Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Structure and Curriculum of Two-Year Degree Programme

Postgraduate Programme of Science and Technology

M.Sc. in Microbiology

Board of Studies in

Microbiology

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

[PG I Year]

w.e.f. June, 2026

(In Accordance with NEP-2020)

Review Statement

The NEP CELL reviewed the Curriculum of **M.Sc. in Microbiology** Programme to be effective from the **Academic Year 2026-27.** It was found that, the structure is as per the NEP-2020 guidelines of Govt. of Maharashtra.

Date: 13/04/2026

Place: Latur

NEP CELL

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

CERTIFICATE

I hereby certify that the documents attached are the Bonafide copies of the Curriculum of **M.Sc. (Honors/Research) in Microbiology** to be effective from the **Academic Year 2026-27.**

Date: 13/04/2026

Place: Latur

(Asso. Prof S. N. Shinde)
Chairperson
Board of Studies in Microbiology
Rajarshi Shahu Mahavidyalaya, Latur
Empowered Autonomous Institution

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Members of Board of Studies in Microbiology

Under the Faculty of Science

Sr. No.	Name	Designation	In position
1	**Asso. Prof S. N. Shinde** Head, Department of Microbiology, Rajarshi Shahu Mahavidyalaya, Latur	Chairperson	HoD
2	**Dr. Ravindra Rakh,** Guru Buddhiswami Mahavidyalya Purna Dist. Parbhani	Member	V.C. Nominee
3	**Dr. Jeetendra Kulkarni,** Dept. of Biotechnology, Dr. BAM University Sub Centre, Dharashiv.	Member	Academic Council Nominee
4	**Dr. Shrikumar Mahamuni** Dept. of Microbiology, Shardabai Pawar Mahila ACS college Baramati Dist. Pune	Member	Academic Council Nominee
5	**Dr. Mahesh S. Dharane**, Hon. Member Sr. Scientist, Division of Biochemical Sciences, Dr. Homi Babha Road, Pashan, NCL, Pune.	Member	Expert from outside for Special Course
6	**Dr. M. K. Ranjekar,** Green Vitals Biotech Ranje, Post-Arvi, Tal. Bhor, Dist. Pune.	Member	Expert from Industry
7	**Dr. Manmohan Bajaj** Product Manager BIOGENE, INDIA, New Delhi.	Member	P.G. Alumni
8	**Ms. Sonali S. Patil**	Member	Faculty Member
9	**Ms. Rani S. Gudda**	Member	Faculty Member
10	**Ms. Rakhi S. Shinde**	Member	Faculty Member
11	**Ms. Priyanka V. Kandepatil**	Member	Faculty Member
12	**Mr. Aditya A. Kadam**	Member	Faculty Member

From the Desk of the Chairperson…

The Department of Microbiology was established in 1986 and is one of the leading departments in the field of teaching and student-centric activities. After autonomy, and in keeping pace with advances in various aspects of Microbiology, the department has introduced courses including Fundamentals of Microbiology, Methods in Microbiology, Microbial Diversity, Immunology, Medical Microbiology, Industrial Microbiology, Molecular Microbiology, Genetics, Biostatistics, Bioinformatics, Bioinstrumentation, and others. The Department has academic autonomy and has been revising its curriculum regularly. The department has successfully implemented the Choice Based Credit System (CBCS) for grading students. The curriculum of the B.Sc. and M.Sc. has been designed by considering NET, SET, GATE, and other competitive examinations.

The Institution's Motto, *Aroha Tamaso Jyoti* (The Journey from Dark to Light), the Mission of Pursuit of Excellence, the Vision to evolve as a World Class Dynamic Center of Higher Education, and the Core Values have been frequently reflected in the present curriculum.

The Higher Education System in India and across the world has undergone a paradigm shift in both qualitative and quantitative aspects, the best example of which is the National Education Policy (NEP-2020). The National Education Policy 2020 emphasizes developing the overall personality of students by incorporating humanitarian and constitutional values, creativity and critical thinking, harnessing innovation, use of modern technology, and interaction with various stakeholders. It recognizes that pedagogy should evolve to make education more experiential, holistic, integrated, learner-centric, and flexible, developing skills to shape students capable of facing future challenges. The new policy also envisages refinement and improvement in the Learning Outcome-Based Curriculum Framework.

Microbiology is one of the most applied branches of Life Sciences. It is a broad subject encompassing classical and modern systematic aspects of microbial diversity as well as contemporary disciplines such as Molecular Biology, Bioinformatics, and Biotechnology. The present Learning Outcome-Based Curriculum Framework for the M.Sc. in Microbiology is designed to provide a focused, outcome-oriented syllabus at the postgraduate level, offering structured teaching-learning experiences catering to the advanced needs of students. The postgraduate programme in Microbiology will prepare students both academically and in terms of research aptitude and professional employability. This programme also inculcates attributes such as problem-solving, research skills, and critical

thinking — values encompassing emotional stability, social justice, creative and analytical reasoning, well-being, and various competencies required for sustained employability, thus preparing students for continuous learning and academic sustainability.

As per institutional policy, the curriculum and syllabi of the Postgraduate programme are up-graded after every two years progressively. Accordingly, the curriculum and syllabi of PG-I have been upgraded and PG-II has been revised with minor modifications based on the needs and suggestions of stakeholders. Courses have been designed to incorporate recent advancements and techniques to upgrade the research and analytical skills of postgraduate students. The new structure is expected to enhance the depth of understanding and maintain the standard of the M.Sc. Degree in Microbiology at the national level. Efforts have been made to integrate the use of recent technology and MOOCs to assist the teaching-learning process. This framework offers flexibility and innovation in syllabi design and in the methods adopted for teaching, learning, and assessment.

The present structure comprises Discipline Specific Courses (MMC), Discipline Specific Electives (MEC), Major Mandatory Courses (MMC), Major Elective Courses (MEC), and a Research Methodology Course (RMC). The Discipline Specific Courses and Major Mandatory Courses are compulsory, while elective courses may be chosen from the designated basket. Most courses comprise both theory and practicals.

Dissertation and research project work are especially emphasized in this structure. The project primarily involves original experimental work, and students are consulted regarding their research interests and specialization preferences. Students also undertake a Research Methodology Course (RMC) that equips them with essential tools of experimental design, statistical analysis, scientific writing, and research ethics.

These courses offer skills to pursue research and teaching in the field of Microbiology and are designed to produce competent postgraduate professionals capable of meeting the demands of academia, industry, and society. This curriculum framework for the M.Sc. in Microbiology has been developed with a student-centric learning pedagogy that is entirely outcome-oriented, focusing on a pragmatist approach whereby practical application of theoretical concepts is covered through laboratory work, field visits, seminars, and research projects.

The postgraduate curriculum offers advanced knowledge across diverse areas of Microbiology including Biochemistry, Cell Biology, Virology, Microbial Physiology, Dairy Microbiology, Recombinant DNA Technology, Diagnostic Microbiology, Applied Mycology and Phycology. This syllabus has been prepared keeping in view the unique requirements of M.Sc. Microbiology students, with content drawn to accommodate the widening horizons of the discipline. A semester-wise course

distribution and detailed syllabus for each course is appended along with a list of suggested references.

The major objective of this curriculum is to elevate the subject knowledge of postgraduate students, making them critical thinkers capable of independently solving problems and issues related to Microbiology logically, rigorously, and efficiently.

(Asso. Prof S. N. Shinde)
Chairperson
Board of Studies in Microbiology
Rajarshi Shahu Mahavidyalaya, Latur
Empowered Autonomous Institution

Shiv Chhatrapati Shikshan Sanstha's

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Empowered Autonomous Institution

Index

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Structure for Two Year Postgraduate Programme (M.Sc. I) in Microbiology (In accordance with NEP-2020)

Year & Level	Sem	Major		Minor DSM	GE/ OE	VSC, SEC (VSEC)	AEC/ VEC	OJT, FP, CEP, RP	Credit per Sem.	Cum./Cr. per exit
		MMC Mandatory	MEC Elective							
6.0	VII	MMC I: 4 Cr. MMC II: 4 Cr. MMC III: 4 Cr. MMC IV: 2 Cr.	MEC I: 4 Cr.	RSM: 4 Cr.	NA	NA	NA	NA	22	44
	VIII	MMC V: 4 Cr. MMC VI: 4 Cr. MMC VII: 4 Cr. MMC VIII: 2 Cr.	MEC II: 4 Cr.	NA	NA	NA	NA	FP/OJT: 4 Cr.	22	
	Cum. Cr.	**Major: 28 Cr.**	**MEC: 8 Cr**	**Minor: 4 Cr**	**NA**	**NA**	**NA**	**FP/OJT-04 Cr**	**44**	

Exit Option: Award of UG Diploma in Major with 44 Credits and Additional 04 Credits Core NSQF Course/Internship or continue with Major and Minor

Abbreviations:

1. MMC : Major Mandatory Course (Major)
2. MEC : Mandatory Elective Course (Major)
3. RMC : Research Methodology Course
4. OJT : On Job Training
5. FP : Field Project
6. RP : Research Project/Dissertation
7. AP : Academic Project
8. SES : Shahu Extension Services

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Department of Microbiology M.Sc. Microbiology

Year & Level	Semester	Course Code	Course Title	Credits	No. of Hrs.
6.0	I	MMC-I	Microbial Physiology	3	45
			Lab Course- I	1	30
		MMC-II	Biochemistry	3	45
			Lab Course- II	1	30
		MMC-IIII	Dairy Microbiology	3	45
			Lab Course- III	1	30
		MMC-IV	Teaching, Communication and Research Aptitude	2	30
		MEC-I	Recombinant DNA Technology OR Diagnostic Microbiology	3	45
			Lab Course- IV	1	30
		RMC	Research Methodology	4	60
	Total Credits			**22**	
	II	MMC-V	Cell Biology	3	45
			Lab Course- V	1	30
		MMC-VI	Virology	3	45
			Lab Course- VI	1	30
		MMC-VII	Applied Mycology and Phycology	3	45
			Lab Course- VII	1	30
		MMC-VIII	Analytical, Quantitative and Scientific Aptitude	2	30
		MEC-II	Ecophysiology of Extremophiles OR Biocontrol agents	3	45
			Lab Course- VIII	1	30
		OJT/AP-II	Academic Project	4	60
	Total Credits			**22**	
Total Credits (Semester I & II)				**44**	

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Name of the Programme: M.Sc. Microbiology

Programme Outcomes (POs)	
PO No.	After completion of this programme the students will be able to -
PO 1	**Advanced Scientific Competence** Apply and integrate advanced concepts of microbiology, biochemistry, cell biology, virology and molecular biology to interpret biological systems across clinical, environmental, industrial, and agricultural contexts.
PO 2	**Analytical and Critical Reasoning** Analyze complex biological data, evaluate experimental outcomes, and construct evidence-based explanations for microbiological phenomena using scientific reasoning and quantitative approaches
PO 3	**Experimental Design and Methodological Rigor** Design, execute, and optimize laboratory experiments using appropriate microbiological, biochemical, and molecular techniques while ensuring accuracy, reproducibility, and methodological validity.
PO 4	**Research and Innovation Capability** Formulate research questions, synthesize interdisciplinary knowledge, and develop innovative solutions or experimental models addressing real-world microbiological challenges.
PO 5	**Technological and Computational Application** Apply modern tools, instrumentation, and analytical techniques including molecular diagnostics, bioanalytical methods, and data interpretation systems in scientific and industrial workflows.
PO 6	**Societal, Environmental, and Biosafety Awareness** Evaluate the impact of microbiological applications on public health, environment, agriculture, and industry while adhering to biosafety, bioethics, and regulatory frameworks
PO 7	**Professional and Scientific Communication** Communicate scientific concepts, experimental findings, and research interpretations effectively through technical writing, data visualization, and structured presentations in academic and professional settings.
PO 8	**Lifelong Learning and Adaptive Expertise** Update knowledge, adapt to emerging technologies and scientific advancements, and engage in independent learning for academic progression and professional growth.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

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Name of the Programme: M.Sc. Microbiology

Programme Specific Outcomes (PSOs)	
PSO No.	After completion of this programme the students will be able to -
PSO 1	**Core Microbiological Knowledge Integration** Ability to apply integrated knowledge of microbial physiology, biochemistry, genetics, immunology, virology, ecology, diary microbiology, cell biology, Recombinant DNA Technology, fermentation technology, bioinstrumentation, biostatics, Bioinformatics
PSO 2	**Scientific Outlook** Aptitude to address the increasing need for skilled scientific manpower with an understanding of research ethics in Microbial science. Apply the scientific temperament analyzing microorganisms to contribute to application, advancement and impartment of knowledge in the field of microbiology and molecular biology globally
PSO 3	**Industrial and Applied Microbiology Competence** Ability to analyze and develop microbiological processes in food, dairy, environmental, and industrial systems, including fermentation, quality control, and microbial product development.
PSO 4	**Entrepreneurship and Translational Application** Ability to evaluate and translate microbiological knowledge into practical applications such as biofertilizers, probiotics, diagnostics, small-scale biotechnological ventures and microbial products production process.
PSO 5	**Personal and Professional Competence** Capability to empower himself/herself with laboratory training to prepare for careers in broad range of Microbial science fields. Ability to analyse samples and data obtained from experiments, field visits, projects, survey and will make scientific draft/report for solving problems

Semester - I

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Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- I)

Course Type: MMC-I

Course Title: Microbial Physiology

Course Code: _____

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. Explain metabolic diversity in bacteria including chemolithotrophy, phototrophy, and respiratory pathways.
LO 2. Apply concepts of bacterial respiration, permeation, and transport systems to interpret physiological behavior.
LO 3. Analyze membrane transport mechanisms and stress response pathways in relation to microbial survival and adaptation.
LO 4. Evaluate microbial physiological responses under varying environmental conditions to infer implications in diagnostics and control.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Describe chemolithotrophic and phototrophic metabolism including electron transport and carbon fixation pathways.
CO 2. Interpret bacterial respiration processes, ATP generation mechanisms, and effects of inhibitors on energy metabolism.
CO 3. Apply principles of membrane structure and transport mechanisms (diffusion, active transport, PTS) to microbial systems.
CO 4. Assess microbial stress responses including oxidative, thermal, osmotic stress and sporulation in relation to survival and resistance.

Unit No.	Title of Unit & Contents	Hrs.
I	**Bacterial Chemolithotrophs and Phototrophs**	**12**
	1. Chemolithotrophs: Physiological groups 2. Ammonia oxidation by members of genus Nitro groups, Nitrate oxidation by nitro group of genera. 3. Oxidation of molecular hydrogen by Hydrogenomonas species. 4. Ferrous and sulfur/sulfide oxidation by Thiobacillus species. 5. Phototrophs: Photosynthetic microorganisms and Photosynthetic pigments. 6. Generation of reducing power by cyclic and non-cyclic photophosphorylation. 7. Electron transport chain in photosynthetic microorganisms 8. Carbon dioxide fixation pathways	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1. Explain chemolithotrophic metabolism including oxidation of ammonia, hydrogen, iron, and sulfur compounds. UO 2. Analyse phototrophic processes including photophosphorylation, electron transport, and carbon fixation pathways.	
II	**Bacterial Respiration**	**12**
	1. Bacterial aerobic respiration 2. Components of electron transport chain. 3. Free energy changes and electron transport 4. Oxidative phosphorylation and its theories of ATP formation 5. Inhibition of electron transport chain. 6. Electron transport chain in some heterotrophic bacteria 7. Mechanism of oxygen toxicity, Catalase, Super oxide dismutase. 8. Bacterial anaerobic respiration 9. Electron transport chain in some anaerobic bacteria. 10. Nitrate, Carbonate and Sulfate as electron acceptors.	
	Unit Outcomes: UO 1. Describe aerobic and anaerobic respiration including electron transport chains and ATP generation mechanisms. UO 2. Analyse effects of inhibitors, oxygen toxicity, and alternative electron acceptors on bacterial respiration.	
III	**Bacterial Permeation**	**12**
	1. Structure and organization of membrane (Glyco-conjugants and Proteins in membrane system), 2. Methods to study diffusion of solutes in bacteria 3. Diffusion: Passive diffusion and Facilitated diffusion 4. Different mechanisms of active transport: Proton motive force, PTS 5. Role of permeases in transport, Different permeases in E.coli. 6. Transport of amino acids and Inorganic ions in microorganisms and their mechanisms.	
	Unit Outcomes: UO 1. Explain membrane structure and mechanisms of solute transport including diffusion and active transport systems. UO 2. Apply transport concepts to interpret movement of ions and biomolecules across bacterial membranes.	
IV	**Microbial Stress Responses**	**09**
	1. Osmotic Stress and Osmoregulation 2. Aerobic to Anaerobic Transitions 3. Oxidative Stress 4. pH Stress and Acid Tolerance	

Unit No.	Title of Unit & Contents	Hrs.
	5. Thermal Stress and the Heat Shock Response 6. Nutrient Stress and the Starvation—Stress Response 7. Bacterial sporulation: Sporulating bacteria and Molecular architecture of spores. 8. Induction and stages of Sporulation 9. Influence of different factors on sporulation. 10. Cytological and macromolecular changes during sporulation. 11. Heat resistance and sporulation	
	Unit Outcomes: UO 1. Describe microbial responses to osmotic, oxidative, thermal, and nutrient stress conditions. UO 2. Analyse sporulation processes, structural changes, and factors influencing bacterial survival under stress.	

Learning Resources:

1 Advances in Microbial Physiology, by A. H. Rose. Academic Press. New York.
2 Applied microbial physiology: A practical Approach by P. Rhodes & P. Stansbury (1997), IRL Press, New York.
3 Bacterial physiology and Metabolism by Byung Hong Kim & Geoffrey Michael Gadd (2008), Cambridge University Press.
4 Brocks Biology of Microorganisms (Eleventh Edition) by Michael T. Madigan, John M. Martinko (2006), Pearson Prentice Hall.
5 Microbial physiology and metabolism by D. R. Caldwell (1995) Brown Publisher.
6 Microbial physiology by A. G. Moat, J. W. Foster & M. P. Spector (1999), Wiley.
7 Prokaryotic Development by V. W. Burn & I. J. Shimkots (2000). ASM. Press.
8 The Bacteria. Volume by I.C. Gunsalus and Rogery Stainer. Academic Press.
9 Advances in Microbial Physiology, by A. H. Rose. Academic Press. New York.
10 Applied microbial physiology: A practical Approach by P. Rhodes & P. Stansbury (1997), IRL Press, New York.
11 Bacterial physiology and Metabolism by Byung Hong Kim & Geoffrey Michael Gadd (2008), Cambridge University Press.
12 Microbial physiology and metabolism by D. R. Caldwell (1995) Brown Publisher.
13 Microbial physiology by A. G. Moat, J. W. Foster & M. P. Spector (1999), Wiley.
14 Prokaryotic Development by V. W. Burn & I. J. Shimkots (2000). ASM. Press.
15 The Bacteria. Volume by I.C. Gunsalus and Roger Y. Stainer. Academic Press.

Internal Examination Pattern :

CAT – I: Poster Presentation/ Seminar/ Journal Reading.

CAT – II: Surprise Test/ Quiz

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1	1	2	2	3	2	2	1	1
CO2	3	3	2	2	1	1	2	2	3	2	2	1	2
CO3	3	2	2	2	2	1	1	2	3	2	1	2	2
CO4	3	3	2	3	1	3	2	3	3	3	2	3	2

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

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Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- I)

Course Type: Lab Course

Course Title: Lab Course- I (Based on MMC-I)

Course Code: _____

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. Demonstrate proficiency in isolation, enrichment, and cultivation of photosynthetic and chemolithotrophic bacteria.

LO 2. Explain mechanisms of microbial transport and metabolism through experimental models such as glucose uptake and oxidation reactions.

LO 3. LO3. Analyse effects of environmental and chemical factors (UV, pH, disinfectants, metals) on bacterial spores and physiological activity.

LO 4. Evaluate experimental data from microbial assays (oxidation rates, ion estimation) to infer physiological and biochemical characteristics.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Perform isolation, enrichment, and cultivation techniques for photosynthetic and chemolithotrophic bacteria under laboratory conditions.

CO 2. Conduct and interpret experiments on membrane transport mechanisms such as active and passive diffusion using microbial systems.

CO 3. Assess the impact of physical and chemical factors on spore germination and microbial survival.

CO 4. Quantify microbial metabolic activities and biochemical components (oxidation rates, calcium estimation) using standard laboratory methods.

Sr. No.	Name of Experiment
1	Isolation of photosynthetic bacteria.
2	Glucose uptake by *E. coli / Sacchromyces cerevisiae* [Active and Passive diffusion].
3	Effect of UV, pH on spore germination of *Bacillus* sp.
4	Effect of disinfectants, chemicals and heavy metal ions on spore germination of *Bacillus* sp.
5	Determination of Iron Oxidation Rate of *Thiobacillus ferrooxidans.*
6	Determination of Sulfur Oxidation Rate of *Thiobacillus thiooxidans.*
7	Enrichment and cultivation of chemolithotrophic bacteria.
8	Estimation of calcium ions present in Sporulating bacteria by EDTA method.

Learning Resources:

1. Maheshwari, D.K. and Dubey, R.C. Practical Microbiology. S. Chand & Company, New Delhi.
2. Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. Microbiology: Concepts and Applications. Tata McGraw-Hill, New Delhi.
3. Prescott, L.M., Harley, J.P. and Klein, D.A. Microbiology, 7th edition. McGraw-Hill / Tata McGraw-Hill, New Delhi.
4. Aneja, K.R. Experiments in Microbiology, Plant Pathology and Biotechnology. New Age International Publishers, New Delhi.
5. Gupta, P.K. Elements of Biotechnology. Rastogi Publications, Meerut.
6. Silverman, M.P. and Lundgren, D.G. (1959). Studies on the chemoautotrophic iron bacterium Ferrobacillus ferrooxidans. Journal of Bacteriology, 77: 642–647.
7. Waksman, S.A. and Joffe, J.S. (1922). Microorganisms concerned in the oxidation of sulfur in the soil. Journal of Bacteriology, 7: 239–256.
8. Pfennig, N. (1967). Photosynthetic Bacteria. Annual Review of Microbiology, 21: 285–324.
9. Gerhardt, P., Murray, R.G.E., Wood, W.A. and Krieg, N.R. (Eds.) Methods for General and Molecular Bacteriology. American Society for Microbiology, Washington D.C.
10. Trivedi, P.C., Pandey, S. and Bhadauria, S. Textbook of Microbiology. Aavishkar Publishers and Distributors, Jaipur.

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Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- I)

Course Type: MMC-II

Course Title: Biochemistry

Course Code: _____

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. Explain chemical principles governing biomolecular structure, interactions, and thermodynamics in biological systems.

LO 2. Describe structure and functional roles of major biomolecules including carbohydrates, lipids, proteins, and nucleic acids.

LO 3. Apply concepts of biophysical chemistry (pH, buffers, kinetics, thermodynamics) to biological processes.

LO 4. Analyse structural organization and stability of biomolecules to understand their functional implications.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Describe atomic interactions, bonding, and stabilizing forces underlying biomolecular structure and function.

CO 2. Interpret properties and biological roles of carbohydrates, lipids, vitamins, and hormones.

CO 3. Explain protein structure, folding, stability, and conformational dynamics in relation to function.

CO 4. Analyse nucleic acid structure, conformations, and stability in relation to genetic function.

Unit No.	Title of Unit & Contents	Hrs.
I	**Chemical Foundations of Biochemistry**	**12**
	1. Structure of atoms, molecules and chemical bonds — ionic, covalent, polar, non-polar bonds; resonance; electronegativity 2. Stabilizing interactions — van der Waals forces, electrostatic interactions, hydrogen bonding, hydrophobic interactions, steric effects; their role in biological systems 3. Principles of biophysical chemistry — pH and its significance, buffer systems (Henderson-Hasselbalch equation, biological buffers), reaction kinetics (zero, first, second order), thermodynamics (ΔG, ΔH, ΔS, equilibrium), colligative properties (osmosis, osmolality)	
	Unit Outcomes: UO 1. Explain chemical bonding, molecular interactions, and their role in	

Unit No.	Title of Unit & Contents	Hrs.
	biological systems. UO 2. Apply principles of pH, buffers, kinetics, and thermodynamics to biochemical systems.	
II	**Structure and Function of Biomolecules — I**	**11**
	1. Carbohydrates — monosaccharides, disaccharides, polysaccharides; structural and storage carbohydrates; glycoconjugates 2. Lipids — fatty acids, triacylglycerols, phospholipids, sphingolipids, sterols; membrane lipids and their roles 3. Vitamins — fat-soluble and water-soluble vitamins; coenzyme roles; deficiency diseases, significance of vitamin D in neurophysiological conditions 4. Hormones	
	Unit Outcomes: UO 1. Describe structure and classification of carbohydrates, lipids, and vitamins. UO 2. Analyse functional roles of biomolecules and their relevance in physiological conditions.	
III	**Structure and Function of Biomolecules — II**	**11**
	1. Proteins: i. Amino acid classification and ii. Properties of amino acid iii. Peptide bond, iv. Primary to quaternary structure 2. Conformation of proteins : i. Ramachandran plot ii. secondary structures (α-helix, β-sheet, turns, loops); domains, motifs, and folds 3. Stability of protein -forces maintaining protein structure; i. Denaturation and renaturation ii. Protein folding and chaperones	
	Unit Outcomes: UO 1. Explain levels of protein structure and conformational organization. UO 2. Analyse protein stability, folding, and factors affecting denaturation and function.	
IV	**Nucleic Acid: Structure and Stability**	**11**
	1. Nucleic acids — composition, structure, and function of DNA and RNA; types of RNA and their roles 2. Conformation of nucleic acids — structural characteristics of A, B, and Z-DNA; RNA conformation (tRNA, rRNA, ribozymes); supercoiling	

Unit No.	Title of Unit & Contents	Hrs.
	3. Stability of nucleic acids — base stacking, hydrogen bonding, Tm, denaturation and renaturation of nucleic acids	
	Unit Outcomes: UO 1. Describe structure, types, and conformations of DNA and RNA. UO 2. Analyze factors affecting nucleic acid stability including base pairing, Tm, and denaturation.	

Learning Resources:

1. Biochemistry Stryer, L., Berg, J. M., and Tymoczko, J. L. W. H. Freeman and Company, New York 2019
2. Biochemistry Voet, D. and Voet, J. G. John Wiley and Sons, New Jersey 2011
3. Biochemistry: The Chemical Reactions of Living Cells Metzler, D. E. Academic Press, New York 2003
4. Biophysical Chemistry Cantor, C. R. and Schimmel, P. R. W. H. Freeman and Company, New York 1980
5. Cell Biology Cooper, G. M. and Hausman, R. E. ASM Press, Washington 2019
6. Fundamentals of Biochemistry Voet, D., Voet, J. G., and Pratt, C. W. John Wiley and Sons, New Jersey 2016
7. Harper's Illustrated Biochemistry Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., and Weil, P. A. McGraw-Hill Education, New York 2018
8. Introduction to Biophysics Haynie, D. T. Cambridge University Press, Cambridge 2001
9. Lehninger Principles of Biochemistry Nelson, D. L. and Cox, M. M. W. H. Freeman and Company, New York 2021
10. Molecular Biology of the Cell Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., and Walter, P. W. W. Norton and Company, New York 2022
11. Molecular Cell Biology Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., and Martin, K. W. H. Freeman and Company, New York 2021
12. Outlines of Biochemistry Conn, E. E. and Stumpf, P. K. John Wiley and Sons, New York 1976

Internal Examination Pattern :

CAT – I: PPT Presentation/ Journal Reading.

CAT – II: Descriptive Test/ Open Book Test.

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	1	1	1	0	1	2	3	2	1	1	1
CO2	3	2	2	2	2	2	2	2	3	2	3	3	2
CO3	3	3	2	3	2	1	2	3	3	3	2	2	2
CO4	3	3	2	3	3	1	2	3	3	3	1	2	2

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- I)

Course Type: Lab Course

Course Title: Lab Course- II (Based on MMC-II)

Course Code: _____

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. Demonstrate fundamental biochemical laboratory techniques including buffer preparation, b titration, and analytical assays.

LO 2. Explain physicochemical principles underlying biochemical experiments such as pKa, reaction kinetics, and colligative properties.

LO 3. Analyse biomolecules (carbohydrates, lipids, proteins, nucleic acids) using qualitative and quantitative methods.

LO 4. Evaluate experimental data from biochemical techniques (chromatography, electrophoresis, spectrophotometry) to infer molecular properties.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Prepare and standardize buffer systems and perform titration-based determination of pKa.

CO 2. Conduct experiments to assess reaction kinetics, temperature effects (Q10), and colligative properties.

CO 3. Perform extraction, separation, and estimation of biomolecules using biochemical assays and chromatography.

CO 4. Analyse proteins and nucleic acids using electrophoretic techniques (SDS-PAGE, agarose gel) and interpret structural properties such as denaturation and Tm.

Sr. No.	Name of Experiment
1	Preparation and Standardization of Buffer Solutions
2	Determination of pKa of a Weak Acid by Titration
3	Effect of Temperature on Reaction Rate — Demonstration of Q10
4	Determination of Colligative Properties — Osmolality by Freezing Point Depression
5	Qualitative and Quantitative Analysis of Carbohydrates
6	Extraction and Identification of Lipids by chromatography
7	Estimation of Total Protein by Bradford Assay and Effect of pH on Protein Solubility
8	Identification of Vitamins — Qualitative Chemical Tests
9	SDS-PAGE — Protein Separation and Molecular Weight Determination
10	Study of Protein Denaturation and Renaturation
11	Isolation and Quantification of DNA — Determination of Melting Temperature (Tm)
12	Agarose Gel Electrophoresis and Study of DNA Conformations

Note: Any Ten Practicals from above.

Learning Resources:

1. Sawhney, S.K. and Singh, R. Introductory Practical Biochemistry. Narosa Publishing House, New Delhi.
2. Plummer, D.T. An Introduction to Practical Biochemistry, 3rd edition. Tata McGraw-Hill, New Delhi.
3. Jayaraman, J. Laboratory Manual in Biochemistry. Wiley Eastern / New Age International, New Delhi.
4. Wilson, K. and Walker, J. Principles and Techniques of Biochemistry and Molecular Biology, 7th edition. Cambridge University Press.
5. Lehninger, A.L., Nelson, D.L. and Cox, M.M. Principles of Biochemistry, 5th/6th edition. W.H. Freeman and Company / Macmillan.
6. Varley, H., Gowenlock, A.H. and Bell, M. Practical Clinical Biochemistry, Vol. 1, 5th edition. William Heinemann Medical Books, London.
7. Sambrook, J. and Russell, D.W. Molecular Cloning: A Laboratory Manual, 3rd edition. Cold Spring Harbor Laboratory Press, New York.
8. Bollag, D.M., Rozycki, M.D. and Edelstein, S.J. Protein Methods, 2nd edition. Wiley-Liss, New York.
9. Chattopadhyay, P. and Rakshit, A.K. Experimental Biochemistry. Books and Allied (P) Ltd., Kolkata.
10. Strickberger, M.W. and Murray, R.K. (with Indian adaptation by) Murray, R.K., Granner, D.K. and Rodwell, V.W. Harper's Illustrated Biochemistry, 28th/29th edition. Lange Medical Books / McGraw-Hill.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- I)

Course Type: MMC-III

Course Title: Dairy Microbiology

Course Code: _____

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. Explain composition, microflora, and physicochemical properties of milk influencing microbial growth.
LO 2. Describe principles of milk preservation and fermentation, including roles of starter cultures and processing techniques.
LO 3. Analyse microbial spoilage, milk-borne diseases, and safety concerns associated with dairy products.
LO 4. Evaluate bacteriological quality and safety of milk using standard testing methods and regulatory criteria.

Course Outcomes:

After completion of the course the students will be able to

CO 1. Describe milk composition, sources of contamination, and factors affecting microbial growth.
CO 2. Apply principles of preservation (pasteurisation, sterilisation, refrigeration) and fermentation in dairy processing.
CO 3. Analyse spoilage patterns and milk-borne diseases to assess risks in dairy products.
CO 4. Perform and interpret bacteriological quality tests and detect adulteration in milk.

Unit No.	Title of Unit & Contents	Hrs.
I	**Milk — Composition, Microflora and Contamination**	**12**
	1. Properties of milk, Nutritive value of milk 2. Microflora of raw milk — sources of contamination (udder, milking equipment, environment, handlers); types of Microbial contaminants — bacteria, yeasts, moulds, coliforms, psychrotrophs, thermoduric, thermophiles 3. Factors affecting microbial growth in milk — pH, temperature, water activity, nutrient availability, antimicrobial factors (lactoferrin, lysozyme, lactoperoxidase system, immunoglobulins) 4. Spoilage of milk and milk products — souring, ropiness, bitterness, rancidity, colour changes, off-flavours; spoilage of butter, cheese, cream, and condensed milk	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1. Explain composition of milk and sources/types of microbial contamination. UO 2. Analyse factors affecting microbial growth and spoilage patterns in milk and dairy products.	
II	**Preservation of Milk and Fermented Dairy Products**	**12**
	1. Preservation of milk 2. Thermization — definition, temperature range, purpose and limitations 3. Pasteurisation — principles and objectives; types: LTLT (63°C/30 min), HTST (72°C/15 sec), Ultra pasteurisation (138°C/2 sec); comparison and applications 4. Sterilization — UHT sterilisation, in-container sterilisation; principles and commercial significance 5. Introduction to fermented dairy products — role of lactic acid bacteria (LAB), starter cultures, fermentation types 6. production process, starter culture, nutritional significance & quality parameters Curd, Yogurt, Sour cream, Acidophilus milk, Kefir, Villi, Koumiss. 7. Cheese — types and classification (hard, semi-hard, soft, fresh); different varieties — Cheddar, Gouda, Brie, Camembert, Mozzarella, Cottage cheese; microbiology of ripening 8. Buttermilk — traditional and cultured buttermilk; organisms involved	
	Unit Outcomes: UO 1. Describe principles and methods of milk preservation including pasteurization, sterilization, and refrigeration. UO 2. Analyze role of microorganisms and starter cultures in production of fermented dairy products.	
III	**Milk-Borne Diseases and Food Safety**	**11**
	1. Introduction to milk-borne diseases — routes of transmission, significance of milk as disease vector 2. Bacterial Diseases: Diphtheria, Q Fever, Tuberculosis, Mastitis 3. Viral Diseases: Foot and Mouth Disease, Enterovirus infections 4. Fungal contamination: Microsporum, Aspergillus 5. Prevention and control of milk-borne diseases — pasteurization, veterinary surveillance, hygienic practices	
	Unit Outcomes: UO 1. Analyze milk-borne diseases, routes of transmission. UO 2. Explain preventive measures of Milk borne disease	
IV	**Bacteriological Quality Testing of Milk**	**10**
	1. Introduction to bacteriological testing of milk — importance, regulatory standards (FSSAI, BIS), quality grading 2. MBRT, RT, Phosphate test, SPC, DMC, COB (Clot on Boiling)	

Unit No.	Title of Unit & Contents	Hrs.
	test, cAMP Test, Detection of *Staphylococcus aureus* in milk, Lactometer Test. 3. Adulteration: Urea contamination, Antibiotic determination.	
	Unit Outcomes: UO 1. Describe principles and methods of bacteriological quality testing of milk. UO 2. Evaluate milk quality and detect adulteration using standard microbiological and chemical tests.	

Learning Resources:

1. Modern Food Microbiology, James M. Jay, Martin J. Loessner, David A. Golden, Springer, 2005
2. Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products, Richard K. Robinson, Wiley-Interscience, 2005
3. Applied Dairy Microbiology, Elmer H. Marth, James L. Steele, Marcel Dekker, 2001
4. Advanced Dairy Chemistry Volume 1: Proteins, Parts A&B, P. F. Fox, Paul L. H. McSweeney, Springer, 2013
5. Encyclopedia of Dairy Sciences, Richard K. Robinson, Academic Press, 2002
6. Dairy Microbiology, Chandra R. and Gupta R.P., Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, n.d.
7. Outlines of Dairy Technology, De S., Oxford University Press, New Delhi, n.d.
8. Dairy Microbiology, Bist B.S., Kalyani Publishers, New Delhi / Ludhiana, n.d.
9. Microbiology: Concepts and Applications, Pelczar M.J., Chan E.C.S. and Krieg N.R., McGraw-Hill / Tata McGraw-Hill, New Delhi, n.d.
10. Laboratory Methods in Food and Dairy Microbiology, Harrigan W.F. and McCance M.E., Academic Press, n.d.
11. Compendium of Methods for the Microbiological Examination of Foods, Downes F.P. and Ito K. (Eds.), American Public Health Association (APHA), 2001
12. Elements of Dairy Microbiology and Technology, Gupta P.K., Rastogi Publications, n.d.

Internal Examination Pattern :
CAT – I: Seminar / Field Visit,
CAT – II: Quiz/ Open Book Test.

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	1	1	1	3	1	2	3	1	3	2	1
CO2	3	2	3	2	3	3	2	2	3	2	3	3	2
CO3	3	3	2	3	1	3	2	2	3	2	3	1	2
CO4	2	3	3	2	3	3	3	2	2	3	3	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- I)

Course Type: Lab Course

Course Title: Lab Course- III (Based on MMC-III)

Course Code: _____

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. Demonstrate aseptic techniques for preparation, handling, and sterilization of milk and dairy samples.
LO 2. Explain principles of microbiological quality testing in milk, including indicator organisms and reduction tests.
LO 3. Analyse microbial populations in dairy products including lactic acid bacteria, spoilage organisms, yeasts, and molds.
LO 4. Evaluate milk quality and safety using biochemical, microbiological, and adulteration detection methods.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Perform sterilization, sample preparation, and standard microbiological techniques for dairy analysis.
CO 2. Conduct and interpret milk quality tests including SPC, MPN, MBRT, and Resazurin assays.
CO 3. Isolate and identify beneficial and spoilage microorganisms from dairy products.
CO 4. Assess milk safety through enzymatic tests, probiotic analysis, and detection of adulterants (urea, antibiotics).

Sr. No.	Name of Experiment
1	Preparation and Sterilization of Milk Samples
2	Standard Plate Count for Milk Samples Detection of Coliforms in Milk by MPN Method
3	Methylene Blue Reduction Test for Milk Quality
4	Resazurin Test for Assessing Milk Quality
5	Isolation and Identification of Lactic Acid Bacteria from Yogurt
6	Production of Yogurt using Commercial Starter Cultures
7	Isolation of Spoilage Microorganisms from Milk
8	Microbial Examination of Cheese
9	Examination of Milk for Phosphatase Activity
10	Isolation and Enumeration of Yeasts and Molds in Dairy Products
11	Study of Probiotic Cultures in Fermented Dairy Products
12	Urea detection and Antibiotic determination

Note: Any Ten Practicals from above.

Learning Resources:

1. Dairy Microbiology, Chandra R. and Gupta R.P., Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, n.d.
2. Outlines of Dairy Technology, De S., Oxford University Press, New Delhi,
3. Dairy Microbiology, Bist B.S., Kalyani Publishers, New Delhi / Ludhiana,
4. Microbiology: Concepts and Applications, Pelczar M.J., Chan E.C.S. and Krieg N.R., McGraw-Hill / Tata McGraw-Hill, New Delhi,
5. Laboratory Methods in Food and Dairy Microbiology, Harrigan W.F. and McCance M.E., Academic Press, London
6. Compendium of Methods for the Microbiological Examination of Foods, Downes F.P. and Ito K. (Eds.), American Public Health Association (APHA), Washington D.C., 2001
7. Elements of Dairy Microbiology and Technology, Gupta P.K., Rastogi Publications, Meerut, n.d.
8. Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products, Robinson R.K. (Ed.), John Wiley & Sons, New York, 2005
9. Technology of Indian Milk Products, Aneja R.P., Mathur B.N., Chandan R.C. and Banerjee A.K., Dairy India Yearbook, New Delhi, n.d.
10. IS 1479 — Methods of Test for Dairy Industry. Parts I, II, and III, Bureau of Indian Standards (BIS), BIS, New Delhi, n.d.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- I)

Course Type: MMC IV

Course Title: Teaching, Communication and Research Aptitude

Course Code: _____

Credits: 02 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. Understand the concepts, objectives and levels of teaching-learning, along with learner characteristics and factors affecting learning.

LO 2. Comprehend different types of communication, barriers, and methods of effective classroom and group communication.

LO 3. Gain knowledge of research methodologies, hypothesis formulation, thesis writing and research ethics using ICT tools.

LO 4. Develop logical reasoning and data interpretation skills for analyzing arguments, solving problems and interpreting data.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. explain and apply teaching-learning principles, instructional strategies, and evaluation techniques in biotechnology education and professional contexts.

CO 2. demonstrate effective scientific communication skills (oral, written, and digital) for presenting biological concepts and research findings.

CO 3. analyze research problems, design basic experimental methodologies, formulate hypotheses, and follow ethical practices in life sciences.

CO 4. apply logical reasoning, quantitative analysis, and data interpretation techniques to solve biological and biotechnological problems.

Unit No.	Title of Unit & Contents	Hrs.
I	**Teaching and Learning Aptitude & Research Aptitude**	**08**
	1. Teaching: concept, objectives and levels (Memory, Understanding, Reflective) 2. Learner's characteristics (cognitive, emotional, social) 3. Factors affecting teaching-learning process 4. Teaching methods: teacher-centered vs learner-centered 5. Teaching support systems and evaluation methodsResearch: meaning, types and characteristics 6. Research methods: experimental, qualitative, quantitative 7. Research process and hypothesis 8. Thesis writing and referencing styles	
	Unit Outcomes: UO 1 Explain teaching-learning processes and evaluation systems. UO 2 Apply research principles in scientific writing.	
II	**Communication and Comprehension**	**06**
	1. Communication: types, characteristics and barriers 2. Verbal, non-verbal and group communication	

Unit No.	Title of Unit & Contents	Hrs.
	3. Classroom and mass communication 4. Reading comprehension (passage-based questions)	
	Unit Outcomes: UO 1 Explain communication processes and barriers. UO 2 Apply comprehension and communication skills.	
III	**ICT & Higher Education System**	**08**
	1. CT: Basics, E-learning Platforms 2. Digital Initiatives in India (SWAYAM, e-PG Pathshala) 3. Higher Education System in India 4. Regulatory Bodies (UGC, AICTE, NAAC) 5. Policies & Governance (NEP 2020 Overview)	
	Unit Outcomes: UO 1 Analyze the significance of e-learning platforms such as SWAYAM and e-PG Pathshala in enhancing access to education. UO 2 Explain the basic concepts of Information and Communication Technology (ICT) and its role in higher education	
IV	**Logical Reasoning & Data Interpretation**	**08**
	1. Logical reasoning: series, coding-decoding, analogies 2. Structure of arguments, fallacies, syllogism, Venn diagram 3. Indian logic: Pramanas and inference 4. Data interpretation: tables, graphs and charts	
	Unit Outcomes: UO 1 Analyze logical reasoning and argument structures. UO 2 Interpret data using graphical methods.	

Learning Resources:

1. Pearson Education. UGC NET/SET Paper I guide. 2023 ed. New Delhi: Pearson Education.
2. Kothari CR. Research methodology: Methods and techniques. New Delhi: New Age Internationa Publishers; 2004.
3. Kumar R. Research methodology: A step-by-step guide for beginners. New Delhi: SAGE Publications; 2011.
4. McQuail D. Mass communication theory. New Delhi: SAGE Publications; 2010.
5. IGNOU. Teaching and research aptitude study materials. 2022 ed. New Delhi: IGNOU Publications.
6. Government of India. National education policy (NEP 2020). New Delhi: Ministry of Education; 2020.
7. NCBI. NCBI database. 2024 ed. Available from: National Center for Biotechnology Information.
8. National Library of Medicine. PubMed database. 2024 ed. Available from: NLM.
9. KEGG. KEGG pathway database. 2024 ed. Available from: Kyoto Encyclopedia of Genes and Genomes.
10. UGC. Higher education system and quality assurance documents. 2023 ed. New Delhi: University Grants Commission.

Internal Examination Pattern:

CAT – I: Analytical Case Study on Applied Concepts in the Prescribed Syllabus

CAT – II: Critical Review and Analysis of Research Literature Relevant to the Syllabus

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	1	2	1	3	3	2	2	1	1	3
CO2	2	1	1	1	2	1	3	2	2	2	1	1	3
CO3	2	3	3	3	2	2	2	2	2	3	2	2	3
CO4	2	3	2	2	3	1	2	2	2	2	2	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- I)

Course Type: MEC I (a)

Course Title: Recombinant DNA Technology

Course Code: _____

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. Explain principles and enzymatic tools involved in recombinant DNA technology.

LO 2. Describe cloning strategies, vectors, and gene transfer methods used in genetic engineering.

LO 3. Apply nucleic acid amplification, sequencing, and hybridization techniques in molecular biology.

LO 4. Evaluate applications, ethical concerns, and regulatory aspects of recombinant DNA technology.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Describe structure, function, and mechanisms of enzymes used in recombinant DNA technology.

CO 2. Apply cloning, transformation, and screening techniques using appropriate vectors and host systems.

CO 3. Analyse PCR, sequencing, and hybridization methods for nucleic acid detection and manipulation.

CO 4. Evaluate applications of recombinant DNA technology in medicine, agriculture, and biotechnology along with ethical and legal implications.

Unit No.	Title of Unit & Contents	Hrs.
I	**Enzymes of r DNA Technology**	**09**
	1. Introduction 2. Nucleases – Types and Mechanism of action i. Exonucleases (BAL 31 nuclease, Exonuclease I, III), ii. Endonucleases (S1 nuclease). iii. Restriction endonucleases: Restriction modification system, Type I, Type II & Type III RE. 3. DNA polymerase (DNA pol. I, T7 DNA Pol.) 4. DNA ligase, 5. DNA Manipulating enzymes	

Unit No.	Title of Unit & Contents	Hrs.
	i. Polynucleotide kinase, ii. Phosphatase, iii. Methylase, iv. Topoisomerase v. Ribonucleases, vi. Terminal Transferase vii. Reverse Transcriptase.	
	Unit Outcomes: UO 1. Explain types and mechanisms of nucleases, polymerases, ligases, and other DNA-modifying enzymes. UO 2. Analyse roles of these enzymes in DNA manipulation and recombinant construct formation.	
II	**Cloning and Screening methodologies**	**12**
	1. Introduction 2. Cloning Vectors (their structure, genealogy and derivatives): Plasmids (pBR 322 andpUC18). Bacteriophage lambda (λ), Cosmids, Phasmids and Phagemids as vectors. SV40vaccina/bacculo vector. Expression vectors (Ti plasmid expression, Ri plasmid) Shuttle vectors, Integrative vectors 3. Artificial chromosome vectors (YACs, BACs, PACs). 4. Insertion of foreign DNA into the host cells: transformation, transfection: liposome fusion, microinjection, electroporation, biolistic, somatic cell fusion, gene transfer by pronuclear microinjection. 5. Cloning and expression in yeast (Saccharomyces). 6. Construction of cDNA and genomic DNA libraries (cDNA and genomic cloning, expression cloning, phage display). Screening libraries with gene probes, colony hybridization, plaque hybridization, screening by gain of function, immunological screening	
	Unit Outcomes: UO 1. Describe vectors, gene transfer methods, and cloning strategies in prokaryotic and eukaryotic systems. UO 2. Analyse construction and screening of genomic and cDNA libraries using molecular techniques.	
III	**Nucleic acid amplification, Sequencing and Hybridization Techniques**	**12**
	1. Polymerase Chain Reaction (PCR) -Primer design, fidelity of thermal enzymes, DNA polymerase, Types of PCR and their applications in Molecular dignosis. 2. PCR in gene recombination, deletion, addition, overlap extension and SOEing 3. Gene probes: development and labeling of DNA and RNA probes	

Unit No.	Title of Unit & Contents	Hrs.
	4. Methods of nucleic acid Isolation and detection, sequencing methods (enzymatic DNA sequencing, chemical DNA sequencing, Automated DNA sequencing, RNA sequencing, thermal cycle dideoxy DNA sequencing and pyrosequencing). 5. Methods of nucleic acid hybridization (Southern blotting, Northern blotting, In-situ hybridization), chromosome walking and jumping.	
	Unit Outcomes: UO 1. Explain principles and types of PCR, sequencing, and probe development. UO 2. Apply hybridization and sequencing techniques for detection and analysis of nucleic acids.	
IV	**Applications of rDNA technology and Legal issues**	**12**
	1. Molecular Markers- types and applications. DNA chip Technology and Microarrays (a brief account). 2. Applications of recombinant DNA technology in medicine, agriculture, Forensic sciences (DNA fingerprinting). Creation of knockout (KO) cells and transgenic animals. 3. Engineering microbes for the production of antibiotics, enzymes, Insulin, growth hormones, monoclonal antibodies etc. Human genetic engineering and Gene therapy. Gene silencing in bacteria. CRISPR- Cas systems for editing and targeting genome. 4. Science and the constitution - ethical, legal and environmental issues associated with rDNA Technology.	
	Unit Outcomes: UO 1. Describe applications of recombinant DNA technology including gene therapy, transgenics, and CRISPR systems. UO 2. Evaluate ethical, legal, and environmental issues associated with recombinant DNA technology.	

Learning Resources:

1. DNA cloning: A practical approach by D.M. Glover and D.D. Harmes, RL press,Oxford 1995.
2. Essentials of molecular biology vol. I (A Practical Approach) by Brown T.A.,IRL press Oxford. 1995.
3. From Gene to Clone by E. L. Winnacker.
4. Genetic engineering, principles and practice, by Sandhya Mitra. Macmillan IndiaLtd.
5. Genome mapping and sequencing by Ian Dunham. Horizon Scientific press.
6. Manipulation and expression of Recombinant DNA. Robertson.
7. Methods in enzymology gene expression technology by D.A Godgel. Academicpress Inc, San Diego.
8. Methods in enzymology guide to molecular cloning techniques, vol. 152 S.L. Berger. Academic press. Inc, san Diegn, 1996.
9. Molecular biotechnology (2nd edition), by S.B. Primrose, Blackwell Scientific publishers,

Oxford.
10. Molecular biotechnology: principles and application of Recombinant DNA II by Bernard R. Glick and J. Pastemak, ASM publication.
11. An introduction to genetic engineering (2nd edition) by Nicholl D.S.T., Cambridge University press, Cambridge, U.K.
12. PCR application. Protocol for functional genomics by Michael A. Innis. DavidH., Gelfand John J. Sninsky, Academic Press.
13. PCR technology- principles and application for DNA amplification by Henry AErilch (Ed) Stockton Press. 1989.
14. Route maps in gene technology by M.R. Walker and R. Rapley, Blackwellscience, Oxford.
15. Molecular cloning by Sambrook J, Fritsch E.F and Maniatis, cold spring harbor laboratory press, New York.
16. Principles of Gene Manipulation and Genomics, Third Edition. S.B. Primrose, S.B. and R.M. Twyman, Blackwell Publishing Company, Oxford, UK. 2006
17. Gene Cloning and DNA Analysis: An Introduction. Fifth Edition. T.A.Brown, WileyBlackwell, UK. 2006.
18. Ethics of Emerging Technologies: Scientific Facts and Moral Challenges. JohnWiley and Sons Inc. Thomas F. Budinger and Miriam D. Budinger. 2006.

Internal Examination Pattern :

CAT – I: Model Presentation/ Seminar/ Journal Reading.

CAT – II: Descriptive Test/ Surprise Test.

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	2	2	1	0	1	2	3	2	1	1	1
CO2	3	3	3	3	3	1	2	3	3	2	3	3	3
CO3	3	3	3	3	3	1	2	3	3	3	2	2	3
CO4	2	3	1	3	2	3	3	3	2	3	3	3	2

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- I)

Course Type: Lab Course

Course Title: Lab Course- IV (Based on MEC-I(a))

Course Code: _____

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. Demonstrate isolation and purification of genomic and plasmid DNA using standard protocols.
LO 2. Explain principles of DNA analysis techniques including electrophoresis, restriction digestion, and blotting.
LO 3. Apply enzymatic methods such as ligation and PCR for DNA manipulation and amplification.
LO 4. Analyse experimental outcomes from molecular techniques to interpret DNA integrity, size, and amplification.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Perform isolation of genomic and plasmid DNA using appropriate extraction methods.
CO 2. Conduct agarose gel electrophoresis and determine DNA size and quality.
CO 3. Apply restriction digestion and ligation techniques for DNA manipulation.
CO 4. Perform PCR amplification and analyse results using electrophoretic and blotting techniques.

Sr. No.	Name of Experiment
1	Isolation of pBR 322 by alkaline detergent method (Demonstration)
2	Isolation of genomic DNA.
3	Analysis of genomic DNA by agarose gel electrophoresis.
4	Confirmation of genomic DNA by Southern blotting
5	Isolation of plasmid DNA.
6	Restriction digestion of plasmid DNA.
7	DNA molecular size determination.
8	DNA ligation by T4 DNA ligase.
9	PCR amplification of genomic DNA

Learning Resources:

1. Molecular Cloning: A Laboratory Manual, Sambrook J. and Russell D.W., Cold Spring Harbor Laboratory Press, 2001
2. Principles of Gene Manipulation and Genomics, Primrose S.B., Twyman R.M. and Old R.W., Blackwell Publishing / Wiley, 2006
3. Biotechnology: Expanding Horizons, Singh B.D., Kalyani Publishers, 2018
4. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, Verma P.S. and Agarwal V.K., S. Chand & Company, 2016
5. Gene Cloning and DNA Analysis: An Introduction, Brown T.A., Wiley-Blackwell, 2010
6. Current Protocols in Molecular Biology, Ausubel F.M., Brent R., Kingston R.E., Moore D.D., Seidman J.G., Smith J.A. and Struhl K., John Wiley & Sons, 2002
7. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Glick B.R. and Pasternak J.J., ASM Press, 2003
8. Genes X, Lewin B., Jones and Bartlett Publishers, 2000
9. Genetic Engineering and Biotechnology, Bhattacharya S., Bhattacharya A. and Basu S., Central Book Agency, 2004
10. Laboratory Manual of Molecular Biology and Genetic Engineering, Madhan Mohan C. and Subramanian R.B., I.K. International Publishing House, 2010

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- I)

Course Type: MEC I (b)

Course Title: Diagnostic Microbiology

Course Code: _____

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. Demonstrate competence in collecting, processing, and microscopically examining diverse clinical specimens following standard biosafety and quality protocols.

LO 2. Interpret laboratory findings from hematological, microbiological, mycological, and parasitological investigations to support clinical diagnosis.

LO 3. Evaluate the diagnostic utility of conventional and molecular techniques including ELISA, RT-PCR, Western blot, and antimicrobial susceptibility testing in clinical settings.

LO 4. Integrate multidisciplinary diagnostic data to propose evidence-based laboratory diagnoses for common infectious and non-infectious conditions.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Perform correct collection, labeling, transport, and processing of clinical specimens including blood, urine, stool, sputum, pus, and body fluids as per standard operating procedures.

CO 2. Conduct and interpret routine hematological tests — including CBC, differential WBC count, ESR, PCV, platelet count, PT, and APTT — and correlate findings with pathological conditions.

CO 3. Apply laboratory methods for identification of bacterial, fungal, and parasitic pathogens from clinical specimens using morphological, cultural, serological, and molecular diagnostic approaches.

CO 4. Assess antimicrobial susceptibility patterns and interpret molecular diagnostic results to recommend appropriate diagnostic conclusions in case-based scenarios.

Unit No.	Title of Unit & Contents	Hrs.
I	**Clinical Specimen Collection, Processing & Bacteriology**	**12**
	1. Introduction to clinical microbiology laboratory 2. Human clinical specimens 3. Throat swab and sputum 4. Blood specimen. 5. Urine specimen 6. Stool specimen 7. Pus and wound specimens 8. Body fluids	

Unit No.	Title of Unit & Contents	Hrs.
	9. Microscopic identification of bacterial pathogens from urine specimens 10. Microscopic identification of bacterial pathogens from pus specimens 11. Motility examination 12. Practical integration and case-based review.	
	Unit Outcomes: UO 1. Select and collect appropriate clinical specimens and perform aseptic processing under biosafety standards. UO 2. Examine urine and pus microscopy to identify bacterial features and support diagnosis.	
II	**General Clinical Pathology and Hematology**	**12**
	1. Introduction to hematology laboratory 2. Preparation of peripheral blood smear 3. Microscopic examination of blood smear 4. Morphological abnormalities of RBCs 5. RBC count 6. Differential WBC count 7. Reticulocyte count and absolute eosinophil count 8. ESR (Westergren method) and PCV (haematocrit) 9. Blood indices 10. Platelet count 11. Prothrombin time (PT) and APTT 12. FDP (Fibrin Degradation Products) estimation	
	Unit Outcomes: UO 1. Prepare blood smears, identify RBC abnormalities, perform WBC counts, and calculate indices. UO 2. Interpret coagulation, ESR, PCV, and platelet data to differentiate disorders.	
III	**Urine & Stool Examination, Mycology and Parasitology**	**12**
	1. Urine examination 2. Urine chemical tests 3. Urine microscopy 4. Pregnancy test 5. Diagnostic protocol of urinary tract infection (UTI) 6. Stool examination 7. Stool microscopy 8. Laboratory methods in basic Mycology 9. Fungal culture media 10. Serological tests for fungi 11. Antifungal susceptibility testing 12. Laboratory methods for parasitic infections from faecal specimens	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1. Perform urine and stool analysis, including chemical, microscopic, and infection diagnostics. UO 2. Identify fungal and parasitic pathogens using culture, serology, and susceptibility data.	
IV	**Molecular Diagnostics, Antimicrobial Susceptibility & Applied Diagnostics**	**09**
	1. Sputum examination 2. Identification of protozoa 3. Malaria diagnosis 4. ELISA. 5. Western blot analysis for HIV. 6. RT-PCR for COVID-19 7. Detection of viral antigens 8. Antimicrobial susceptibility testing 9. Current contours and applied review	
	Unit Outcomes: UO 1. Perform and interpret ELISA, Western blot (HIV), RT-PCR (COVID-19), and parasitic diagnostics. (Applying — Level 3) UO 2. Evaluate antimicrobial susceptibility with molecular/serological data to propose diagnostic strategies. (Evaluating — Level 5)	

Learning Resources:

1. Textbook of Microbiology, Ananthanarayanan R and CK Jayaram Panicker, Orient Longman, 2017
2. Medical laboratory techniques, Abdul Khader, Frontline Publications, 2003
3. Text Book of Medical Laboratory Technology, P.B. Godkar, Bhalani Publication, 2003
4. Diagnostic Microbiology, Bailey and Scott's, The Mosby Company, 2013
5. Advanced Techniques in Diagnostic Microbiology: Volume 2: Applications, Yi-Wei Tang and Charles W. Stratton, Springer, 2019
6. Handbook of Medical Microbiology, Talib V.H., CBS Publishers, 2008
7. Microbiology: A Laboratory Manual, Cappuccino and James G., Pearson India, 2021
8. A Text Book of Microbiology, Dubey R.C. and D.K. Maheshwari, S. Chand & Co., 2022
9. Manual for Medical Laboratory Technology, Rajan S., Anajanaa Book House, 2012
10. Textbook of Medical Parasitology, Subash O. Parija, All India Publishers and Distributors, 2013
11. Medical Parasitology, Rajesh Karyakarte and Ajith Damle, Books and Allied Pvt. Ltd., 2005
12. Medical Lab technology, Kani L Mukherjee, Hill Publishing Co. Ltd., 2010

Internal Examination Pattern :

CAT – I: Poster Presentation/ Field Visit/ Journal Reading

CAT – II: Surprise Test/ Quiz

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	2	3	1	2	3	2	2	2	2	1	1	3
CO2	3	3	3	2	3	2	2	2	3	2	1	2	3
CO3	3	3	3	3	3	3	2	3	3	3	2	3	3
CO4	3	3	2	3	3	3	3	3	3	3	2	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation

Shiv Chhatrapati Shikshan Sanstha's

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Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- I)

Course Type: Lab Course

Course Title: Lab Course- IV (Based on MEC- I (b))

Course Code: _____

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. To apply biosafety protocols and biomedical waste management practices for safe handling, processing, and disposal of clinical samples in laboratory settings.

LO 2. To perform microscopic, hematological, and microbiological techniques such as hanging drop, cell counting, and sample analysis for accurate observation and preliminary diagnosis.

LO 3. To analyze immunological and molecular diagnostic methods including ELISA, RPR, Widal test, and PCR for detection and identification of pathogens.

LO 4. To evaluate clinical samples such as urine, stool, pus, and blood using standard laboratory procedures to interpret results and correlate them with disease conditions.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Apply biosafety guidelines and biomedical waste disposal methods effectively during handling of clinical specimens and laboratory procedures.

CO 2. Perform microbiological and hematological techniques including hanging drop, platelet count, and RBC/WBC estimation for diagnostic analysis.

CO 3. Analyze results obtained from immunological and serological tests such as ELISA, RPR, and Widal test for identification of infections.

CO 4. Evaluate clinical samples using biochemical, microscopic, and molecular techniques such as PCR to interpret findings and support disease diagnosis.

Sr. No.	Name of Experiment
1	Biosafety and Medical waste disposal
2	Hanging Drop Technique
3	Demonstration of ELISA
4	Enumeration of Platelet count
5	RBC/WBC count
6	RPR/ Widal test
7	Analysis of Urine and Stool sample
8	Analysis of Pus and Blood sample
9	Demonstration of PCR

Learning Resources:

1. Textbook of Microbiology, Ananthanarayan R. and Paniker C.K.J., Universities Press (Orient Longman), 2017
2. Mackie and McCartney Practical Medical Microbiology, Mackie T.J., McCartney J.E. and Collee J.G., Churchill Livingstone / Elsevier, 1996
3. District Laboratory Practice in Tropical Countries, Parts 1 and 2, Cheesbrough M., Cambridge University Press, 2006
4. Parasitology — Protozoology and Helminthology, Chatterjee K.D., CBC Publishers and Distributors, 2008
5. Practical Haematology, Dacie J.V. and Lewis S.M., Churchill Livingstone / Elsevier, 2011
6. Textbook of Microbiology for Dental Students, Baveja U.K., Arya Medi Publishing House, 2013
7. Practical Pathology and Microbiology, Kapila K. and Verma K., Jaypee Brothers Medical Publishers, n.d.
8. Molecular Cloning: A Laboratory Manual, Sambrook J. and Russell D.W., Cold Spring Harbor Laboratory Press, 2001
9. Biomedical Waste Management Rules, 2016 (amended 2018 and 2019), Ministry of Environment, Forest and Climate Change, Government of India, 2016
10. Textbook of Medical Laboratory Technology, Sood R., Jaypee Brothers Medical Publishers, n.d.

Semester - II

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Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- II)

Course Type: MMC-V

Course Title: Cell Biology

Course Code: _____

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. Explain structure and function of cellular organelles and cytoskeletal components.
LO 2. Describe mechanisms of cell signaling, communication, and signal transduction pathways.
LO 3. Apply concepts of cell cycle regulation and division to normal and abnormal cellular processes.
LO 4. Analyse mechanisms of cell death and their roles in development and disease.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Describe organization and functions of intracellular compartments and cytoskeletal elements.
CO 2. Analyse cell signaling pathways including receptor types, second messengers, and signal integration.
CO 3. Explain cell cycle regulation, checkpoints, and mechanisms of mitosis and meiosis.
CO 4. Evaluate mechanisms of cell death (apoptosis, necrosis, autophagy) in relation to disease conditions.

Unit No.	Title of Unit & Contents	Hrs.
I	**Intracellular Compartmentalization of Eukaryotic Cell**	**12**
	1. Introduction 2. Structure, organization and functions of: i. Nucleus, ii. Mitochondria, iii. Chloroplast, iv. Endoplasmic Reticulum, v. Golgi Body, vi. Peroxisome, vii. Lysosome viii. Endosomes. 3. Cytoskeleton: Actin filaments, microtubules and intermediate filaments 4. Cell motility; Integrating cell into tissue: 5. Cell junctions.	

Unit No.	Title of Unit & Contents	Hrs.
	6. Cell- Cell adhesions, Cell – extracellular matrix adhesion. 7. Molecular mechanism of vesicular trafficking.	
	Unit Outcomes: UO 1. Explain structure and functions of organelles and cytoskeletal components. UO 2. Analyse cell adhesion, motility, and vesicular trafficking mechanisms.	
II	**Cell Signaling & signal transduction**	**12**
	1. Basic signaling mechanisms (Paracrine, endocrine and autocrine signaling); 2. Mechanism of signal transduction: Signaling molecules, Ligand-receptors interaction, Transmembrane and intracellular signaling, Cell surface receptors (G protein-coupled, enzyme-linked and ion channel-linked receptors), 3. Second messengers and their role in signal transduction, Signal integration, Signal amplification.	
	Unit Outcomes: UO 1. Describe types of cell signaling and receptor mechanisms. UO 2. Analyze signal transduction pathways including second messengers and amplification.	
III	**Cell Cycle and Cell Division**	**12**
	1. Cell cycle: Molecular events, Cyclin, CDKs, Checkpoints in cell cycle, Intracellular control of cell cycle events, 2. Abnormalities in cell cycle: Oncogenesis (Causes, proto-oncogenes and tumor suppresser genes, Oncogenic mutations); 3. Cell division: Molecular mechanism of mitosis and meiosis.	
	Unit Outcomes: UO 1. Explain molecular regulation of cell cycle, cyclins, CDKs, and checkpoints. UO 2. Analyse cell division processes and abnormalities leading to oncogenesis.	
IV	**Cell Death Pathways**	**9**
	1. Necrosis 2. Autophagy 3. Senescence 4. Apoptosis: Mechanisms of apoptosis i. Signals triggering apoptosis ii. Apoptosis inducing factors iii. Apoptosis in cancer	
	Unit Outcomes: UO 1. Describe mechanisms of apoptosis, necrosis, autophagy, and senescence. UO 2. Analyse roles of cell death pathways in disease, especially cancer.	

Learning Resources:

1. Molecular biology of the cell, Alberts B., Johnson A., Lewis J., Raff M., Roberts K. and Walter P., Garland Science, 2008
2. Molecular cell biology, Lodish H., Berk A., Kaiser C.A., Krieger M., Scott M.P., Bretscher A., Ploegh H. and Matsudaira P., W.H. Freeman and Company, 2016
3. The Cell: A Molecular Approach, Cooper G.M. and Hausman R.E., ASM Press, 2019
4. Cellular and molecular biology, de Robertis E.D.P. and de Robertis E.M.F., Saunders, 1981
5. Cell Biology, Pollard T.D., Earnshaw W.C. and Schwartz J.L., Saunders, 2002
6. Cell and Molecular Biology: Concepts and Experiments, Karp G., John Wiley and Sons, 2016
7. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, Verma P.S. and Agarwal V.K., S. Chand & Company, 2016
8. Cell and Molecular Biology, De Robertis E.D.P. and De Robertis E.M.F., Lippincott Williams & Wilkins / Lea & Febiger, 2010
9. Practical Cell Biology, Bhamburkar M.W. and Bhamburkar R.M., Himalaya Publishing House, n.d.
10. Practical Cell Biology, Bhamburkar M.W. and Bhamburkar R.M., Himalaya Publishing House, n.d.

Internal Examination Pattern :

CAT – I: Model Presentation/ Poster Presentation,
CAT – II: Surprise Test/ Quiz

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	1	2	2	0	1	2	3	2	1	1	1
CO2	3	3	2	3	2	1	2	3	3	3	2	2	2
CO3	3	3	2	3	2	1	2	3	3	3	1	1	2
CO4	3	3	2	3	2	3	2	3	3	3	1	2	2

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation

Shiv Chhatrapati Shikshan Sanstha's

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Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- II)

Course Type: Lab Course

Course Title: Lab Course- V (Based on MMC-V)

Course Code: _____

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. Demonstrate microscopy techniques for observation of plant and animal cells and cellular structures.

LO 2. Explain cytochemical and staining methods used to visualize cellular components.

LO 3. Analyse cell division processes (mitosis and meiosis) and chromosomal alterations such as polyploidy.

LO 4. Evaluate cellular structures and abnormalities using microscopic and photomicrographic evidence.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Prepare slides and perform staining techniques for visualization of cellular components.

CO 2. Identify cell organelles and structures using light microscopy and electron micrographs.

CO 3. Analyse stages of mitosis, meiosis, and effects of colchicine-induced polyploidy.

CO 4. Interpret normal and abnormal cellular features including cancer cells using microscopy.

Sr. No.	Name of Experiment
1	Study a representative plant and animal cell by microscopy.
2	Study of the structure of cell organelles through electron micrographs
3	Cytochemical staining of DNA – Feulgen
4	Demonstration of the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B
5	Study of polyploidy in Onion root tip by colchicine treatment.
6	Identification and study of cancer cells by photomicrographs.
7	Preparation of temporary slide and study of Mitosis in Onion/Garlic root tips.
8	Preparation of temporary slide and study of Meiosis in Onion/Tradescantia floral buds.

Learning Resources:

1. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, Verma P.S. and Agarwal V.K., S. Chand & Company, n.d.
2. Cell and Molecular Biology, De Robertis E.D.P. and De Robertis E.M.F., Lippincott Williams & Wilkins / Lea & Febiger, 2006
3. Practical Cell Biology, Bhamburkar M.W. and Bhamburkar R.M., Himalaya Publishing House, n.d.
4. Chromosome Techniques: Theory and Practice, Sharma A.K. and Sharma A., Butterworths, 1989
5. Cell and Molecular Biology: Concepts and Experiments, Karp G., John Wiley & Sons, 2016
6. Cytology, Genetics and Evolution, Gupta P.K., Rastogi Publications, n.d.
7. Molecular Biology of the Cell, Alberts B., Johnson A., Lewis J., Raff M., Roberts K. and Walter P., Garland Science / Taylor & Francis, 2014
8. Practical Cytology and Histology, Singh R.K., Emkay Publications, n.d.
9. Cytogenetics: The Chromosome in Division, Inheritance and Evolution, Swanson C.P., Merz T. and Young W.J., Prentice-Hall, 1981
10. Practical Zoology — Cytology, Genetics and Biotechnology, Upadhyay V.B. and Agrawal S., Shivlal Agarwal & Company / Krishna Prakashan Media, n.d.

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Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- II)

Course Type: MMC-VI

Course Title: Virology

Course Code: _____

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. Explain fundamental properties, classification, and structure of viruses.

LO 2. Describe mechanisms of viral replication, gene expression, and host interaction.

LO 3. Analyse viral pathogenesis, infection patterns, and host responses.

LO 4. Evaluate applications of virology including bacteriophages, vaccines, antiviral drugs, and emerging viruses.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Describe classification, structure, cultivation, and assay of viruses.

CO 2. Explain mechanisms of viral entry, replication, transcription, translation, and assembly.

CO 3. Analyse viral infections, virulence factors, and mechanisms of pathogenesis in different hosts.

CO 4. Evaluate roles of bacteriophages, vaccines, antiviral drugs, and viral evolution in disease control.

Unit No.	Title of Unit & Contents	Hrs.
I	**Viruses: General Characters**	**12**
	1. Brief outline on discovery of viruses, nomenclature and Types of viruses, Introduction and Definitive properties of viruses 2. Classification of viruses-International Committee on Biocontrol agents of viruses (ICTV), Structure based classification, Baltimore classification, Homes classification, LHT system of classification. 3. Morphology and Ultra structure of Viruses. 4. Cultivation of Viruses: Cell culture, Embryonated egg and Laboratory animals 5. Assay of viruses: Measurement of infectious units, Efficiency of plating. 6. Measurement of virus particles and their components: 7. One step growth cycle, Physical (Electron microscopy), Chemical methods (Protein and Nucleic acid studies), Infectivity assay	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1. Explain classification, morphology, cultivation, and assay of viruses. UO 2. Analyse viral growth cycle and methods for measurement of viral particles and infectivity.	
II	**Multiplication of Viruses**	**12**
	1. Introduction, 2. Architecture of cell surfaces, 3. Multiplication of viruses: Interaction of viruses with cell receptors, Uptake of macromolecules by cells, Mechanism of virus entry into cells, Transport of viral genome into the cell nucleus. 4. Genomic replication of Viruses (DNA/RNA), mRNA production by animal viruses, Mechanism of RNA synthesis, Transcription mechanism and Post transcriptional processing. 5. Translation of viral protein, Assembly, Exit and Maturation of progeny virions.	
	Unit Outcomes: UO 1. Describe mechanisms of viral entry, genome replication, and gene expression. UO 2. Analyse processes of viral assembly, maturation, and release from host cells.	
III	**Viral Pathogenesis**	**12**
	1. Mechanisms of Pathogenesis: Animal Models of Human Diseases 2. Patterns of Infection, Incubation Period 3. Mathematics of Growth Correlate with Patterns of Infection 4. Acute Infections, Persistent Infections, Latent Infections 5. "Slow" Infections, Abortive Infections, Transforming Infections 6. Viral Virulence, Measuring Viral Virulence, Alteration of Viral Virulence. 7. Viral Virulence Genes 8. Pathogenesis of animal viruses (Adenovirus, Herpes virus, Picorna virus, Influenza virus) 9. Pathogenesis of plant viruses (TMV) and Insect viruses (NPV). 10. Host cell transformation by viruses and oncogenesis of DNA and RNA viruses	
	Unit Outcomes: UO 1. Explain types of viral infections, virulence factors, and host–virus interactions. UO 2. Analyse mechanisms of pathogenesis and oncogenesis in animal, plant, and insect viruses.	

Unit No.	Title of Unit & Contents	Hrs.
IV	**Bacterial Viruses, Viral vaccines and antiviral drugs**	**09**
	1. Introduction 2. Bacterial Viruses-Bacteriophage structural organization; life cycle: lytic and lysogenic cycle, 3. Application of bacteriophages; brief details on M13, Mu, T7, T4, Lamda and P1. Viruses of Cyanabacteria, algae, fungi. 4. Viral vaccines, Preparation of viral vaccines, new vaccine technology 5. Antiviral drugs 6. Virus evolution and Emergence of new viruses.	
	Unit Outcomes: UO 1. Describe bacteriophage biology, life cycles, and applications. UO 2. Evaluate vaccines, antiviral drugs, and factors driving viral evolution and emergence.	

Learning Resources:

1. An Introduction to Viruses by S. B. Biswas & Amita Biswas (2009), Vikas Publishing House PVT LTD.
2. Applied Virology Research: New Diagnostic Procedures by Edouard Kurstak, R. G. Marusyk, F. A. Murphy (1984), Academic press Inc.
3. Brocks Biology of Microorganisms (Eleventh Edition) by Michael T. Madigan, John M. Martinko (2006), Pearson Prentice Hall.
4. Clinical Virology Manual by Steven C. Specter, Richard L. Hodinka, Danny L. Wiedbrauk, Stephen A. Young (2009), ASM Press.
5. Introduction to Modern Virology 4 Th Edition by N. J. Dimmock & S. B. Primrose (1994), Blackwell Scientific publications, Oxford.
6. Notes on Medical Virology, 10th Edition by Morag C. Timbury (1994).
7. Principles of Virology: Molecular Biology, Pathogenesis and Control by S. J. Flint, L.W. Enquist, V. R. Racaniello, A. M. Skalkaj (2009), ASM Press, Washington.
8. Principles of Molecular Virology (4th edn.), Edward Arnold & A. J. Cann (2005). Academic Press, London.
9. Text Book on principles of Recombinant DNA Technology, Virology and Immunology by Topley and Wilsons
10. Textbook of Microbiology, Ananthanarayan, R. and Paniker, C.K.J. 10th edition. Universities Press (Orient Longman), Hyderabad.

Internal Examination Pattern :

CAT – I:

1. Model Presentation/ Seminar/ Journal Reading.

CAT – II: Quiz/ Open Book Test.

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	3	2	2	1	2	2	3	2	1	1	2
CO2	3	3	2	3	2	1	1	3	3	2	1	2	2
CO3	3	3	2	3	2	3	2	3	3	3	2	2	2
CO4	3	3	2	3	3	3	3	3	3	3	2	3	2

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation

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Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- II)

Course Type: Lab Course

Course Title: Lab Course- VI (Based on MMC- VI)

Course Code: _____

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. Demonstrate techniques for isolation, cultivation, and quantification of viruses using host systems.

LO 2. Explain principles of viral growth kinetics, lysogeny, and transduction.

LO 3. Apply molecular methods such as DNA isolation and PCR for viral analysis.

LO 4. Analyze experimental outcomes from virological assays to interpret viral replication and host interaction.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Perform isolation and enumeration of bacteriophages using plaque assay techniques.

CO 2. Conduct one-step growth curve experiments and determine viral titre.

CO 3. Apply techniques such as lysogen induction, transduction studies, and viral DNA isolation.

CO 4. Cultivate and assay viruses in biological systems (embryonated eggs, tissue culture) and interpret infection patterns.

Sr. No.	Name of Experiment
1	Isolation of coliphage by plaque formation assay.
2	One-step growth curve for determination of virus titre.
3	Induction of lambda lysogen by UV radiations.
4	Studies on Specialized transduction.
5	Isolation of lambda DNA and their characterization.
6	Amplification of lambda DNA by PCR.
7	Cultivation and assay of virus using embryonated eggs and tissue culture Technique.
8	Study of symptoms of plant viral diseases by simple detached leaf technique

Learning Resources:

1. Molecular Cloning: A Laboratory Manual, Sambrook J. and Russell D.W., Cold Spring Harbor Laboratory Press, 2001
2. Bacteriophages, Adams M.H., Interscience Publishers, 1959
3. Biotechnology: Expanding Horizons, Singh B.D., Kalyani Publishers, 2018
4. Medical Microbiology, Jawetz E., Melnick J.L., Adelberg E.A., Brooks G.F., Butel J.S. and Ornston L.N., Lange Medical Books / McGraw-Hill, 2004
5. Textbook of Microbiology, Ananthanarayan R. and Paniker C.K.J., Universities Press (Orient Longman), 2017
6. Molecular Biology of Bacterial Viruses, Stent G.S., W.H. Freeman and Company, 1963
7. Principles of Gene Manipulation and Genomics, Primrose S.B., Twyman R.M. and Old R.W., Blackwell Publishing / Wiley, 2006
8. Plant Pathology, Agrios G.N., Elsevier Academic Press / Academic Press, 2005
9. Plant Viruses — Evolutionary Links, Pathogenicity and Economic Importance, Verma H.N., Baranwal V.K. and Bhattacharyya S., n.d.
10. Practical Virology, Malhotra S.K. and Vashisht V.K., Himalaya Publishing House, n.d.

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Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- II)

Course Type: MMC-VII

Course Title: Applied Mycology and Phycology

Course Code: _____

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. Explain diversity, structure, and life cycles of algae and fungi in different environments.

LO 2. Describe ecological roles and interactions of algae and fungi in natural and applied systems.

LO 3. Analyse industrial, agricultural, and medical applications of algae and fungi.

LO 4. Evaluate environmental and biotechnological significance of algae, fungi, lichen and mycorrhizae.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Describe classification, morphology, and reproductive strategies of algae and fungi.

CO 2. Explain ecological roles and interactions of algae and fungi in ecosystems.

CO 3. Analyse applications of algae and fungi in industry, medicine, agriculture, and biotechnology.

CO 4. Evaluate roles of fungi and algae in environmental sustainability, bioremediation, and bioindication.

Unit No.	Title of Unit & Contents	Hrs.
I	**Phycology**	**12**
	1. Algae: Introduction, occurrence and distribution; habitat diversity in aquatic and terrestrial environments. 2. Thallus organization, morphological characteristics, modes of nutrition, classification systems, and reproductive strategies (vegetative, asexual, sexual). 3. Brief account of major algal divisions — Chlorophyta, Bacillariophyta (diatoms), Phaeophyta, and Rhodophyta — with reference to distinguishing features, life cycles, and ecological roles; algal ecology and community structure.	

Unit No.	Title of Unit & Contents	Hrs.
	4. Algal biotechnology: commercial applications, mass cultivation techniques, and downstream processing. 5. Algae as bioindicators of water quality; role in eutrophication — causes, consequences, and monitoring. 6. Role of algae in bioremediation: heavy metal uptake, wastewater treatment, and phytoremediation strategies. 7. Role of algae in environmental sustainability (biofertilizers) 8. Algae in biotechnology: production of pigments, biofuels and high-value bioactive molecules (omega-3 fatty acids, polysaccharides, vitamins).	
	Unit Outcomes: UO 1. Explain diversity, structure, classification, and reproduction of algae. UO 2. Analyze ecological roles and biotechnological applications of algae.	
II	**Mycology**	**12**
	1. Fungi: Introduction, occurrence and distribution. 2. Fungi and ecosystems: saprophytic, parasitic, mutualistic and symbiotic associations with plants and animals; nutrient cycling and decomposition 3. Reproduction in fungi: vegetative and asexual methods (fragmentation, spore formation); sexual reproduction (plasmogamy, karyogamy, meiosis); parasexual cycle and its significance. 4. Systematic study of fungal classes with reference to occurrence, somatic structure, life cycle, and economic importance, covering representative genera: • Myxomycetes - endosporous (Fuligo) and exosporous (Ceratiomyxa) • Oomycetes- Phytophthora • Zygomycetes -Rhizopus • Ascomycotina: Hemiascomycetes- Saccharomyces; Plectomycetes - Penicillium; Pyrenomycetes- Neurospora; Loculoascomycetes- Alternaria	
	Unit Outcomes: UO 1. Describe structure, classification, and reproduction of fungi. UO 2. Analyze ecological roles and life cycles of representative fungal groups.	
III	**Application of Fungi in industries**	**12**
	1. Fungi in production of alcohol (beer, wine, ethanol), organic acids (citric acid, gluconic acid, lactic acid); enzyme production (amylases, proteases, lipases) (mechanisms and commercial production) 2. Fungi in Medicine: production of antibiotics (penicillin, griseofulvin, cephalosporins); immunosuppressants	

Unit No.	Title of Unit & Contents	Hrs.
	(cyclosporin); statins and other bioactive compounds. (mechanisms and commercial production) 3. Fungi in Agriculture and Forestry: biological control of plant pathogens; mycofungicides, bioherbicides (weedicides), and mycoinsecticides (mechanisms and commercial production) 4. Fungi as food: a. edible mushrooms- types, cultivation and growth requirements, nutritional composition and medicinal properties (Lingzhi Mushroom) b. single-cell protein from Saccharomyces and Fusarium 5. Fermented food products from fungi	
	Unit Outcomes: UO 1. Explain industrial, medical, and agricultural importance of fungi. UO 2. Analyse roles of fungi in disease, food production, and biotechnology.	
IV	**Lichens and Mycorrhiza**	**09**
	1. Lichens: nature of the symbiotic association, morphological forms (crustose, foliose, fruticose), thallus structure, reproduction 2. lichen substances and their applications; lichens as bioindicators of air pollution. 3. Mycorrhiza: types — ectomycorrhiza, endomycorrhiza, ectendomycorrhiza, and vesicular-arbuscular mycorrhiza (VAM), 4. Mechanism of nutrient (phosphorus) uptake 5. Mycorrhiza role in plant growth promotion and stress tolerance; mycorrhizal inoculants in sustainable agriculture.	
	Unit Outcomes: UO 1. Describe structure, classification, and functions of lichens and mycorrhizae. UO 2. Evaluate their roles in symbiosis, biocontrol, environmental monitoring, and sustainability.	

Learning Resources:

1. Introduction to Mycology, Alexopoulos C.J. and Mims C.W., Wiley Eastern Ltd., 1979
2. The Fungi, Carlile M. and Watkinson S.C., Academic Press, n.d.
3. Fundamentals of the Fungi, E. Moore-Landecker, Prentice Hall, n.d.
4. Algae: Anatomy, Biochemistry, and Biotechnology, Barsanti L. and Gualtieri P., n.d.
5. Algae Energy: Algae as a New Source of Biodiesel, Demirbas A. and Demirbas M. Fatih, n.d., 2010
6. Algae, Graham Linda E., Graham James M. and Graham James M., n.d., 2009
7. Fundamentals of Mycology, Burnett J.H., Edward Arnold / Crane Russak, n.d.
8. Topley And Wilson's Microbiology And Microbial Infections, Collier, Balows and Sussman, Edward Arnold, n.d.
9. Introductory Mycology, Constantine J. Alexopoulos, n.d.
10. Text Book of Medical Mycology, Jagdish Chander, Mehta Publishers, n.d.
11. An Introduction to Mycology, Mehrotra, New Age International, n.d.

Internal Examination Pattern :

CAT – I: Poster Presentation/ PPT Presentation/Field Visit.
CAT – II: Descriptive Test/ Open Book Test.

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	2	1	1	1	2	2	3	2	1	1	2
CO2	3	3	1	2	1	3	2	2	3	2	2	2	1
CO3	3	3	2	3	3	2	2	3	3	3	3	3	2
CO4	3	3	2	3	2	3	2	3	3	3	3	3	2

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- II)

Course Type: Lab Course

Course Title: Lab Course- VII (Based on MMC- VII)

Course Code: _____

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. Demonstrate isolation, identification, and culturing techniques for fungi and algae.

LO 2. Explain principles of microbial fermentation and metabolite production using fungi and algae.

LO 3. Analyse physiological traits such as enzyme production, dimorphism, and growth under different conditions.

LO 4. Evaluate applications of fungi and algae in biotechnology, including biofuels, SCP, and environmental remediation.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Perform isolation, identification, and cultivation of fungi and algae from various sources.

CO 2. Conduct fermentation experiments for enzyme and organic acid production using fungi.

CO 3. Analyse growth characteristics, dimorphism, and metabolic activities of fungi and algae.

CO 4. Assess biotechnological applications of algae and fungi in biofuel production, SCP, and pollution control.

Sr. No.	Name of Experiment
1	Isolation and identification of fungi from different sources.
2	Production of enzyme, fungal amylase using submerged and solid state fermentation.
3	Production of organic acids using fungi.
4	Collection and study of basidiomycetous fungi
5	Study and culturing of yeasts.
6	Study yeast dimorphism, Isolation and identification of algae from

	different habitats,
7	Culturing of algae under lab conditions,
8	Study hydrogen and bioethanol production by algae,
9	Algae as a source of SCP
10	Study pollution control by algae

Learning Resources:

1. Introductory Mycology, Alexopoulos C.J., Mims C.W. and Blackwell M., John Wiley & Sons, 1996
2. An Introduction to Mycology, Mehrotra R.S. and Aneja K.R., New Age International Publishers, 1999
3. New Developments in Solid State Fermentation, Pandey A. and Larroche C., Elsevier Science, 2006
4. Industrial Microbiology, Prescott S.C. and Dunn C.G., CBS Publishers and Distributors, 1987
5. Cytology, Genetics and Evolution, Sinha U. and Sinha S., Rastogi Publications, n.d.
6. Algal Biofertilizers and Rice Production, Venkataraman G.S., Today & Tomorrow's Printers and Publishers, 1981
7. The Structure and Reproduction of the Algae, Volumes I and II, Fritsch F.E., Cambridge University Press, 1935
8. Cyanophyta, Desikachary T.V., Indian Council of Agricultural Research (ICAR), 1959
9. Microalgae: Biotechnology and Microbiology, Becker E.W., Cambridge University Press, 1994
10. Experiments in Microbiology, Plant Pathology and Biotechnology, Aneja K.R., New Age International Publishers, 2003

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- II)

Course Type: MMC VIII

Course Title: Analytical, Quantitative and Scientific Aptitude

Course Code: _____

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. Cultivate and demonstrate logical reasoning, pattern recognition, and analytical thinking to solve complex problems efficiently.

LO 2. Apply and compute quantitative aptitude concepts, including arithmetic, algebra, and time-based problem-solving techniques in real-life contexts.

LO 3. Analyze and integrate advanced mathematical concepts such as geometry, permutation, combination, and probability for scientific applications.

LO 4. Interpret, evaluate, and correlate data using statistical tools, graphical methods, and general science concepts with emphasis on environmental sustainability.

Course Outcomes:

After completion of course the student will be able to-

CO 1 analyze and solve problems involving logical reasoning, pattern recognition, sequences, coding–decoding, and relationships.

CO 2 compute, apply, and solve numerical and arithmetic problems involving ratios, percentages, profit & loss, time-work, and algebraic concepts.

CO 3 analyze, evaluate, and apply geometrical concepts, permutation and combination, and probability in real-world and scientific problem-solving.

CO 4 interpret, analyze, and evaluate data using statistical tools, graphical representations, and apply scientific and environmental concepts for sustainable development.

Unit No.	Title of Unit & Contents	Hrs.
I	**Logical Reasoning and Mental Ability**	**07**
	1. Observational skills and pattern recognition Logical deductions and analytical reasoning 2. Sequence and series 3. Coding-decoding, analogies and relationships	
	Unit Outcomes: UO 1 Analyze reasoning and deduction patterns. UO 2 Apply logical reasoning techniques.	
II	**Quantitative Aptitude**	**08**
	1. Numerical ability and arithmetic 2. Ratio, percentage, averages	

Unit No.	Title of Unit & Contents	Hrs.
	3. Profit and loss 4. Time, work and speed 5. Quadratic equations 6. Clock, calendar, years, weeks and days	
	Unit Outcomes: UO 1 Apply quantitative techniques in problem solving. UO 2 Analyze mathematical relationships.	
III	**Advanced Mathematics and Probability**	**08**
	1. Geometry of shapes and measurement 2. Directional geometry 3. Moving object dynamics (basic) 4. Permutation and combination 5. Probability	
	Unit Outcomes: UO 1 Apply mathematical and probabilistic concepts. UO 2 Analyze problem-solving strategies.	
IV	**Data Interpretation and General Science**	**07**
	1. Data analysis and graphical interpretation 2. Statistical tools (mean, variation) 3. General science (basic concepts and applications) 4. Environmental issues and sustainable development	
	Unit Outcomes: UO 1 Interpret data using statistical and graphical tools. UO 2 Evaluate scientific and environmental concepts.	

Learning Resources:

1. Pathfinder Academy. CSIR-NET life sciences. 2024 ed. New Delhi: Pathfinder Publication.
2. Aggarwal RS. Quantitative aptitude for competitive examinations. 2024 ed. New Delhi: S. Chand Publishing.
3. Verma R, Sharma S. Logical reasoning and data interpretation. 2023 ed. New Delhi: Arihant Publications.
4. NCERT. Mathematics textbooks (Class XI & XII). 2023 ed. New Delhi: NCERT.
5. Lucent Publications. Lucent's general science. 2024 ed. New Delhi: Lucent Publications.
6. Made Easy Editorial Board. GATE life sciences guide. 2024 ed. New Delhi: Made Easy Publications.
7. Verma R. Fast track objective arithmetic. 2023 ed. New Delhi: Arihant Publications.
8. Pandey MK. Analytical reasoning. 2023 ed. New Delhi: BSC Publishing.
9. Various authors. Previous years' question papers (CSIR-NET / SET / DBT-JRF / JAM). 2024 ed.
10. Government of India. Scientific and environmental policy documents. 2023 ed. New Delhi: Government of India.

Internal Examination Pattern :

CAT – I: Analytical Case Study on Applied Concepts in the Prescribed Syllabus

CAT – II: Critical Review and Analysis of Research Literature Relevant to the Syllabus

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	3	2	2	2	0	1	2	1	2	1	1	3
CO2	1	3	2	2	3	0	1	2	1	2	2	2	3
CO3	2	3	3	3	3	1	2	2	2	3	2	2	3
CO4	2	3	2	2	3	3	3	2	2	2	2	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- II)

Course Type: MEC-II (a)

Course Title: Ecophysiology of Extremophiles

Course Code: _____

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. To explain the diversity, ecological distribution, and metabolic adaptations of extremophilic microorganisms with emphasis on methanogens in extreme environments.

LO 2. To analyze physiological, molecular, and genetic adaptations of thermophiles and psychrophiles in response to temperature extremes and their biotechnological applications.

LO 3. To evaluate cellular mechanisms, metabolic strategies, and environmental significance of alkaliphiles and acidophiles in extreme pH conditions.

LO 4. To apply knowledge of osmotic and pressure adaptations in halophiles and barophiles to interpret survival strategies and industrial applications in extreme habitats

Course Outcomes:

After completion of course the student will be able to-

CO 1. Describe and classify extremophilic microorganisms based on ecological distribution, metabolic pathways, and adaptive strategies across diverse extreme environments.

CO 2. Analyze physiological and molecular mechanisms underlying adaptation of extremophiles to temperature, pH, salinity, and pressure stresses.

CO 3. Evaluate metabolic pathways and ecological roles of extremophiles, including methanogenesis and stress adaptation, in environmental and industrial contexts.

CO 4. Apply knowledge of extremophilic systems to interpret and propose their use in biotechnology, environmental sustainability, and industrial applications.

Unit No.	Title of Unit & Contents	Hrs.
I	**Methanogens**	**10**
	1. Introduction to Extremophilic Microorganisms. 2. Introduction to extremophilic Bacteria and Archaea 3. Habitat and distribution of Methanogens 4. Adaptations in Methanogens 5. Metabolic pathways of methanogenesis • hydrogenotrophic, • acetoclastic, • methylotrophic 6. Environmental and economical importance of Methanogens.	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1. Describe diversity of Extremophilic Microorganisms. UO 2. Understand Commercial aspects of Methanogens and their applications.	
II	**Thermophiles & Psychrophiles**	**13**
	1. Classification (Thermotolerant microorganisms, moderate, extreme & hyperthermophiles) 2. Habitat and ecological aspects of thermophiles 3. Molecular basis of thermo - stability, 4. Heat stable enzymes and metabolism, 5. Genetics of thermophiles. 6. Commercial aspects of thermophiles and application of thermoenzymes. 7. Diversity of Psychrophiles at cold ecosystem: (snow and glaciers ice, subglacial environments psychropiezophiles, permafrost) anaerobic and cyanobacteria in cold ecosystem, microalgae in Polar Regions. 8. Molecular adaptations to cold habitats – 9. Membrane components and cold sensing, • cold adapted enzymes, • cryoprotectants • ice binding proteins, • role of exopolymers in microbial adaptations to sea ice.	
	Unit Outcomes UO 1: Discuss diversity, habitat, adaptation and application of Thermophiles UO 2: Describe diversity, habitat, adaptation and application of Psychrophiles.	
III	**Alkaliphiles and Acidophiles**	**12**
	1.Alkaliphiles- Distribution & classification 2. Cellular adaptations in alkaliphiles.(Antiporters) 3. Physiology & Growth conditions of alkaliphiles 4. Genetics and Metabolism: • Molecular adaptation alkaliphiles • Alkaliphiles as sources of DNA secretion vectors & promoters. • Intracellular enzymes. 5. Environmental and economical importance of Alkaliphiles 6. Acidophiles- Distribution & classification, 7. Mechanism of acido – tolerance in Acidophiles 8. Applications of Acidophiles	
	Unit Outcomes UO 1: Understand the diversity, habitat, adaptation and application of Alkaliphiles UO 2: Describe diversity, habitat, adaptation and application of Acidophiles	

Unit No.	Title of Unit & Contents	Hrs.
IV	**Halophiles and Barophiles**	**09**
	1. Halophiles- Classification (Eukaryotic and prokaryotic halophiles Halobacteria) 2. Distribution in Hypersaline Environments 3. Mechanism of halotolerance & Halophilicity • Osmotic protection • Compatible solutes, • Osmoadaptations in cell wall. Membranes 4. Applications of halophiles and their enzymes. • Barophiles/ Piezophiles- Classification, high pressure habitat, life under pressure, death under pressure.	
	Unit Outcomes UO 1: Understand the diversity, habitat, adaptation and application of Halophiles UO 2: Describe diversity, habitat and application of Barophiles	

Learning Resources:

1. Advances in applied microbiology. Vol.X, by Wayne W. Umbreit and D. Pearlman Academic Press.
2. Brock biology of Microorganisms. XI by Michael T. Madigan, John M. Martinko. Pearson Education International.
3. Extreme environment. Metabolism of microbial Adaptation by Milton R., Heinirich Academic Press.
4. Microbial ecology. Fundamental and applications by Ronald M. Atlas and Richard Bartha. II and IV edition.
5. Microbial Ecology. IInd edition by R. Campbell. Blackwell scientific publication.
6. Microbial life in extreme Environment by D.J. Kushner. Academic Press.
7. Microbiology of extreme Environment and its potentials for Biotechnology by N. S. Da Coasta, J. C. Duarata,, R.A.D. Williams. Elsisver applied science, London
8. Thermophiles. General, Molecular and applied Microbiology by Thomas D.Brock. Wiley Interscience publication.
9. Microbial ecology, Larry L. Barton and Diana E. Northup, Wiley-Blackwell.
10. Principles of microbial diversity, James W. Brown, American Society for Microbiology press.

Internal Examination Pattern :

CAT – I: Seminar/ Field Visit,
CAT – II: Descriptive Test/ Quiz

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	1	1	1	2	2	3	3	2	2	1	1
CO2	3	3	1	2	2	1	2	3	3	3	2	2	1
CO3	3	3	1	2	1	3	2	2	3	2	3	2	2
CO4	3	2	2	3	2	3	3	3	3	3	3	3	2

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- II)

Course Type: Lab Course

Course Title: Lab Course- VIII (Based on MEC- II (a))

Course Code: _____

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. To explain the physiological and biochemical adaptations of extremophiles (halophiles, alkaliphiles, and acidophiles) that allow them to thrive in high salinity, high pH, and low pH environments.

LO 2. To demonstrate mastery in preparing extreme-environment media and performing aseptic enrichment techniques specifically tailored for slow-growing or specialized microorganisms

LO 3. To explore the biotechnological potential of extremophilic enzymes (amylases/proteases) and metabolic processes (methanogenesis/sulfur oxidation) in waste management and industry..

LO 4. To teach students how to systematically analyze growth curves and metabolic byproducts to evaluate the efficiency of microbial processes.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Isolate and maintain pure cultures of halophiles, alkaliphiles, and acidophiles from diverse environmental samples using selective media and incubation conditions.

CO 2. Test and analyze the activity of alkaline enzymes and biogenic methane production, interpreting the relationship between environmental factors and microbial output.

CO 3. Quantify and evaluate the salt tolerance limits and pH ranges of isolates to determine their classification (e.g., extreme vs. moderate halophiles).

CO 4. Design and execute a laboratory-scale bioprocess for methane production or sulfur oxidation using various waste substrates or mineral sources.

Sr. No.	Name of Experiment
1	Isolation of pigment producing Halophiles from high salt habitat.
2	Studies on salt tolerance ability of Halophiles isolated from high salt habitat.
3	Isolation of Alkaliphiles from high pH habitat.
4	Studies on Alkaliphilic amylase and proteas
6	Isolation of Acidophiles from Industrial Wastewater
7	Biogenic methane production using different wastes.
8	Isolation of Thiobacillus spp. from metal sulfides/ rock coal/ Metal rust water.

Learning Resources:

1. Microbial Ecology. IInd edition by R. Campbell. Blackwell scientific publication.
2. Microbial life in extreme Environment by D.J. Kushner. Academic Press.
3. Microbiology of extreme Environment and its potentials for Biotechnology by N. S. Da Coasta, J. C. Duarata,, R.A.D. Williams. Elsisver applied science, London
4. Thermophiles. General, Molecular and applied Microbiology by Thomas D.Brock. Wiley Interscience publication.
5. Microbial ecology, Larry L. Barton and Diana E. Northup, Wiley-Blackwell.
6. Principles of microbial diversity, James W. Brown, American Society for Microbiology press

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- II)

Course Type: MEC II (b)

Course Title: Biocontrol agents

Course Code: _____

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. Explain principles, types, and significance of biological control in agriculture.
LO 2. Describe isolation, identification, and mechanisms of action of microbial bio-agents.
LO 3. Apply methods for evaluation, mass production, and formulation of bio-agents.
LO 4. Evaluate field applications, regulatory aspects, and effectiveness of biocontrol strategies.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Describe types, advantages, and limitations of biological control and major bio-agents.
CO 2. Apply isolation, purification, and identification techniques for microbial bio-agents.
CO 3. Analyse mechanisms of biocontrol and evaluate efficacy against plant pathogens.
CO 4. Evaluate mass production, formulation, quality control, and field application of bio-agents.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction to Bio-agents**	**11**
	1. Definition & History of Biological Control 2. Types of Biological Control – Classical, Augmentative, Conservative 3. Advantages & Limitations of Biological Control 4. Overview of Bio-agents – Fungi, Bacteria & their Role 5. Rhizosphere Soil – Definition, Importance & Sampling Methods 6. Role of Trichoderma spp, Pseudomonas spp, Bacillus spp., Paecilomyces spp. as Biocontrol agents 7. Purification Techniques – Serial Dilution, Plating Methods 8. Identification of Bio-agents.	
	Unit Outcomes: UO 1. Describe the ecological role of rhizospheric soil and summarize the functions of microorganisms as bio-agents in plant disease suppression	

Unit No.	Title of Unit & Contents	Hrs.
	UO 2 Evaluate the advantages and limitation of biological control over chemical methods	
II	**Efficacy Evaluation & Culture Media Selection**	**11**
	1. Mechanisms of Biocontrol – Mycoparasitism, Antibiosis, Competition 2. Mechanisms – Induced Systemic Resistance (ISR) & Plant Growth Promotion 3. Efficacy study of bioagents against Fungal & Bacterial Pathogens – Dual Culture Method 4. In-vitro vs In-vivo Efficacy Testing Methods 5. Introduction to Fermentation – Solid State vs Liquid State Fermentation 6. Selection of Solid Culture Media for Bio-agent Production 7. Selection of Liquid Culture Media for Bio-agent Production 8. Optimization of Culture Conditions – pH, Temperature, Moisture	
	Unit Outcomes: UO 1. Explain the mechanisms by which microorganisms suppress plant pathogens. UO 2. Describe how Induced Systematic Resistance enhance host plant defense against biotic stress	
III	**Mass Production, Formulation & Quality Analysis**	**12**
	1. Mass Production of Bioagent (Fungus & Bacteria)– Solid & Liquid Fermentation 2. Types of Formulations – Wettable Powder, Granules, Liquid, Talc-based & Carrier-based Formulations 3. Liquid Formulations – Oil Dispersion, Suspension Concentrate 4. Packaging of Bio-agent Formulations – Materials & Methods 5. Shelf Life & Storage Conditions of Bio-agent Formulations 6. Quality Analysis of Formulations – CFU Count, Viability Testing 7. Quality Parameters – Moisture Content, pH, Particle Size 8. Guidelines of Central Insecticide Board (CIB) 9. Registration Committee Guidelines & Regulatory Framework	
	Unit Outcomes: UO 1. Explain the principal of solid and submerged fermentation used in mass production of bio-agents UO 2. Evaluate bio-agent formulations against CIB and Registration Committee standards.	
IV	**Enrichment, Application Methods & Field Practices**	**11**
	1. Enrichment of Bio-agents with Organic Inputs – Compost, FYM 2. Enrichment with Vermicompost & Neem-based Inputs 3. Compatibility of Bio-agents with Chemical Pesticides &	

Unit No.	Title of Unit & Contents	Hrs.
	Fertilizers 4. Seed Treatment Method – Protocol & Advantages 5. Seedling Dip Method – Protocol & Advantages 6. Foliar Application Method – Protocol & Advantages 7. Soil Application Method – Protocol & Advantages 8. Integrated Pest Management (IPM) – Role of Bio-agentsL43Case Studies – Success Stories of Biocontrol in Field CropsL44Challenges & Future Prospects of Biological Control	
	Unit Outcomes: UO 1. Explain how enrichment with organic inputs enhances bio-agent activity. UO 2. Describe the compatibility of bio-agents with chemical pesticides and fertilizers.	

Learning Resources:

1. Biopesticides: Production and Application, Upadhyay R.K., Dubey N.K. and Upadhyaya A.K., CABI, 2018
2. Biocontrol Potential and its Exploitation in Sustainable Agriculture, Upadhyay R.K., Mukerji K.G. and Chamola B.P., Kluwer Academic, 2000
3. Biocontrol of Plant Diseases, Mukerji K.G. and Garg K.L., CRC Press, 1988
4. Experiments in Microbiology, Plant Pathology and Biotechnology, Aneja K.R., New Age International, 2007
5. Plant Pathology, Agrios G.N., Academic Press, n.d.
6. Biological Control of Soil-borne Plant Pathogens, Tilak K.V.B.R., ICAR, 2006
7. Plant Disease Management, Chaube H.S. and Singh U.S., CRC Press, 1991
8. Plant Diseases, Singh R.S., Oxford & IBH Publishing, 2005
9. Diseases of Field Crops, Gupta V.K. and Paul Y.S., Indus Publishing, 2001
10. Handbook of Microbial Biofertilizers, Rai M.K., IBH, 2006
11. Industrial Microbiology, Sahasrabudhe N.A., Nirali Prakashan, 2011
12. A Textbook of Biotechnology, Dubey R.C., S. Chand & Company, 2014
13. Ecology and Environment, Sharma P.D., Rastogi Publications, 2010

Internal Examination Pattern :

CAT – I: Model Presentation/ Seminar,
CAT – II: Quiz/Open Book Test.

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	1	2	1	3	2	2	3	2	2	2	1
CO2	3	2	3	2	3	2	1	2	3	2	2	2	3
CO3	3	3	2	3	2	3	2	3	3	3	3	2	2
CO4	2	3	3	3	3	3	3	3	2	3	3	3	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Microbiology

PG-I (Semester- II)

Course Type: Lab Course

Course Title: Lab Course- VIII (Based on MEC II (b))

Course Code: _____

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. To apply isolation, enumeration, and purification techniques for obtaining fungal and bacterial bio-agents and plant pathogens from environmental and plant samples under controlled laboratory conditions.

LO 2. To analyze the characteristics and functional roles of key biocontrol agents such as Trichoderma and Pseudomonas in suppressing plant pathogens through biological mechanisms.

LO 3. To evaluate the effects of environmental factors such as temperature and pH on the growth, survival, and efficacy of biocontrol agents in laboratory conditions.

LO 4. To apply techniques for efficacy testing, mass production, formulation, and field application of bio-agents for sustainable plant disease management.

.Course Outcomes:

After completion of the course the students will be able to-

CO 1. Apply isolation, enumeration, and purification methods to obtain and maintain pure cultures of bio-agents and plant pathogens.

CO 2. Analyze the biocontrol potential of microbial agents such as Trichoderma and Pseudomonas based on their growth characteristics and antagonistic activity.

CO 3. Evaluate the impact of environmental factors and experimental conditions on the performance and effectiveness of biocontrol agents.

CO 4. Apply dual culture techniques, formulation methods, and application strategies to develop and utilize bio-agents for controlling plant pathogens.

Sr. No.	Name of Experiment
1	Isolation of fungal and bacterial bio-agents and their enumeration and purification
2	Study of *Trichoderma* as a biocontrol agent
3	Study of *Pseudomonas* as a biocontrol agent
4	Effect of temperature and pH on biocontrol agents
5	Isolation of Fungal and Bacterial plant pathogens
6	Testing the efficacy of biocontrol agents against plant pathogens by dual culture technique
7	Formulation of fungal and Bacterial biocontrol agents
8	Production of bioagents
9	Methods of application of bioagents

Learning Resources:

1. Biocontrol of Plant Diseases, Volumes I and II, Mukerji K.G. and Garg K.L. (Eds.), CRC Press, 1988
2. Experiments in Microbiology, Plant Pathology and Biotechnology, Aneja K.R., New Age International Publishers, 2007
3. Trichoderma and Gliocladium, Volumes I and II, Vinale F., Sivasithamparam K., Ghisalberti E.L., Marra R., Woo S.L. and Lorito M., Taylor & Francis, 1998
4. PGPR: Biocontrol and Biofertilization, Siddiqui Z.A. (Ed.), Springer, n.d.
5. A Textbook of Biotechnology, Dubey R.C., S. Chand & Company, n.d.
6. Plant Pathology, Agrios G.N., Elsevier Academic Press, 2005
7. Plant Pathology, Sharma P.D., Rastogi Publications, n.d.
8. Induction of plant defence by Pseudomonas fluorescens, Nakkeeran S., Kavitha K., Chandrasekar G., Renukadevi P. and Fernando W.G.D., Springer, n.d.
9. Trichoderma: Biology and Applications, Kubicek C.P. and Harman G.E. (Eds.), CAB International, n.d.
10. Biological Control of Crop Diseases, Gnanamanickam S.S., Marcel Dekker / CRC Press, n.d.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Extra Credit Activities

Sr. No.	Course Title	Credits	Hours T/P
1	MOOCs	Min. of 02 credits	Min. of 30 Hrs.
2	Certificate Courses	Min. of 02 credits	Min. of 30 Hrs.
3	IIT Spoken English Courses	Min. of 02 credits	Min. of 30 Hrs.

Guidelines:

Extra -academic activities

1. All extra credits claimed under this heading will require sufficient academic input/ contribution from the students concerned.
2. Maximum 04 extra credits in each academic year will be allotted.
3. These extra academic activity credits will not be considered for calculation of SGPA/CGPA but will be indicated on the grade card.

Additional Credits for Online Courses:

1. Courses only from SWAYAM and NPTEL platform are eligible for claiming credits.
2. Students should get the consent from the concerned subject Teacher/Mentor/Vice Principal and Principal prior to starting of the course.
3. Students who complete such online courses for additional credits will be examined/verified by the concerned mentor/internal faculty member before awarding credits.
4. Credit allotted to the course by SWAYAM and NPTEL platform will be considered as it is.

Additional Credits for Other Academic Activities:

1. One credit for presentation and publication of paper in International/National/State level seminars/workshops.
2. One credit for measurable research work undertaken and field trips amounting to 30 hours of recorded work.
3. One credit for creating models in sponsored exhibitions/other exhibits, which are approved by the concerned department.
4. One credit for any voluntary social service/Nation building exercise which is in collaboration with the outreach center, equivalent to 30 hours
5. All these credits must be approved by the College Committee.

Additional Credits for Certificate Courses:

1. Students can get additional credits (number of credits will depend on the course duration) from certificate courses offered by the college.
2. The student must successfully complete the course. These credits must be approved by the Course Coordinators.
3. Students who undertake summer projects/ internships/ training in institutions of repute through a national selection process, will get 2 credits for each such activity. This must be done under the supervision of the concerned faculty/mentor.

Note:

1. The respective documents should be submitted within 10 days after completion of Semester End Examination.
2. No credits can be granted for organizing or for serving as office bearers/ volunteers for Inter-Class / Associations / Sports / Social Service activities.
3. The office bearers and volunteers may be given a letter of appreciation by the respective staff coordinators. Besides, no credits can be claimed for any services/ activities conducted or attended within the college.
4. All claims for the credits by the students should be made and approved by the mentor in the same academic year of completing the activity.
5. Any grievances of denial/rejection of credits should be addressed to Additional Credits Coordinator in the same academic year.
6. Students having a shortage of additional credits at the end of the third year can meet the Additional Credits Coordinator, who will provide the right advice on the activities that can help them earn credits required for graduation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Examination Framework

Theory:

40% Continuous Assessment Tests (CATs) and 60% Semester End Examination (SEE)

Practical:

50% Continuous Assessment Tests (CATs) and 50% Semester End Examination (SEE)

Course	Marks	CAT & Mid Term Theory				CAT Practical		Best Scored CAT & Mid Term	SEE	Total
1	2	3				4		5	6	5 + 6
		Att.	CAT I	Mid Term	CAT II	Att.	CAT			
MMC/MEC/ GE/OE/Minor	100	10	10	20	10	-	-	40	60	100
MMC	75	05	10	15	10	-	-	30	45	75
Lab Course/AIPC/ OJT/FP/SEC (Science & Technology)	50	-	-	-	-	05	20	-	25	50
VSC/SEC/ AEC/VEC/CC	50	05	05	10	05	-	-	20	30	50

Note:

1. All Internal Exams are compulsory
2. Out of 02 CATs best score will be considered
3. Mid Term Exam will be conducted by the Exam Section
4. Mid Term Exam is of Objective nature (MCQ)
5. Semester End Exam is of descriptive in nature (Long & Short Answer)
6. CAT Practical (20 Marks): Lab Journal (Record Book) 10 Marks, Overall Performance 10 Marks

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Examination Question Paper Pattern (Theory)

Max. Marks: 45 **Time: 2 Hrs**

Q.1 Answer the following questions (3 Marks each) 12 Marks

a) Based on Unit - I

b) Based on Unit - II

c) Based on Unit - III

d) Based on Unit - IV

Q.2 Answer any THREE of the following (5 Marks each) 15 Marks

a) Based on Unit - I

b) Based on Unit - II

c) Based on Unit - III

d) Based on Unit - IV

Q.3 Answer any ONE of the following 08 Marks

a) Based on Unit – I

b) Based on Unit – II

Q.4 Answer any ONE of the following 10 Marks

a) Based on Unit - III

b) Based on Unit – IV