, V. and Gautham, N. (2002) *Biophysics.* Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
- Rolf Ekman, Jerzy Silberring, Ann Westman- Brinkmalm, Agnieszka Kraj (2009) *Mass spectrometry : instrumentation, interpretation, and applications*, John Wiley & Sons, Inc.,Canada.

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	2		2		2		2			
CO 2						2	2		2	
CO 3							2		2	
CO 4	2						2			
CO 5				2					2	
CO 6										
CO 7										
CO8										

Justification for the mapping

PO1: Disciplinary Knowledge:

CO1 and CO4 contribute significantly to disciplinary knowledge as they require students to understand the fundamental principles of UV-Visible spectroscopy, molecular transitions, and the interpretation of spectra to identify functional groups and chemical properties. This knowledge forms the basis for expertise in the field of spectroscopy.

Critical Thinking and Problem Solving:

CO3 challenges students to perform quantitative analysis using UV-Visible spectroscopy, necessitating critical thinking skills to determine concentrations and molar absorptivity.

CO5 also promotes critical thinking by requiring students to develop experimental methods for specific applications, such as kinetics studies and quality control.

Social Competence:

While UV-Visible spectroscopy may not directly relate to social competence, the skills developed in operating and applying spectroscopic techniques (CO2, CO5) can be used in collaborative research efforts or in industries with social implications, promoting social competence through effective teamwork.

PO4: Research-related Skill:

CO5, focusing on developing experimental methods for specific applications, aligns with research-related skills. It requires students to apply their knowledge to design experiments, contributing to the development of research skills necessary for scientific inquiry.

PO5: Transdisciplinary Knowledge:

The principles and skills gained from UV-Visible spectroscopy (CO1-CO6) can be applied across various scientific disciplines, showcasing transdisciplinary knowledge. The ability to troubleshoot and perform routine maintenance (CO6) is valuable in maintaining instrumentation across different fields.

PO6: Personal and Professional Competence:

CO2 emphasizes proficiency in operating instruments, and CO6 focuses on troubleshooting and maintenance. These aspects contribute to personal and professional competence by ensuring that students are adept at using and maintaining equipment commonly found in professional settings

PO7: Effective Citizenship and Ethics:

While UV-Visible spectroscopy itself may not directly address citizenship, the ethical use of scientific methods and data interpretation (implicit in CO1-CO4) is crucial. Adhering to principles like the Beer-Lambert Law promotes ethical scientific practices.

Environment and Sustainability:

CO6, involving routine maintenance procedures, indirectly aligns with environmental sustainability. Proper maintenance ensures the longevity of equipment, reducing the need for frequent replacements and minimizing the environmental impact associated with manufacturing and disposal.

PO9: Self-directed and Lifelong Learning:

CO2, CO5, and CO6 collectively contribute to self-directed and lifelong learning. Operating instruments, developing experimental methods, and troubleshooting issues require continuous learning and adaptation to new challenges in the field of spectroscopy.