Anekant Education Society's

Tuljaram Chaturchand College, Of Arts, Science & Commerce Baramati – 413102

(Autonomous)

Syllabus (CBCS) for M.Sc. Microbiology

w.e.f. June 2022

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

Course Structure for M.Sc. - I: Microbiology

Semester	Paper Code	Title of Paper	No. of Credits
I	**PSMB111**	Microbial Systematics and Diversity	**4**
	PSMB112	Quantitative Biology	**4**
	PSMB113	Biochemistry	**4**
	PSMB114	Cell Biology	**4**
	PSMB115	Practical Course: Microbial Systematics	**4**
	PSMB116	Practical Course: Cell biology and Biochemistry	**4**
	HR 1	Human Rights Awareness Course	**2**
	CYS I	Introduction to Cyber Security – I	**2**
		Total Credits	**28**
II	**PSMB121**	Virology	**4**
	PSMB122	Instrumentation	**4**
	PSMB123	Metabolism	**4**
	PSMB124	Evolution and Ecology	**4**
	PSMB125	Practical Course: Biophysics & Virology	**4**
	PSMB126	Practical Course: Enzymology & Microbial Metabolism	**4**
	CYS II	Introduction to Cyber Security – II	**2**
	CC40	**Research Methodology**	**2**
		Total Credits	**28**

Course Structure for M.Sc. - II: Microbiology

Semester	Paper Code	Title of Paper	No. of Credits
III	**PSMB231**	Immunology	**4**
	PSMB232	Molecular Biology I	**4**
	PSMB233	Industrial Waste Water Treatment	**4**
ELECTIVE	**PSMB234A**	Biophysical Techniques	**4**
	PSMB234B	Developmental Biology	**4**
	PSMB235	Practical Course: Practical course based on Immunology, Pharmaceutical Microbiology and Industrial waste water treatment	**4**
	PSMB236	Practical Course: Practical course based on Molecular Biology (I and II) and Microbial Technology	**4**
	SD 23	Skill Development I	**2**
		Total Credits	**26**
IV	**PSMB241**	Pharmaceutical Microbiology	**4**
	PSMB242	Molecular Biology II	**4**
	PSMB243	Microbial Technology	**4**
ELECTIVE	**PSMB244A**	Medical Microbiology	**4**
	PSMB244B	Mathematics for Biological Science	**4**
	PSMB245	Dissertation I	**4**
	PSMB246	Dissertation II	**4**
	SD 24	Skill Development II	**2**
		Total Credits	**26**

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- II)
Paper Code: **PSMB121**
Paper: I
Title of Paper: Virology
Credit: 4
No. of lectures: 60

Course Objectives:

1. Enhance students' understanding of fundamental chemistry in the context of microbiology.
2. Describe and review the components of the viral life cycle.
3. Explain vaccine strategies and the mechanisms of antiviral drugs.
4. Assist students in building a progressive and successful career.
5. Discuss and identify various viral detection methods.
6. Detail different cultivation methods of viruses.
7. Describe the mechanisms of action of antiviral and antiretroviral drugs.

Course Outcome:

CO1. The fundamental structures of viruses.
CO2. Gain insight into the principles of virus pathogenesis.
CO3. Acquire basic knowledge of virus cultivation and detection methods.
CO4. Develop a comprehensive understanding of bacteriophage therapy for controlling bacterial diseases.
CO5. Explore viral replication strategies and compare the mechanisms used by different viruses.
CO6. Comprehend various types of vaccines and antiviral agents.
CO7. Appreciate the diverse laboratory techniques and research approaches employed in the field of virology.

UNIT 1: Structure and Replication of viruses (15L)

- Enveloped and non-enveloped viruses
- Capsid symmetries – Icosahedral, Helical, Simple and Complex Capsid
- Structural components of virus – Protein – Envelope proteins (Glycoprotein), Matrix proteins and Lipoproteins, Genome – dsDNA, ssDNA, dsRNA, ssRNA (positive sense, negative sense and ambisense), linear, circular, segmented
- Virus related structures – Viroids and Prions

Replication of viruses

- Mechanism of virus attachment
- Entry into host cell
- Uncoating of viral genome
- Transcription stratergies for RNA genome & DNA genome
- Genome replication - RNA replication, DNA replication
- Reverse Transcription
- Post transcriptional processing

- Translation of viral proteins
- Protein nucleic acid interactions and genome packaging
- Assembly, exit and maturation of progeny virions

UNIT 2: Cultivation and Detection methods for viruses (15L)

Cultivation of viruses

- *In ovo*: using embryonated chicken eggs
- *In vivo*: using experimental animals
- *Ex vivo / In vitro:* using various cell cultures – primary and secondary cell lines, suspension cell cultures and monolayer cell culture

Diagnostic and detection methods for viruses:

- Direct methods of detection – Light microscopy (inclusion bodies), Electron microscopy and Fluorescence microscopy
- Immnuodiagnosis, Hemagglutination and Hemagglutination inhibition tests, Complement fixation, Neutralization, Western blot, Radioactive Immuno Precipitation Assay (RIPA), Flow Cytometry and Immunohistochemistry
- Nucleic acid based diagnosis: Nucleic acid hybridization, Polymerase Chain Reaction (PCR), Microarray and Nucleotide sequencing, LINE probe assay

Infectivity assay for animal and bacterial viruses

- Plaque method
- Pock counting
- End point methods, LD50, ID50, EID50, TCID50.

Infectivity assays of plant viruses.

UNIT 3: Bacteriophages (15L)

Bacteriophage ecology

Morphology, Genome organization and Life cycles of

- T phages (odd and even)
- Lambda phage
- M13 phage
- Phi X 174 phage

Bacteriophage therapy for control of any two bacterial diseases

UNIT 4: Viral Therapeutics (15L)

Vaccines:

- Conventional vaccines: Killed and attenuated
- Modern vaccines: Concepts and examples (DNA vaccines, Recombinant DNA, Recombinant protein vaccines, Subunit vaccines, Peptide vaccines, Anti-idiotype vaccines, Edible vaccines, mRNA vaccine, Vaccine formulations and delivery: Adjuvants, immunomodulators, cytokines)

Antiviral agents:

- Designing and screening
- Mechanism of action (e.g., Nucleoside analogues, Nucleotide analogues, Antisense, Topical immune modulator, neuraminidase inhibitors, Ion channel function inhibitors of M2 proteins, Pyrimidines)

Antiretroviral agents (any two):

- Mechanism of action
- Mechanism of resistance
- Modern approaches of virus control - Small interfering RNA (siRNA), Ribozymes

Text / Reference Books:

1. Cann A.J, (2005), Principles of Molecular Virology, 4th Ed. Elsevier Academic Press.
2. Dimmock N. J., Easton A. J. and K. N. Leppard, (2007), Introduction to Modern Virology, 6th Ed. Blackwell Publishing.
3. Edward K. Wagner, Martinez J. Hewlett, (2004), *Basic Virology*, Blackwell Publishing
4. Flint S. J., V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka, (2003),
5. *Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses*, American Society Microbiology.
6. Haaheim L. R., J. R. Pattison and R. J. Whitley, (2002), *A Practical Guide to Clinical Virology. 2nd Ed.* Edited by, John Wiley & Sons, Ltd.
7. Knipe David M., Peter M. Howley, Diane E. Griffin, Robert A. Lamb, Malcolm A. Martin, Bernard Roizman, Stephen E. Straus, (2007), *Field's Virology,* 5th Ed. Lippincott Williams & Wilkins
8. Luria S. E. et.al. (1978) *General virology*, 3rd Ed, New York. John Wiley and Sons.
9. Straus J. H. and Straus E.S. (1998) *Evolution of RNA Viruses* Ann. Rev. Microbiol. 42: 657 – 83
10. Mahy B. WJ. And Kangro H.O., (1996), Virology Methods Manual, Academic Press.
11. Shors T. (2011), Understanding Viruses, 2nd Ed., Jones & Bartlett Publishers LLC, Canada.
12. Stephenson J. R. and Warnes A., (1998), Diagnostic Virology Protocols: Methods in Molecular Medicine, Humana Press.
13. Wiedbrauk D. L. and Farkas D.H., (1995) Molecular Methods For Virus Detectin, Academic Press.
14. Calendar R. and Abedon S. T. (2006), The Bacteriophages, 2nd Ed. Oxford University Press.
15. Douglas John, (1975), *Bacteriophages*, Chapman and Hall, London.
16. Guttman Burton S. and Elizabeth M. Kutter, (2002), *Bacteriophage Genetics*,
17. Uldis N. Streips and Ronald E. Yasbin, Editors, Modern Microbial Genetics, 2nd Ed., Wiley- Liss Inc. 26 Colmon M. P. (2009) New New antivirals and drug resistance, Annual Review of Biochemistry, 78, 95 – 118.

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 Outcoms	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3				2				2
CO2		3			3			2	3
CO3		2		3	3	3			3
CO4	3	2		2		2		3	3
CO5	3	3							3
CO6	2	1		3	2	2		3	
CO7	3	3		3	3	3			3

Justification for the mapping

PO1: Disciplinary Knowledge

CO1:Attain fundamental knowledge of viruses.

CO4:Acquire knowledge regarding bacteriophage therapy for controlling bacterial diseases.

CO5:Understand strategies and mechanisms of virus replication.

CO6:Gain knowledge of different types of vaccines and antiviral agents.

CO7:Familiarize with various laboratory techniques and research approaches employed in the field of virology.

PO2: Critical Thinking and Problem Solving

CO2: Apply learned knowledge to understand virus pathogenesis.

CO3:Develop basic knowledge of virus cultivation and detection methods.

CO4:Obtain an overall understanding of bacteriophage therapy for controlling bacterial diseases.

CO5: Apply knowledge to compare replication mechanisms used by viruses.

CO6:Understand the mode of action of vaccines and antiviral agents.

CO7:Comprehend techniques and research approaches employed in the field of virology.

PO4: Research-related Skills and Scientific Temper

CO3:Understand basic knowledge of virus cultivation and detection methods.

CO4:Apply knowledge to use bacteriophage therapy for controlling bacterial diseases.

CO6:Apply and analyze the inference of the effects of different types of vaccines and antiviral agents.

CO7:Comprehend and appreciate major and varied laboratory techniques and research approaches employed in the field of virology.

PO5: Trans-disciplinary Knowledge

CO1:Grasp basic structures of viruses.

CO2: Be aware of different virus infections.

CO3:Understand basic knowledge of virus cultivation and detection methods.

CO6:Understand different types of vaccines and antiviral agents.

CO7:Explore and apply knowledge in the field of virology.

PO6: Personal and Professional Competence

CO3: Understand virus cultivation.

CO4:Utilize bacteriophage therapy for controlling bacterial diseases.

CO6:Understand different types of vaccines and antiviral agents.

CO7:Comprehend and appreciate diverse laboratory techniques and research approaches employed in the field of virology.

PO8: Environment and Sustainability

CO2: Be aware of virus pathogenesis.

CO4: Gain an overall understanding of bacteriophage therapy for controlling bacterial diseases.

CO6: Be aware of the action of vaccines and antiviral agents.

PO9: Self-directed and Life-long Learning

Attain comprehensive knowledge related to the virology subject.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- II)
Paper Code: **PSMB122**
Paper: II
Title of Paper: Instrumentation
Credit: 4
No. of lectures: 60

Course Objectives:

1. To define and comprehend fundamental instrumentation concepts, encompassing sensors, transducers, actuators, and signal conditioning.
2. To identify and elucidate the functions of diverse instrumentation components, including amplifiers, filters, and signal processors.
3. To comprehend, analyze, and formulate measurement systems for different physical parameters, taking into account accuracy, precision, and reliability.
4. To acquire practical experience through laboratory exercises, projects, or case studies involving the application and implementation of instrumentation.
5. To explore various sensor technologies and their applications, ranging from temperature sensors and pressure sensors to displacement sensors.
6. To enhance knowledge regarding the calibration of instruments and the assessment of their accuracy, precision, and reliability.
7. To investigate the utilization of instrumentation across diverse industries, such as manufacturing, healthcare, and environmental monitoring.
8. To develop expertise in troubleshooting instrumentation systems and performing routine maintenance to ensure optimal functionality.
9. To cultivate project management skills, encompassing planning, execution, and documentation, within the context of instrumentation projects.

Course Outcome:

CO1. Gain a foundational grasp of instrumentation principles, encompassing sensors, transducers, signal conditioning, and measurement techniques.
CO2. Acquire knowledge about diverse measurement devices utilized in instrumentation, including pressure gauges, temperature sensors, flow meters, and level detectors.
CO3. Develop the proficiency to engineer instrumentation systems tailored to specific applications, taking into account factors like accuracy, precision, and reliability.
CO4. Acquire practical, hands-on experience with instrumentation devices and systems through participation in laboratory exercises, projects, or internships.
CO5. Comprehend the role of instrumentation in control systems and grasp the intricacies of feedback control mechanisms.
CO6. Attain knowledge of safety standards and regulations pertinent to instrumentation, ensuring adherence to industry and safety guidelines.
CO7. Cultivate skills in troubleshooting instrumentation systems and performing routine maintenance to uphold optimal performance.

UNIT 1: Chromatography (15L)

Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms

Principle, components of instrument, operation and application of:

- Gel filtration chromatography
- Ion-exchange Chromatography
- Affinity chromatography
- Gas chromatography
- High Performance Liquid Chromatography

UNIT 2 Spectroscopy (15L)

Electromagnetic spectrum, atomic orbitals, Molecular orbitals, Electronic, Rotational and Vibrational transitions in spectroscopy, Interpretation of spectra.

- UV/Visible spectroscopy- Instrumentation, Molar Absorptivities, Beer and Lamberts Law.
- Fluorescence spectroscopy- Instrumentation, Quantum Yield, Quenching, FRET, Binding and Folding studies
- Infrared spectroscopy- Principle, Instrumentation, Absorption bands, FTIR and its advantages
- Atomic spectroscopy - Principle, Instrumentation and its application

UNIT 3: Electrophoresis and Centrifugation (15L)

- Electrophoresis – AGE, NATIVE PAGE, SDS-PAGE, Isoelectric focusing.
- Ultra-centrifugation, Differential centrifugation, Isopycnic and Rate zonal centrifugation

UNIT 4: Industrial Biosafety and Environment Regulation (15L)

- Laminar air flow
- Biosafety cabinet
- HVAC system

Text / Reference Books:

1. Clive Dennison (2002) *A guide to protein isolation*, Kluwer Academic Publishers
2. Pattabhi, V. and Gautham, N. (2002) *Biophysics.* Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
3. David J Holme, Hazel Peck (1998) *Analytical Biochemistry*, 3rd ed., Prentice Hall Pearson Education Limited, Harlow England.
4. Rodney F. Boyer (2000*) Modern Experimental Biochemistry* 3d edition., Benjamin Cummings.
5. Nölting, B. (2006) *Methods in modern biophysics.* Second Edition. Springer, Germany.
6. Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology*, 6th Ed. Cambridge University Press, New York.
7. Rolf Ekman, Jerzy Silberring, Ann Westman- Brinkmalm, Agnieszka Kraj (2009) *Mass spectrometry: instrumentation, interpretation, and applications*, John Wiley & Sons, Inc.,Canada.
8. Irwin H. Segel (1976) *Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry,* 2nd Edition. John Wiley & Sons.

9. Harvey Lodish, Arnold Berk, S. Lawrence Zipursky, Paul Matsudaira, David Baltimore, And James Darnell (2000) Molecular Cell Biology, 4th edition, W. H. Freeman & co., New York.

Mapping of Program Outcomes with Course Outcomes

Weightage: 1=weakorlowrelation,2=moderateorpartialrelation,3=strongordirectrelation

	Programme Outcomes(POs)								
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	1						
CO2	2	3	2		2				
CO3	1	2	3		2				
CO4			2	3	2	3	2		
CO5		1	1	2	3		2		
CO6				2		3	2		
CO7								3	

Justification for the mapping

PO1:DisciplinaryKnowledge

CO1: Students will understand the basic principles of instrumentation, including sensors, transducers, signal conditioning, and measurement techniques.

CO2: Students will develop a deep understanding ofvarious measurement devices used in instrumentation, such as pressure gauges, temperature sensors, flow meters, and level detectors.

CO3: Students will master and developing the ability to design instrumentation systems for specific applications, considering factors such as accuracy, precision, and reliability.

PO2: Critical Thinking and Problem Solving

CO1: Students will apply their knowledge of instrumentation, including sensors, transducers, signal conditioning, and measurement techniques.

CO2: Students will use their understanding of various measurement devices used in instrumentation, such as pressure gauges, temperature sensors, flow meters, and level detectors.

CO3: Students will apply their knowledge of interpreting ability to design instrumentation systems

CO5: Students will explore the role of instrumentation in control systems and learn about feedback control mechanisms.

PO3: Social competence

CO1: Students will explore to the knowledge of instrumentation in control systems and learn about feedback control mechanisms.

CO2: Students will learn about various measurement devices used in instrumentation, such as pressure gauges, temperature sensors, flow meters, and level detectors.

CO3: Students will gain knowledge to design instrumentation systems for specific applications, considering factors such as accuracy, precision, and reliability.

CO4: Students will develop competence in various practical skills.

CO5: Students will explore the role of instrumentation in control systems and learn about

feedback control mechanisms.

PO4: Research-related skills and Scientific temper

CO4: Students will apply their knowledge of instrumentation devices and systems through laboratory exercises, projects, or internships.
CO5: Students will able to applythe role of instrumentation in control systems and learn about feedback control mechanisms.
CO6: Students will be able to comprehendknowledge of safety standards and regulations related to instrumentation, ensuring that instrumentation systems comply with industry and safety guidelines.

PO5: Trans-disciplinary Knowledge

CO2: Students will apply knowledge of instrumentation, such as pressure gauges, temperature sensors, flow meters, and level detectors.
CO3: Students will understandthe ability to interpret to design instrumentation systems for specific applications.
CO4: Students will apply their knowledge of instrumentation devices and systems through laboratory exercises, projects, or internships.
CO6:Students will put into practicein safety standards and regulations related to instrumentation, ensuring that instrumentation systems comply with industry and safety guidelines.

PO6: Personal and Professional Competence

CO4:Students will demonstrate their expertiseininstrumentation devices and systems through laboratory exercises, projects, or internships.
CO6: Students will showcase their proficiency in interpretingknowledge of safety standards and regulations related to instrumentation, ensuring that instrumentation systems comply with industry and safety guidelines.

PO7:Self-directed and Life-long Learning

CO4: Students will acquire the skill of instrumentation devices and systems
CO5: Students will develop the ability to applythe role of instrumentation in control systems and learn about feedback control mechanisms.
CO6: Students will acquire the skill of learningsafety standards and regulations related to instrumentation, ensuring that instrumentation systems comply with industry and safety guidelines.

PO8: Environment and sustainability

CO7:Students will cultivate skills in troubleshooting instrumentation systems and performing routine maintenance to uphold optimal performance.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- II)
Paper Code: **PSMB123**
Paper: III
Title of Paper: Metabolism
Credit: 4
No. of lectures: 60

Course Objectives

1. Student will able to understand the Basics of Metabolism:
2. Student will able to Understand the function of enzymes in metabolic pathways.
3. Student will able to Explain enzyme kinetics and regulation.
4. Describe the process of photosynthesis and its significance in energy capture.
5. Understand the light-dependent and light-independent reactions.
6. Describe the role of ATP synthase in oxidative phosphorylation and ATP production.
7. Discuss the role of oxygen as the final electron acceptor in aerobic respiration.

Course Outcomes

CO1. Students should demonstrate a thorough understanding of major metabolic pathways, including glycolysis, the citric acid cycle, oxidative phosphorylation, photosynthesis, and various biosynthetic pathways.
CO2. Students should be able to explain the principles of enzyme kinetics and describe how enzymes are regulated in metabolic pathways.
CO3. Understand how cells generate and transfer energy through ATP synthesis and utilization.
CO4. Demonstrate the ability to integrate different metabolic processes and understand how they are interconnected within the cell.
CO5. Gain practical skills in using biochemical techniques to study metabolic processes in the laboratory.
CO6. Apply knowledge of metabolism to real-world scenarios, demonstrating the ability to relate theoretical concepts to practical situations.

UNIT 1: Photosynthesis (15L)

- Structure of chloroplast
- electron carriers in photosynthesis
- photolysis of water
- light and dark reaction
- Hill reaction
- C3
- C4
- CAM plants
- energy consideration in photosynthesis
- Photorespiration
- Regulation of photosynthesis
- Comparison of Bacterial and plant photosynthesis

UNIT 2: Nitrogen metabolism (15L)

- Biochemistry of biological nitrogen fixation
- Properties of nitrogenase and its regulation
- Ammonia assimilation with respect to glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation
- Biosynthesis of five families of amino acids and histidine

UNIT 3: Anaerobic respiration (15L)

- Concept of anaerobic respiration
- Concept of Assimilation and Dissimilative metabolism
- Components of electron transfer system and energy generation of bacteria where nitrate, sulfate and CO_2 act as terminal electron acceptors
- Mechanism of oxygen toxicity.

UNIT 4: Enzyme Kinetics (15L)

- Importance of enzyme kinetics
- King Altman approach to derive – two substrate enzyme catalyzed reactions
- Types of two substrate enzyme catalyzed reactions
- Concept of allosterism, positive and negative co-operativity
- Models of allosteric enzymes (Monod, Wyamann and Changuax model, Koshland, Nemethy and Filmer model)
- kinetics of allosteric enzyme
- Hill plot
- Examples of allosteric enzymes and their significance in allosteric regulation

Text / Reference Books:

1. Nelson D. L. and Cox M. M. (2005) *Lehninger's Principles of Biochemistry*, Fourth edition, W. H. Freeman & Co. New York
2. Hall D. D. and Rao K. K. (1996) *Photosynthesis* 5th Ed.,Cambridge University Press
3. Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark (2012) *Brock Biology of Microorganisms*, Thirteenth edition, Benjamin Cummings, San Francisco.
4. White David (2000) *Physiology and Biochemistry of Prokaryotes.* 2nd Ed. Oxford University Press, New York.
5. Mandelstam Joel and McQuillen Kenneth (1976) *Biochemistry of Bacterial Growth*, Blackwell Scientific Publication London.
6. Moat Albert G. and Foster John W. (1988) *Microbial Physiology* 2nd Ed. John Wiley and Sons New York.
7. Palmer Trevor (2001) *Enzymes: Biochemistry, Biotechnology and Clinical chemistry*, Horwood Pub. Co. Chinchester, England.
8. Segel Irvin H. (1997) *Biochemical Calculations* 2nd Ed., John Wiley and Sons, New York.

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	2						2		2	
CO 3	2								2	
CO 4	2	2			2				2	
CO 5	2			3				3	2	
CO 6	2	6	2		2	2	2		2	

Justification for the mapping

PO1.Disciplinary Knowledge:

CO1: Demonstrating a thorough understanding of major metabolic pathways aligns with disciplinary knowledge. Students are acquiring specialized knowledge in biochemistry and cellular metabolism, which is fundamental to the discipline.

CO2: Explaining the principles of enzyme kinetics and describing enzyme regulation in metabolic pathways contributes to disciplinary knowledge by focusing on the specific mechanisms and intricacies of biochemical processes.

CO3: Understanding how cells generate and transfer energy through ATP synthesis and utilization reinforces disciplinary knowledge in cellular bioenergetics.

CO4: Integrating different metabolic processes and understanding their interconnections within the cell emphasizes a comprehensive grasp of the discipline, showcasing the complexity and interrelatedness of metabolic pathways.

CO5: Gaining practical skills in using biochemical techniques to study metabolic processes in the laboratory enhances disciplinary knowledge through hands-on experience and application of theoretical concepts.

CO6: Applying knowledge of metabolism to real-world scenarios demonstrates the practical relevance of disciplinary knowledge, showcasing its applicability in professional settings.

PO2.Critical Thinking and Problem Solving:

CO4: The ability to integrate different metabolic processes requires critical thinking skills to analyze complex interactions and solve problems related to cellular metabolism.

CO6: Applying knowledge of metabolism to real-world scenarios involves critical thinking to bridge theoretical concepts with practical situations**.**

PO3. Social Competence:

CO6: Applying knowledge of metabolism to real-world scenarios may involve understanding societal implications of metabolic processes, fostering social competence.

PO4. Research-related Skill:

CO5: Gaining practical skills in using biochemical techniques to study metabolic processes in the laboratory aligns with research-related skills, as it involves hands-on experimentation and data collection.

PO5.Transdisciplinary Knowledge:

CO4: Demonstrating the ability to integrate different metabolic processes emphasizes transdisciplinary knowledge, as it involves understanding connections between different biological processes.

CO6: Applying knowledge of metabolism to real-world scenarios involves integrating biochemical knowledge with broader contexts, showcasing transdisciplinary thinking**.**

PO6.Personal and Professional Competence:

CO6: Applying knowledge of metabolism to real-world scenarios not only demonstrates academic competence but also showcases the ability to apply this knowledge in a professional context, contributing to personal and professional competence**.**

PO7.Effective Citizenship and Ethics:

CO2: Describing how enzymes are regulated in metabolic pathways may involve discussing ethical considerations in manipulating biochemical processes, promoting effective citizenship and ethical awareness.

CO6: Applying knowledge of metabolism to real-world scenarios may also involve considering ethical implications, emphasizing the importance of effective citizenship and ethical decision-making.

PO8.Environment and Sustainability:

CO5: Gaining practical skills in using biochemical techniques may involve considering environmental aspects, such as sustainable lab practices, promoting awareness of environmental responsibility.

PO9. Self-directed and Lifelong Learning:

All COs: Inherent in the entire course outcomes is the promotion of self-directed and lifelong learning, as students are acquiring foundational knowledge and skills that are essential for continuous learning and adaptation in the field of biochemistry and related disciplines.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- II)

Paper Code: **PSMB124**

Paper: IV

Title of Paper: Evolution and Ecology

Credit: 4

No. of lectures: 60

Course Objectives:

1. To gain an understanding of complex processes in population and community ecology
2. To familiarized students with the interactions between the organisms and their physical environment
3. To understand population growth and dynamics and its regulation
4. To develop a scientific understanding of the diverse aspects of the field of evolution and ecology
5. To introduce various attributes of populations and communities with help of theoretical concepts and field examples
6. Recognise and justify the importance of ecological interactions in shaping the structure of ecological communities
7. Provides a platform to students to understand the varied forces that lead to variations among populations of a species.

Course Outcome:

CO1. Students will be equipped to understand the evolutionary background and its importance.

CO2. Demonstrate an understanding of the basic concepts of evolution and ecology.

CO3. Students will acquire a theoretical understanding of population and community ecology to apply in the current issues in ecology.

CO4. Students will be able to understand evolutionary concepts and theories.

CO5. Students will acquire knowledge about the evolutionary history of earth - living and nonliving.

CO6. Students will be able to explain the characteristics, dynamics, and growth of population.

CO7. Students will be able to gain knowledge about the relationship of the evolution of various species and the environment they live in.

UNIT 1: Evolution (15L)

- History and development of evolutionary theories.
  Inheritance of acquired characters (Lamarkism)
  Theory of Natural Selection. (Darwinism)
  Neo-Darwinism
- Evidences of evolution
- Pattern of Evolution
- Spontaneous mutation controversy, evolution of rates of mutation.
- Neutral evolution and molecular clocks,
- phylogeny and molecular distances
- Co-evolution. co-evolution of prey-predator interactions – Red Queen hypothesis

- Molecular evolution
- evolutionary stability of cooperation, sociality and multicellularity in microorganisms

UNIT 2: Species and speciation (15L)

- Concept of species and speciation
- Types of species
- Types of interactions,
  interspecific competition, herbivory, carnivory,pollination, symbiosis.
  Intra-specific competition: Competition exclusion principle and Hutchinson's rule.
- Types of speciation
- Speciation in sexual and asexual organisms
- Genetic drift: theory of genetic drift, Founder Effect and Bottleneck phenomenon
- Game Theory

UNIT 3: Ecology and Ecosystem (15L)

Concept of habitat and niche; Niche width and Niche overlap; Fundamental and Realized niche; Resource partitioning; Character displacement.

The Ecosystem

- Concept of ecosystem
- Trophic structure of ecosystem
- Types of ecosystems
- Ecosystem function
- Energy flow in Ecosystem
- Control in Ecosystem Function: Bottom up and Top-down control
- Ecological pyramids
- Ecological succession: Types; mechanisms; changes involved in succession; concept ofclimax.

UNIT 4: Population Ecology and Community Ecology (15L)

- Introduction to population ecology,
- Characteristic of Population
- Types and levels of selection; R and K selection.
- Population genetics, Hardy Weinberg's law
- Population growth curves: exponential and logistic
- Community Ecology:
  Nature of communities; community structure and attributes; levels of species diversity and its measurement; Edges and ecotones

Text / Reference Books:

1. Anders Gorm Pedersen, Molecular Evolution: Lecture Notes,February 2005.
2. Lindell Bromham and David Penny (2003). The Modern MolecularClock.www.nature.com/reviews/genetics. MARCH 2003 | VOLUME 4, **Page. 216.** Nature Publishing Group.
3. Lively Curtis, M. (1996). Host-parasite coevolution and sex. Bioscience **46**, 2, 107.
4. Leo C. Vining (1992). Roles of secondary metabolites from microbes.Edited by Derek J.Chadwick, Julie. Whelm Copyright.

5. Macan, T. T. (1974). Freshwater Ecology. Longman Group Ltd., London,
6. Meadows, P. S. and J. I. Campbell. (1978). An introduction to Marine Science. Blackie &Son Ltd., Glasgow.
7. Richards, B.N. (1987). Microbiology of Terrestrial Ecosystems. Longman Scientific &Technical, New York.

Mapping of course outcomes and programme outcomes:

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

	Programme Outcomes (POs)								
Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3		3	3		3	2		
CO2	3	3						3	3
CO3	3	2	2				3		
CO4	3				2	2			
CO5	3								
CO6	3	2		3					
CO7	3				3			2	2

Justification for the mapping

PO1 **Disciplinary Knowledge:**

CO1: It focuses on the foundational understanding of evolutionary processes and their significance in biological sciences.

CO2: Demonstrating understanding of basic concepts in evolution and ecology adds to disciplinary knowledge, forming the foundational knowledge base in these disciplines

CO3: Acquiring a theoretical understanding of population and community ecology prepare students to address current ecological issues.

CO4: Understanding evolutionary concepts and theories directly contributes to disciplinary knowledge in the field of evolutionary biology..

CO5: Gaining knowledge about the evolutionary history of Earth, encompassing both living and nonliving components, adds to disciplinary knowledge in Earth and environmental sciences.

CO6: Explaining the characteristics, dynamics, and growth of populations contributes to disciplinary knowledge in population ecology and biology..

CO7: Gaining knowledge about the relationship between the evolution of species and their environment contributes in the field of evolutionary ecology.

PO2 **Critical Thinking and Problem Solving:**

CO2: Demonstrating understanding requires critical thinking to analyze and apply foundational concepts in evolution and ecology to various scenarios..

CO3: Applying theoretical understanding to current ecological issues necessitates critical thinking and problem-solving skills.

CO6: Explaining population characteristics, dynamics, and growth requires critical thinking to analyze data, identify patterns, and solve problems related to population ecology.

PO3 **Social competence:**

CO1: Understanding the evolutionary background can foster social competence by enabling students to engage in informed discussions about the broader implications of evolution in societal and environmental contexts

CO3: Applying ecological knowledge to current issues requires social competence to communicate effectively and collaborate with others in addressing complex ecological challenges

PO4 **Research-related skills and Scientific temper:**

CO3: Acquiring a theoretical understanding of ecology involves developing research-related skills and a scientific temper to apply ecological concepts to real-world issues.

CO6: Explaining population characteristics and dynamics requires the application of research-related skills, such as data analysis and interpretation, and a scientific temper in approaching population ecology with inquiry..

PO5 **Trans-disciplinary knowledge:**

CO4: Understanding evolutionary concepts requires integrating knowledge from biology, paleontology, and possibly anthropology, contributing to trans-disciplinary connections.

CO7: Gaining knowledge about the relationship between evolution and the environment integrates concepts from biology, ecology, and environmental science, contributing to a trans-disciplinary understanding

PO6 **Personal and professional competence:**

CO1: Understanding the evolutionary background contributes to personal and professional competence in students by providing a foundational knowledge base relevant to biological sciences.

CO4: Understanding evolutionary concepts and theories enhances personal and professional competence by providing a framework for comprehending the diversity and adaptation of life

PO7 **Effective Citizenship and Ethics:**

CO1: Understanding the evolutionary background contributes to effective citizenship by providing a scientific foundation for informed decision-making and ethical considerations related to biodiversity and conservation.

CO3: Acquiring a theoretical understanding of ecology prepares students to apply this knowledge to current ecological issues responsibly, aligning with ethical considerations in environmental stewardship

PO8 **Environment and Sustainability:**

CO2: Demonstrating understanding in evolution and ecology contributes to environmental and sustainability awareness by highlighting the role of ecosystems and biodiversity in maintaining ecological balance.

CO7: Gaining knowledge about the relationship between evolution and the environment contributes to sustainability efforts by promoting responsible stewardship of ecosystems and biodiversity.

PO9 **Self-directed and Life-long learning:**

CO3: Acquiring a theoretical understanding of ecology prepares students for ongoing learning, encouraging them to stay updated on current ecological issues and advancements in the field..

CO7: knowledge about the relationship between evolution and the environment inspires lifelong learning as it prompts students to explore the dynamic interactions between species and their environments continually.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- II)
Paper Code: **PSMB125**
Paper: V
Title of Paper: Practical Course: Biophysics & Virology
Credit: 4
No. of lectures: 60

Course Objectives:

1. To study life cycle of virus on particular host.
2. To study qualitative and quantitative determination of bacteriophage
3. To study animal virus titration by Hemagglutination inhibition test
4. To learn the technique of chromatographic separation of a mixture biomolecule
5. To study the Biological synthesis of nanoparticles and their characterization in laboratory level
6. To study Calibration of analytical instruments
7. To study the process of gel filtration chromatography

Course Outcome:

CO1. Students will apply their knowledge regarding to cultivation of viruses in laboratory
CO2. Students will understand different virus titration technique in laboratory
CO3. Students will get master's in Calibration of analytical instruments- colorimeter, spectrophotometer
CO4. Student will know the Biological synthesis of nanoparticles and their characterization in laboratory level
CO5. Student will get basic knowledge regarding to Agarose gel electrophoresis
CO6. Student will understand protein electrophoresis by Native PAGE and SDS PAGE
CO7. Students will get over all knowledge of gel filtration chromatography

UNIT 1: Virology (15L)

- Qualitative and quantitative detection of bacteriophage
- Animal virus titration by Hemagglutination inhibition test
- To study the One step growth curve of Bacteriophage.
- Demonstration of Egg inoculation technique for virus cultivation by various routes.

UNIT 2: Biophysics (15L)

- Biological synthesis of nanoparticles (actinomycetes /fungi /yeast) and their characterization by UV-Visible spectroscopy.
- Calibration of analytical instruments – Colorimeter and Spectrophotometer by estimation of biomolecules and Statistical analysis of data generated.
- Determination of molar extinction coefficient of biological molecule.

UNIT 3 and 4: Separation of Biomolecules (30L)

- To determine the ion-exchange capacity and nature of given resin using anion exchange
- chromatography.

- Protein electrophoresis by Native PAGE
- Protein electrophoresis by SDS PAGE
- Agarose Gel Electrophoresis
- Gel filtration chromatography

Text / Reference Books:

1. Nelson D. L. and Cox M. M. (2005) *Lehninger's Principles of Biochemistry*, Fourth edition, W. H. Freeman & Co. New York
2. Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology*, 6th Ed. Cambridge University Press, New York.
3. Palmer Trevor (2001) *Enzymes: Biochemistry, Biotechnology and Clinical chemistry*, Horwood Pub. Co. Chinchester, England.
4. Segel Irvin H. (1997) *Biochemical Calculations* 2nd Ed., John Wiley and Sons, New York

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 Outcoms	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3		2	2	2		3	2
CO2					3	2			3
CO3		2		3	3	3			3
CO4	3	2				2			3
CO5	3					1			3
CO6	2				2	2			
CO7	3	3		3	3	3			3

Justification for the mapping

PO1: Disciplinary Knowledge

CO1andCO2: Student get basic knowledge of viruses cultivation and its titration technique in laboratory

CO3: Acquired knowledge regarding Calibration of analytical instruments- colorimeter, spectrophotometer

CO4: Students get knowledge of biological nanoparticles synthesis in laboratory.

CO5CO6andCO7: Student get knowledge about agarose gel electrophoresis Native PAGE and SDS PAGE gel filtration chromatography

PO2: Critical Thinking and Problem Solving

CO1: Students will apply learned knowledge to cultivation of virus in laboratory

CO3: Students will get master's in Calibration of analytical instruments- colorimeter, spectrophotometer

CO4: Overall understanding about nanoparticles

CO7: To comprehend techniques and research approaches employed in the field of Biophysics and virology

PO4: Research related skill and Scientific temper.
CO1: Students acquired knowledge of virus cultivation in laboratory
CO3: Students will get master's in Calibration of analytical instruments- colorimeter, spectrophotometer
CO7: To comprehend and appreciate the major and varied laboratory techniques and research. approaches employed in the field of Biophysics and virology

PO5: Trans-disciplinary Knowledge
CO1: Understand basic structures of viruses
CO2: Student will aware about different virus infections.
CO3: Understand basic knowledge of virus cultivation and detection methods
CO6: Understand different types of vaccines and antiviral agents
CO7: Students explore and employed the knowledge in the field of virology

PO6: Personal and Professional Competence
CO1andCO2: Student get basic knowledge of viruses cultivation and its titration technique in laboratory
CO3: Acquired knowledge regarding Calibration of analytical instruments- colorimeter, spectrophotometer
CO4: Students get knowledge of biological nanoparticles synthesis in laboratory.
CO5CO6andCO7: Student get knowledge about agarose gel electrophoresis Native PAGE and SDS PAGE and Gel filtration chromatography

PO8: Environment and Sustainability
CO1: Student will aware about virus pathogenesis

PO9: Self-directedandLife-longLearning
Students will understand over all practical knowledge related to Biophysics and virology subject

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- II)

Paper Code: **PSMB126**

Paper: VI

Title of Paper: Practical Course: Enzymology & Microbial Metabolism

Credit: 4

No. of lectures: 60

Course Objectives:

1. Interpret enzyme kinetic data and calculate kinetic parameters.
2. Students should be able to explain the principles of enzyme kinetics
3. Understand the biosynthesis of siderophores and their role in microbial iron acquisition.
4. Develop practical skills in conducting immunological experiments.

Course Outcome

CO1. Demonstrate knowledge of enzyme kinetics, including concepts such as Michaelis-Menten kinetics and enzyme inhibition.
CO2. Calculate and interpret kinetic parameters like Vmax, Km, and Kcat.
CO3. Understand the implications of enzyme research in fields like medicine, biochemistry, and biotechnology.
CO4. Develop critical thinking skills to analyze experimental data related to enzyme activity.
CO5. Learn and apply laboratory techniques for the quantitative and qualitative detection of IAA.
CO6. Explore the diversity of siderophores produced by different microorganisms.

UNIT 1: Purification and kinetics of enzyme (15L)

- Purification of extracellular enzyme (amylase from natural sample) by ammonium sulfate precipitation, and Dialysis.
- Construction of enzyme purification chart
- Determination of Km and Vmax values of any hydrolytic enzyme

UNIT 2: Plant Growth Promoting Rhizobacteria (15L)

- Enrichment, Isolation and characterization of (as nitrogen fixers) *Azospirillum*
- Detection of IAA produced by *Azospirillum*
- Detection of siderophore produced by *Azospirillum* or *Pseudomonas* (PGPR)
- Isolation and characterization of phosphate solublizing bacteria from rhizosphere soil

UNIT 3: Isolation and Characterization of Enzymatic degraders from soil (15L)

- Isolation and characterization of chitin degrading microbe
- Isolation and characterization of cellulose degrading microbe
- Isolation and characterization of pesticide degrading microbe

UNIT 4: Isolation and Characterization of Mycotoxin producing organism (15L)

- Isolation of Aflatoxin producing organism
- Identification of Aflatoxin producing organism

- Extraction of Aflatoxin from food /culture
- Detection of Aflatoxin in food /culture

Text / Reference Books:

1. Nelson D. L. and Cox M. M. (2005) *Lehninger's Principles of Biochemistry*, Fourth edition, W. H. Freeman & Co. New York
2. Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology*, 6th Ed. Cambridge University Press, New York.
3. Palmer Trevor (2001) *Enzymes: Biochemistry, Biotechnology and Clinical chemistry*, Horwood Pub. Co. Chinchester, England.
4. Segel Irvin H. (1997) *Biochemical Calculations* 2nd Ed., John Wiley and Sons, New York

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	3					1				
CO 2	2					2				
CO 3			3		3		2			
CO 4		2		3						
CO 5									5	
CO 6	2									

Justification for the mapping

PO1.Disciplinary Knowledge:

CO1, CO2,CO6: Justification: These outcomes align with disciplinary knowledge as they focus on understanding fundamental concepts and techniques within biochemistry, specifically enzyme kinetics and the diversity of siderophores. Students will gain in-depth knowledge in these areas, establishing a strong foundation in their field.

PO2.Critical Thinking and Problem Solving:

CO4: Justification: Analyzing experimental data requires critical thinking skills. Students will need to assess and interpret results, identify patterns, and draw conclusions, contributing to their critical thinking and problem-solving abilities.

PO3.Social Competence:

CO3:.Justification: This outcome connects enzyme research to broader societal contexts, emphasizing the social relevance of biochemistry in fields such as medicine and biotechnology. Understanding these implications fosters social competence.

PO4.Research-Related Skills:

CO4: Develop critical thinking skills to analyze experimental data related to enzyme activity.

Justification: Analyzing experimental data is a fundamental aspect of research-related skills. Students will learn to assess the validity of data, draw conclusions, and contribute to the research process.

PO5.Transdisciplinary Knowledge:
CO3: Understand the implications of enzyme research in fields like medicine, biochemistry, and biotechnology.Justification: The implications of enzyme research extend beyond the boundaries of biochemistry, reaching into medicine and biotechnology. This outcome reflects the transdisciplinary nature of knowledge in these fields.

PO6.Personal and Professional Competence:
CO1: Demonstrate knowledge of enzyme kinetics, including concepts such as Michaelis-Menten kinetics and enzyme inhibition.
CO2: Calculate and interpret kinetic parameters like Vmax, Km, and Kcat.
Justification: Mastering enzyme kinetics and related calculations enhances personal and professional competence, as these are foundational skills essential for success in biochemistry and related professions.

PO7.Effective Citizenship and Ethics:
CO3: Understand the implications of enzyme research in fields like medicine, biochemistry, and biotechnology.Justification: Considering the broader implications of enzyme research in medicine and biotechnology encourages an understanding of ethical considerations. This outcome contributes to effective citizenship by fostering awareness of the ethical dimensions of scientific research.

PO8.Environment and Sustainability:
(No direct alignment in the provided outcomes)
Justification: The provided outcomes do not explicitly address environmental or sustainability aspects. However, if the curriculum includes discussions on sustainable practices in biotechnology or the environmental impact of enzyme-related processes, it could contribute to this category.

PO9.Self-Directed and Lifelong Learning:
CO5: Learn and apply laboratory techniques for the quantitative and qualitative detection of IAA.Justification: Learning and applying laboratory techniques contribute to self-directed and lifelong learning. Students acquire skills that can be applied independently, fostering a mindset of continuous learning and adaptation.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- II)

Paper Code: CC40

Title of Paper: **Certificate Course in Research Methodology**

Credit: 2

No. of lectures: 30

Course objective:

1. Understand the fundamental philosophical principles and paradigms that underlie various research methodologies.
2. Acquire familiarity with a range of research publication types, understanding their structures and content.
3. Cultivate proficiency in utilizing online referencing tools to create citations and bibliographies effectively.
4. Understand the concept of plagiarism and adopt strategies to prevent it in academic and research writing.
5. Acquire an introductory understanding of statistical software, with a specific emphasis on R software.
6. Understand the principles and techniques involved in constructing titles and crafting brief yet informative abstracts for research papers or proposed projects.
7. Develop skills in composing various sections of a research paper, including materials and methods, results, discussion, conclusion, etc., adhering to academic writing conventions.
8. Cultivate the ability to create comprehensive and well-structured research proposals outlining research methodology, objectives, and expected outcomes.
9. Achieve proficiency in composing and structuring project reports by integrating research findings, analysis, and conclusions effectively.

Course outcome:

CO1. Students will demonstrate comprehension of the fundamental philosophical principles and paradigms that form the basis of diverse research methodologies.

CO2. Students will demonstrate the capacity to distinguish and classify different research publication types, understanding their structures and content.

CO3. Students will cultivate proficiency in employing online referencing tools to accurately generate citations and bibliographies.

CO4. Students will comprehend plagiarism concepts and implement strategies to prevent its occurrence in academic and research writing.

CO5. Students will gain introductory knowledge of statistical software, specifically emphasizing R software.

CO6. Students will develop skills in constructing compelling titles and creating concise yet informative abstracts for research papers or proposed projects.

CO7. Students will exhibit proficiency in composing various sections of a research paper, encompassing materials and methods, results, discussion, conclusion, etc., adhering to academic writing conventions.

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					2		
CO 5					1				
CO 6		2							
CO 7				2					

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Strong (3) relation - Students acquiring comprehension of fundamental philosophical principles forming the basis of research methodologies directly contributes to disciplinary knowledge.

CO2: Moderate (2) relation - Understanding different types of research publications partially aligns with disciplinary knowledge.

PO2: Critical Thinking and Problem Solving

CO4: Strong (3) relation - Comprehending plagiarism concepts and implementing strategies directly aligns with critical thinking.

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

PO4: Research-related Skills and Scientific Temper

CO3: Moderate (2) relation - Proficiency in using online referencing tools partially contributes to research-related skills.

CO7: Moderate (2) relation - Proficiency in composing various sections of a research paper partially aligns with research-related skills.

PO5: Trans-disciplinary Knowledge
CO5: Weak (1) relation - The introductory knowledge of statistical software has minimal trans-disciplinary alignment.

PO7: Effective Citizenship and Ethics
CO4: Moderate (2) relation - Understanding and preventing plagiarism aligns partially with ethical conduct in research.

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