

Shiv Chhatrapati Shikshan Sanstha's
Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)



Structure and Curriculum of Two-Year Degree Programme

Postgraduate Programme of Science and Technology

M.Sc. in Microbiology

Approved by

Board of Studies in Microbiology
Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)

शिव छत्रपती
शिक्षण संस्था
लातूर

॥ आरोग्यं तमसो ज्योतिः ॥

w.e.f. June, 2024

(In Accordance with NEP-2020)

Academic Year: 2024-25

Review Statement

The NEP CELL reviewed the Curriculum of **M.Sc. in Microbiology** Programme to be effective from the **Academic Year 2023-24**. It was found that, the structure is as per the NEP-2020 guidelines of Govt. of Maharashtra.

Date: 0/0/2023

Place: Latur

NEP CELL
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CERTIFICATE

I hereby certify that the documents attached are the Bonafide copies of the Curriculum of **M.Sc. in Microbiology** Programme to be effective from the **Academic Year 2024-25**.

Date: 0/0/2024

Place: Latur



(Dr. K.G. Maske)

Chairperson

Board of

Studies in

Microbiology

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From the Desk of the Chairperson

The National Education Policy lays particular emphasis on the development of the creative potential of each individual. NEP-2020 has conceptualized the idea to develop well rounded competent individuals for making the nation a self-reliant and global leader.

Department of Microbiology has developed a curriculum framework to encompass the goals of NEP 2020. Microbiology is study of microorganisms such as bacteria, protozoa, algae, fungi, viruses, etc. These studies integrate cytology, physiology, ecology, genetics and molecular biology, evolution, taxonomy and systematics with a focus on microorganisms. It is one of the significant branches of sciences to understand the principles of life which has roots in the study of various microbial systems. Microbiology has been at the forefront of research in industry, environment, agriculture, food, dairy, medicine and biology. It is one of the rapidly growing and applied areas of the science. Many job opportunities available for student in this stream. Trained manpower is required in industrial production of microbial products. Considering rural and agro based life background and awareness about the general health and hygiene, our curriculum is designed to educate our students in various important microbiological domains, as well as to promote and develop skills and competencies that have great value.



(Dr. K. G. Maske)

Chairperson

Board of Studies in Microbiology

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Department of Microbiology

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Faculty of
Science

Programme Outcomes (POs) for M.Sc. Programme	
After the completion of the M.Sc. programme, a student will have obtained:	
P01	Disciplinary Masters Knowledge Comprehensive in-depth relevant scientific knowledge and its execution in the specific area of study.
P02	Scientific Outlook The qualities such as observation, precision, analysis, logical thinking, clarity of thought and expression and systematic approach to work on research projects and explain scientific phenomena
P03	Problem Solving Skills Analytical skills to solve problems, evaluate situations and act responsibly to communicate, cooperate and lead the team.
P04	Interpersonal Skills and Ethics Ability to integrate professional ethics and scientific knowledge in life, organization, society and individual to fulfill the needs of mankind in both moral and material aspects.
P05	Self-Directed Life-long Learning Ability to prepare for NET, SET, GATE and other national and international competitive examinations.
P06	Professional Competence Ability to apply the knowledge independently for continuous personal and professional development and identify business opportunities and initiate action to achieve it.
P07	Research and Related Skills Technical know-how about identification of local issues and develop lab to land solutions for the benefit of society at large.



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Programme Specific Outcomes (PSOs) M.Sc. in Microbiology	
PSO No.	After the completion of the M.Sc. Microbiology, a student will have obtained:
PSO1	Academic Competence: In-depth knowledge in Advanced Virology, Microbiology in Food and Dairy, Bioinstrumentation Microbial Genetics and Metabolism, Enzymology, Bioprocess Engineering, Immunology, Advanced Molecular Biology, Microbial Diversity and Extremophiles, Quantitative Biology, Fermentation Technology, Medical and Pharmaceutical Microbiology, Ecology and Environmental Microbiology and Microbial Bioinformatics, Genomics and Proteomics
PSO2	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.
PSO3	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.
PSO4	Entrepreneurial Competence Skillfulness to start their own labs to serve in the field of Medical science. Apply knowledge of Botany to enter in start-up of Food Processing and Bakery Products and related industries and occupation. They will exhibit self-learning, discipline and logical approach.
PSO5	Research Competence: An ability to assess and identify research problem using Microbial techniques and instrumentation and with the help of integrated knowledge do the experiments, interpret the data and findings and provide valid conclusion.



Rajarshi Shahu Mahavidyalaya, Latur

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Members of Board of Studies in the Subject Microbiology

Sr. No.	Name	Designation	In position
1	Dr. K. G. Maske Head, Department of Microbiology, Rajarshi Shahu Mahavidyalaya, Latur (Autonomous)	Chairperson	HoD
2	Dr. B. S. Nagoba Assistant Dean (R D), Professor of Microbiology, MIMSR Medical College, Latur- 413 512 (MS), India	Member	V.C. Nominee
3	Dr. U. K. Patil Government Institute of Science Aurangabad	Member	Academic Council Nominee
4	Dr A. M. Deshmukh Former Professor and President, Microbiologist Society of India	Member	Academic Council Nominee
5	Dr. Manmohan Bajaj Product Manager, BIOGENE INDIA, New Delhi	Member	Expert from outside for Special Course
6	Dr. Vinodkumar Patil Director, Dyna Biotech 98/A5, Hadapsar Industrial Estate Bhd. Kirloskar Pneumatic Co., Hadapsar, Pune	Member	Expert from Industry
7	Dr M. S. Dharane Sr. Scientist, Division of Biochemical Sciences, Dr. Homi Babha Road, Pashan, NCL, Pune	Member	P.G. Alumni
8	Dr.D.V. Vedpathak	Member	Faculty Member
9	Dr. K. I. Momin	Member	Member from same Faculty

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Department of Microbiology

PG Skeleton in Accordance with NEP-2020

Illustrative Credit Distribution Structure for Two Year M.Sc. Degree

Year Level	Sem	Major		Lab Course	RM	OJT/FP	RP	Cum. Cr	Marks	Degree
		Mandatory	Elective		RMC 4Cr	NA	NA	20Cr	Theory: 1Cr=25M Lab Course: 1Cr=50M	PG Diploma (After 03 Year B.Sc. Degree)
I 6.0	I	Major I 3Cr	MEC I 3Cr	LC-I 1Cr						
		Major II 3Cr		LC-II 1Cr						
		Major III 3Cr		LC-III 1Cr LC-IV 1Cr						
	II	Major IV 3Cr	MEC II 3Cr	LC-V 1Cr	NA	OJT-I 4Cr /FPI 4Cr	NA	20Cr	OJT/FP: 1Cr=25M	
		Major V 3Cr		LC-VI 1Cr						
		Major VI 3Cr		LC-VII 1Cr LC-VIII 1Cr						
Total	Major 18Cr	MEC 06Cr	LC-8Cr	RMC 04Cr	OJT/FP 04Cr	NA	40Cr			
Exit Option: PG Diploma with 40 Credits After 03 Year B.Sc. Degree										
II 6.5	III	Major VII 3Cr	MEC III 3Cr	LC-IX 1Cr	NA	NA	RP-I 4Cr	20Cr	RPI & RPII: 1Cr=25M	PG Degree (After 03 Year B.Sc. Degree)
		Major VIII 3Cr		LC-X 1Cr						
		Major IX 3Cr		LC-XI 1Cr LC-XII 1Cr						
	IV	Major X 3Cr	MEC IV 3Cr	LC-XIII 1Cr	NA	NA	RP-II 6Cr	22Cr		
		Major XI 3Cr		LC-XIV 1Cr						
		Major XII 3Cr		LC-XV 1Cr LC-XVI 1Cr						
Total	Major 18Cr	MEC 06Cr	LC-8Cr	NA	NA	RP 10 Cr	42Cr			
Cum. Total of I & II Year		Major 36Cr	MEC 12Cr	LC-16Cr	RMC 04Cr	OJT/FP 04Cr	RP 10Cr	40+42 =82 Cr		82 Credits
Exit Option: Two Years 04 Sem. PG Degree with 82 Credits After 03 Year UG Degree										

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Abbreviations:

1. MMC : Major Mandatory Course
2. MEC : Major Elective Course
3. RMC : Research Methodology Course
4. OJT : On Job Training (Internship/Apprenticeship)
5. FP : Field Project
6. RP : Research Project
7. Cum. Cr : Cumulative Credit



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Faculty of Science

Department of Microbiology

M.Sc. in Microbiology

Year & Level	Semester	Course Code	Course Title	Credits	No. of Hrs.
I 6.0	III	Code MMC-VII	Immunology	04	60
		Code	Lab Course-VI	01	30
		Code MMC-VIII	Advanced Molecular Biology	04	60
		Code	Lab Course-VII	01	30
		Code MMC-IX	Bioprocess Engineering	04	60
		Code	Lab Course-VIII	01	30
		Code MEC-III (A) OR Code MEC-III(B)	Quantitative Biology OR Clinical Microbiology	04	60
		Code	Lab Course-IX OR Lab Course-X	01	30
		Code RMC		04	60
	Total Credits			20	
	IV	Code MMC-X	Fermentation Technology	04	60
		Code	Lab Course-XI	01	30
		Code MMC-XI	Medical and Pharmaceutical Microbiology	04	60
		Code	Lab Course-XII	01	30

		Code MMC-XII	Bioinstrumentation	04	60
		Code	Lab Course-XIII	01	30
		Code MEC- IV(A) OR Code MEC- IV(B)	Bioinformatics, proteomics andgenomics OR Marine Microbiology	04	60
		Code	Lab Course-XIV OR Lab Course-XV	01	30
		Code FP-I	Field Project	04	60
	Total Credits			20	
Total Credits (Semester III & IV)				40	

Semester - Third



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Department of Microbiology

Course Type: MMC

VII

Course Title: Immunology

Course Code:

Credits: 03

Max. Marks: 75

Lectures: 45 Hrs.

Learning Objectives:

LO 1. To understand and be able to explain the defense system of human body.

LO 2. Study of various applications of Immunological techniques.

LO 3. To study Immunological system and immune responses

LO 4. study Hypersensitivity and autoimmune diseases.

Course Outcomes:

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

CO1. Explain and categorize different types of lymphoid organs as primary and secondary lymphoid organs.

CO2. Analyze Immunogen and immunoglobulin, Organization and Expression of Immunoglobulin genes, and MHC.

CO 3. Differentiate between different types of antigens and their role in disease causing.

CO 4. Explain process of sporulation in bacteria.

CO 5. Differentiate between MHC class I and class II structure of molecules Role of MHC in susceptibility of infection.

Unit No.	Title of Unit & Contents	Hrs
I	Organs and Cells of Immune System	12
	1. Primary lymphoid organs, thymus, bone marrow- structure and function. Lymphatic system, transporter of antigen introduction. 2. Secondary lymphoid organs, spleen and lymph node's structure and functions. Mucosal associated lymphoid tissue, (MALT). 3. Lymphoid cells - B- lymphocytes and T lymphocytes - maturation, activation and differentiation. Receptor on B and T cells. Mesangial cells, Microglial cells - Structures and secretions - interleukin I, hydrolytic enzymes, complement proteins, α - Interferon, Tumor necrosis factor (IL- 6, GM- CSF, G- CSF, M- CSF). 4. Immune response generated against parasite by granulocytes And Agranulocytes.	
	Unit Outcomes: UO 1. Student will be able explain different types of lymphoid organs as primary and secondary lymphoid organs	

II	Unit II: Antigens and Antibodies	11
	2 1. Types of antigens - Exogenous, Endogenous, Autologous, Xenogeneic and Allogenic. 2. General properties of antigens -Molecular size, chemical composition,foreignness, specificity 3. haptens, Epitopes: Amino Acid sequence /structure super antigens and adjuvants: Freund, completeand incomplete adjutant s, Depot effect, Macrophage activation, Effect of lymphocyte, antitumor action. 4. Immunoglobulins: Classes, Structure, distribution and function. Isotypic, Allotypic, Idiotypic determinants. Idiotypic network. Antibody production theories.	
	Unit Outcome: UO 1. Student will be able to explain Types of antigens	
III	Unit III: Organization and Expression of Immunoglobulin genes.	11
	3.1 Genetic model for Ig structure, Germ line and somatic variation models, Dryer andBennett two gene models, K chain genes, λ chain genes, Heavy chain genes, VH gene segments. 3.2 Gene rearrangement in VH region -In light chain, In heavy chain, Mechanism ofvariables region DNA rearrangement. 3.3 Generation of antibody diversity, Regulation of Ig gene transcription	
	UO 1. Student will apply this knowledge during study of Organization and Expression of Immunoglobulin genes.	
IV	Unit IV: Immunity and Immune Response	11
	1. Immunity – Definition, Types of Immunity 2. MHC class-I, MHC class-II - Structure of molecules, gene organization. Genetic polymorphism of molecule, Peptide interaction with molecule, 3. MHC and immune Responsiveness (Antigen processing and presentation). MHC and susceptibility to infectious diseases. Minor MHA - structure, role and genetics, HLA system, 4. Immune Response- Humoral and Cellular, Hypersensitivity, Immunology of Tumors, Immunodeficiency diseases, autoimmune diseases, Immunomodulation / Immunological tolerance.	
	Unit Outcomes: UO 1. Student will able to study Immunity and Immune Response	

Learning Resources:

- 1 A handbook of practical immunology by G. P. Talwar, Vikas Publishing House, New Delhi.
- 2 Genes VII by Benjamin Lewin, Oxford University Press.
- 3 Immunology (2nd edition) by C. Vaman Rao, Narosa publication.
- 4 Immunology (2nd edition) by Janis Kuby, W. H. Freeman and company.
- 5 Immunology (8th Edition) by D. M. Weir, Churchill Livingstone.
- 6 Roitt's Essential Immunology (9th edition) by Ivan Roitt, Blackwell Sciences.
- 7 Prokaryotic Development by V. W. Burn & I. J. Shimkots (2000). ASM. Press.
- 8 The Bacteria. Volume by I.C. Gunsalus and Roger Y. Stainer. Academic Press



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Department of Microbiology

Course Type: Lab Course

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

Course Code:

Credits: 01

Max. Marks: 50

Lectures: 30 Hrs.

Learning Objectives:

- LO 1. To Understand diverse Microbiological processes. Basic skills such as culturing microbes, maintaining microbes, safety issues related to handling of microbes, Good Microbiological practices etc.
- LO 2. Moderately advanced skills in working with microbes such as Pathogens.
- LO 3. The student will be equipped to take up a suitable position in academia or industry, and to pursue a career in research if so desired.

Course Outcomes:

After successful completion of this course student will

- CO 1. Acquire skills to perform different immunological reactions.
- CO2. Apply skills to perform serological diagnosis of diseases

Practical No.	Experiment
1	Antigen – Antibody reactions 1. Agglutination – Widal test A. Slide Test – Widal test B. Flocculation Test - Slide - VDRL, RPR (Quantitative and Qualitative) C. Complement fixation test - Coomb's test (demonstration)
2	Radial Immunodiffusion
3	Immunohaematology. DLC, TLC, RBC count
4	Separation of serum proteins by electrophoresis.
5	Preparation of 'H' antigen of <i>S. typhi</i> by Craigie's tube method.
6	Preparation of 'O' antigen of <i>S. typhi</i> by phenol agar method.

Social Activity:
Blood Group Testing Camp

Learning Resources:

- 1 A handbook of practical immunology by G. P. Talwar, Vikas Publishing House, New Delhi.
- 2 Genes VII by Benjamin Lewin, Oxford University Press.
- 3 Immunology (2nd edition) by C. Vaman Rao, Narosa publication.
- 4 Immunology (2nd edition) by Janis Kuby, W. H. Freeman and company.
- 5 Immunology (8th Edition) by D. M. Weir, Churchill Livingstone.
- 6 Roitt's Essential Immunology (9th edition) by Ivan Roitt, Blackwell Sciences.
- 7 Prokaryotic Development by V. W. Burn & I. J. Shimkots (2000). ASM. Press.
- 8 The Bacteria. Volume by I.C. Gunsalus and Roger Y. Stainer. Academic Press



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Department of Microbiology

Course Type: MMC-

VIII

Course Title: Advanced Molecular
Biology

Technology Course Code:

Credits: 03

Max. Marks: 75

Lectures: 45Hrs.

➤ Learning Objectives:

- LO 1. Understand Modern techniques in molecular biology.
- LO 2. Understand cloning methods of cloning.
- LO 3. Understand role of Recombinant DNA in industrial and forensic science field.
- LO 4. Understand manipulation of microbial genome for beneficial purpose.

Course Outcomes:

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

- CO 1. Describe and demonstrate techniques of gene cloning and categorize essential tools in genetic engineering and hybridization techniques.
 - CO 2. Compose polymerase chain reaction and apply PCR for molecular diagnosis of viral bacterial pathogens.
 - CO 3. Describe different immobilization techniques.
 - CO 4. Describe methods of DNA insertion into host cell and construction of cDNA.
- Apply plant transformation technology.

Unit No.	Title of Unit & Contents	Hours
I	Unit I: Enzymes of r DNA Technology	12
	1. Nucleases – Types and Mechanism of action Exonucleases (BAL 31 nuclease, Exonuclease I, III), Endonucleases (S1 nuclease). Restriction endonucleases. 2. DNA polymerase (DNA pol. I, T ₇ DNA Pol.) 3. DNA ligase, DNA Manipulating enzymes (Polynucleotide kinase, Phosphatase, Methylase, Topoisomerase and Ribonucleases, Terminal Transferase and Reverse Transcriptase).	
	Unit Outcome: UO 1. Student will explain Nomenclature of enzymes. UO 2. Student can explain enzyme modification.	
Unit No II	Cloning and Screening methodologies	11H

	1. Cloning Vectors (their structure, genealogy and derivatives): Plasmids (pBR 322 and pUC18). Bacteriophage lambda (λ), Cosmids, Phasmids and Phagemids as vectors. SV40vaccina/baculo vector. Expression vectors (Ti plasmid expression, Ri plasmid) Shuttle vectors, Integrative vectors 2. Artificial chromosome vectors (YACs, BACs, PACs). 3. Insertion of foreign DNA into the host cells: transformation, transfection: liposome fusion, microinjection, electroporation, biolistic, somatic cell fusion, gene transfer by pronuclear microinjection. 4. Cloning and expression in yeast (Saccharomyces). 5. 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 Outcome: UO 1. Student will be able to explain Cloning and expression UO 2. Student will be able to describe Cloning Vectors.	
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 diagnosis. 2. PCR in gene recombination, deletion, addition, overlap extension and SOEing 3. Gene probes: development and labeling of DNA and RNA probes 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. Student will be able to describe Nucleic acid amplification	
IV	Applications of rDNA technology and Legal issues	09

	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.	
	UO 1. Student will be able to describe Applications of rDNA	

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 India Ltd.
- 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. Academic press Inc, San Diego.
- 8) Methods in enzymology guide to molecular cloning techniques, vol. 152 S. L. Berger. Academic press. Inc, San Diego, 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. David H., Gelfand John J. Sninsky, Academic Press.
- 13) PCR technology- principles and application for DNA amplification by Henry A Erilch (Ed) Stockton Press. 1989.
- 14) Route maps in gene technology by M.R. Walker and R. Rapley, Blackwell science, 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, Wiley Blackwell, UK. 2006.
- 18) Ethics of Emerging Technologies: Scientific Facts and Moral Challenges. John Wiley and Sons Inc. Thomas F. Budinger and Miriam D. Budinger. 2006.

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Department of Microbiology

Course Type: Lab Course

Course Title: Lab Course –X (Based on MMC-VIII)

Course Code:

Credits: 01

Max. Marks: 50

Hours: 30

Learning Objectives:

- LO 1. Understand Basic molecular techniques.
- LO 2. Understand Determination of molecular size of DNA, and Plasmid.
- LO 3. Understand and design experiments to study gene expression in bacteria.
- LO 5. Understand gene cloning and its uses.

Course outcomes

After completion of course the student will be able to-

- CO 1. Isolation of DNA and Plasmid
- CO 2. PCR techniques.
- CO 3. Restriction mapping
- CO 4. Selection of Transformed cells.

Practical No.	
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) PCR application. Protocol for functional genomics by Michael A. Innis. David H., Gelfand John J. Sninsky, Academic Press.
- 2) PCR technology- principles and application for DNA amplification by Henry A Erilch (Ed) Stockton Press. 1989.
- 3) Route maps in gene technology by M.R. Walker and R. Rapley, Blackwell science, Oxford.
- 4) Molecular cloning by Sambrook J, Fritsch E.F and Maniatis, cold spring harbor laboratory press, New York.
- 5) Principles of Gene Manipulation and Genomics, Third Edition. S.B. Primrose, S.B. and R.M. Twyman, Blackwell Publishing Company, Oxford, UK. 2006
- 6) Gene Cloning and DNA Analysis: An Introduction. Fifth Edition. T.A. Brown, Wiley Blackwell, UK. 2006.
- 7) Ethics of Emerging Technologies: Scientific Facts and Moral Challenges. John Wiley and Sons Inc. Thomas F. Budinger and Miriam D. Budinger. 2006.



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Department of Microbiology

Course Type: MMC-IX

Course Title: Bioprocess Engineering

Course Code:

Credits: 03

Max. Marks: 75

Lectures: 45 Hrs.

Learning Objectives Course objectives:

- LO 1. Understand ancient microbial practice that is fermentation
- LO 2. Understand industrial utilization of microbial fermentation processes.
- LO 3. Understand upstream and downstream practices.
- LO 4. Understand process of isolation and manipulation of industrially important microbes.

Course outcomes: After completion of course the student will be able to-

CO 1. Describe basic modern design of bioreactors.

CO 2. Describe different types of cultures and its requirements.

CO 3. Describe importance of upstream and downstream processes.

CO 4. Explain the beneficial role of microorganisms and their enzymes in modern food production industries.

Unit No.	Title of Unit & Contents	Hours
I	Introduction to Industrial Bioprocess Engineering and Bioreactors	12
	1 Industrial microbiology and Bioprocess engineering 2 Construction and Design of Bioreactor- Different parts of the bioreactor, Baffles, Impellers, Foam separators, Air spargers, Culture vessel, Cooling and heating devices, Probes for on-line monitoring. 3 Continuous culture, types of bioreactor-Batches, Continuous flow stirred tank bioreactor, Packed bed bioreactor, bubble column bioreactor, Fluidized bed bioreactor, Trickle bed bioreactor. 4 Growth Kinetics- Batch Culture (Monod's equation) and Continuous Culture Chemostat and Turbidostat (Construction and Working). 5 Atomization in fermentation technology.	
	Unit Outcome: UO 1. Student will be able to describe Industrial microbiology and Bioprocess engineering	
II	Mass Transfer and Sterilization	11
	1. Transport phenomena in bioprocess system: Gas liquid mass transfer in cellular systems, 2. The oxygen requirement in industrial fermentation. 3. Determination of $K_L a$ values, Gassing out techniques.	

	4. Aeration/Agitation and its importance. 5. Medium sterilization, i) The Design of Batch sterilization processes calculation of Del factor. ii) The design of continuous sterilization processes	
	Unit Outcome: UO 1. Student will be able to describe Mass Transfer and Sterilization	
III	Upstream processing	10
	1. Screening of Industrial Microorganism and strain development program, 2. Maintenance Methods of stock culture and culture collection Industrial Important Microorganism 3. Formulation of media, Development of Inoculum. 4. Scale up of the fermentation process from shake flask to industrial level. 5. Solid state fermentation process.	
	Unit Outcomes: UO 1. Student will be able to describe Upstream processing	
IV	Down Stream Processing	12
	1. Downstream process: Introduction, 2. Separation of Insoluble material- Floatation, Filtration, Centrifugation, Sedimentation, 3. Emerging technologies for cell recovery. 4. Product isolation- Extraction, Solvent extraction, Aqueous two-phase system, sorption, Coagulation, Crystallization, Precipitation, Reverse osmosis, Ultra filtration, Absorption, Elution, Chromatography-Ion Exchange, Molecular Exclusion Chromatography, Affinity Chromatography. 5. Product Formulation –Packaging and labeling, FDA and BIS 6. Recent trends in Product recovery:	
	Unit Outcome: UO 1. Student will be able to describe Down Stream processing	

Learning Resources:

1. James E. Bailey and David F Ollis, Biochemical Engineering Fundamentals,
2. McGraw Hill Publication.
3. Shuler and FikretKargi, Bioprocess Engineering basic concepts, 2nd edition,
4. Prentice Hall publication.
5. Stanbury PF, Whitekar, A And Hall S J, Principles of fermentation
6. Technology, Pergam on Press.
7. Peppler and Perlmen, Microbial Technology, Vol I and II, Academic Press.
8. Cruger and Cruger, Biotechnology: A text Book of Industrial Microbiology. Fundamental Food Microbiology, Bibek Ray, ArunBhunia. 2013. Fifth Edition. CRC Press.
9. Food Spoilage Microorganism C Blackburn.2006. ms. Woodhead Publishing
10. Applied Dairy Microbiology Elmer H. Marth, James Steele. 2001., Second Edition. CRC Press.
11. Food Microbiology. Frazier W.C. and Westhoff C.D. 2008 Tata Mc Graw Hill Publishing Company Limited, New Delhi. Indian Edition.
12. Modern Food Microbiology, Jay James M., Loessner, Martin J., Golden, David A. 2004.. 7th ed



Rajarshi Shahu Mahavidyalaya, Latur (Autonomous)

Department of Microbiology

Course Type: Lab Course

Course Title: Lab Course –XI (Based on MMC IX)

Course Code:

Credits: 01

Max. Marks: 50

Hours: 30

Learning Objectives

- LO 1. To Understand isolation techniques of industrially important microbes and the effect of different physical parameter on it.
- LO 2. Understand isolation and estimation of enzyme, protein and amino acid.
- LO 3. Understand effect of various culture on fermentation process.
- LO 4. Understand effect of various culture on fermentation process.

Course outcome

After completion of course the student will be able to-

- CO 1. Isolate industrially important microbes.
- CO 2. Study different types of culture methods.
- CO 3. Isolation and estimation of biomolecules.

Practical No.	
1	Screening of Industrially important microorganisms for microbial processes. I. Protease II. Pectinase III. IAA
2	Cultivation of Isolates (From experiment 1) In desired medium and analysis of products.
3	Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer.
4	Optimization of conditions for production of Protease, Pectinase, IAA
5	Lab Scale production
6	Harvest and Recovery of product.
7	Assay of product (Specific)
8	Activity: Designing and Construction of Bioreactor

Learning Resources:

1. Stanbury PF, Whitekar, A And Hall S J, Principles of fermentation
2. Technology, Pergamon Press.
3. Pepler and Perlman, Microbial Technology, Vol I and II, Academic Press.
4. Cruger and Cruger, Biotechnology: A text Book of Industrial Microbiology. Fundamental Food Microbiology, Bibek Ray, ArunBhunia. 2013. Fifth Edition. CRC Press .
5. Food Spoilage Microorganism C Blackburn.2006. ms. Woodhead Publishing
6. Applied Dairy Microbiology Elmer H. Marth, James Steele. 2001., Second Edition. CRC Press.
7. Food Microbiology. Frazier W.C. and Westhoff C.D. 2008 Tata Mc Graw Hill Publishing Company Limited, New Delhi. Indian Edition.
8. Modern Food Microbiology, Jay James M., Loessner, Martin J., Golden, David A. 2004.. 7th ed



Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
Department of Microbiology

Course Type: MEC

III (A)

Course Title: Quantitative Biology

Course Code:

Credits: 03

Max. Marks:75

Lectures: 45 Hrs.

Learning Objectives

To understand role of statistics in biological field.

LO 1. To understand application of different statistical parameters.

LO 2. To use of computer for biological data assessment through statistics.

LO 3. To understand role of different statistical test for validation of experimental data.

Course outcomes

After completion of course the student will be able to-

CO 1. Explain basic of biostatistics, like mean, mode, standard deviation etc.

CO 2. Explain and understand the different methods that has been used in research like framing of hypothesis, research paper formulation, types of research papers etc.

CO 3. Describe working of computer application and it's uses.

Unit No.	Title of Unit & Contents	Hrs.
I	Introductory biostatistics and Measures of Central Tendency	12
	1. Introductory biostatistics: Sampling. Data collection and presentation: Types of data, Methods of data collection. Graphical (Histogram, frequency polygon and ogive curves, Box plot, Scatter plot, survival curves) and diagrammatic (Simple bar diagram, percentage bar diagram, multiple bar diagram, sub - divided bar diagram and pie diagram) representation of data. 2. Measures of central tendency: Arithmetic mean, mode, and median, Quartile and percentile. 3. Measures of Dispersion: Range, Standard deviation, variance and coefficient of variance. Standard Error and its significance. Unit Outcome: UO 1. Student will be able to describe Introductory biostatistics	
II	Tests of Significance and Designing of Experiment	12

	1. Tests of Significance: The concept of Null and alternative hypothesis. Parametric and non- parametric tests of significance (Chi square, t - test, F - test,). Correlation and Regression: Bi variate data and scatter diagram, Simple (linear) correlation and regression, Coefficient of correlation and regression and their properties. 2. Probability: Definition, Elementary properties, Types, Rules of probability. Probability distributions - Binomial, Poisson, Normal (Only definitions and problems). 3. Analysis of Variance: ANOVA. Experimental designs- Completely Randomized Design, Randomized Block Design.	
	Unit Outcome: UO 1. Student will be able to study Tests of Significance and Designing of Experiment	
III	Computer: Introduction and applications	12
	1. Introduction: Organization of computers. Classification of computers. Concept of hardware and software. Operating System (command line and WIMP). 2. Elementary ideas about programming languages and application packages for microbiologists. LIMS. 3. MS Office, MS word, MS PowerPoint, and MS excel. 4. Computer based statistical techniques and statistical packages (Basics and Introduction in Short): Features of statistical software's (free open source) Examples: SAS University Edition, Scilab, Statistical Lab.	
	Unit Outcomes: UO 1. Student will be able to study Computer: Introduction and applications	
IV	Research Methodology	09

	1. Introduction: Definition, Importance and meaning of research. Qualities of a good researcher. 2. Characteristics of research. Types of research. Steps in research. Identification and selection of research problems. Formulation of hypothesis. Literature search: Information sources. 3. Scientific writing: Basic concepts of scientific writing. Scientific Documents: Definition and types. 4. Basic structure of a Research Article: IMRAD format. Essential features of abstract, introduction, review of literature, materials, methods, results and discussion, conclusion and outcome. 5. Legal aspects of scientific authorship: Copyright considerations, Plagiarism and plagiarism detection software. Presenting and publishing research. Bibliometric measures (Impact factor & h - index).	
	Unit Outcome: UO 1. Student will be able to study Research Methodology	

Learning Resources:

- 1) Biostatistical methods by John M. Lachin. John Wiley & Sons.
- 2) Biostatistics- 7th edition by Wayne W. Daniel. John Wiley & Sons.
- 3) Sampling methods by Murthy M.N., Indian Statistical Institute, Kolkata.
- 4) Biostatistics by Arora and Malhan, Himalaya Publishing House
- 5) Fundamentals of Biostatistics (5th) by Bernard Rosner, Ed. Duxbury Thomson
- 6) Fundamentals of biostatistics by Irfan A Khan, Atiya Khanum. UkaazPublications.
- 7) Statistics for biologist by Campbell R.C (1974). Cambridge University Press,UK.
- 8) Statistics in biology Vol: 1 by Bliss, C.I.K (1967) Mc Graw Hill, New York.
- 9) Design and analysis of experiments by Montgomery D.C., John Wiley & Sons
- 10)How computer work (2000) by Ron White. Tech Media.
- 11)How the internet work (2000) by Preston Garlla Tech. Media.
- 12)Practical statistics for experimental biologist by Alastair C. Wardlaw. Wiley.
- 13)Research methodology methods and statistical techniques by Santosh Gupta.Deep & Deep Publications.
- 14)Research methodology methods and techniques by C.R. Kothari. New AgeInternational.
- 15)Research methods in Biological sciences by Palanisamy S. and M. Shanmugavelu. 1997. Palani Paramount publications, Tamilnadu. India
- 16)From Research to Manuscript- A Guide to Scientific Writing by MichaelJay Katz. Springer
- 17)How to write and publish a Scientific paper by R.A.Day
- 18)Scientific English: A Guide for Scientists and Other Professionals, Day,Robert; Sakaduski, Nancy (2011). Third Edition. ABC-CLIO.



Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Microbiology

Course Type: Lab Course

Course Title: Lab Course –XII (Based on MEC
III-A)

Course Code:

Credits: 01

Max. Marks: 50

Hours: 30

Learning Objectives Course Objectives:

- To study data validation by using statistical analysis.
- To study implementation of statistical formulas to different types of data.
- To learn computer application.

Specific Course Outcomes:

- Students apply statistical knowledge and to correlate statistically extracted value by performing knowledge based practical.
- Students Also acquires skill to represent data by using the computer knowledge of MS Word, Excel and power point presentation.

Practical No.	Experiment
1	Representation of statistical data by A)Histogram b) Ogive curve
2	Determination of statistical averages/central tendencies. a. Arithmetic mean b. Median c. Mode.
3	Determination of measure of dispersion. a. Mean deviation. b. Standard deviation and coefficient of variation. c. Quartile deviation.
4	Tests of significance-Applications of following. a) Chi-square test. b) t-test c) Standard error
5	Creating files, folders and directories.
6	Application of computers in biology using MS-office. a) MS-word b) Excel c) Power point.

7	Data presentation and analysis using MS Excel/Open-Source free Statistical Packages: a) Plotting graphs – bar charts, line graphs, pie charts, adding error bars b) Statistical analysis of data – Students t test, ANOVA, Chi square test, F test
8	Preparation and presentation of sample project .

Learning Resources:

- 1) Statistics in biology Vol: 1 by Bliss, C.I.K (1967) Mc Graw Hill, New York.
- 2) Design and analysis of experiments by Montgomery D.C., John Wiley & Sons
- 3) How computer work (2000) by Ron White. Tech Media.
- 4) How the internet work (2000) by Preston Garlla Tech. Media.
- 5) Practical statistics for experimental biologist by Alastair C. Wardlaw. Wiley.
- 6) Research methodology methods and statistical techniques by Santosh Gupta. Deep & Deep Publications.
- 7) Research methodology methods and techniques by C.R. Kothari. New Age International.
- 8) Research methods in Biological sciences by Palanisamy S. and M. Shanmugavelu. 1997. Palani Paramount publications, Tamilnadu. India
- 9) From Research to Manuscript- A Guide to Scientific Writing by Michael Jay Katz. Springer
- 10) How to write and publish a Scientific paper by R.A. Day
- 11) Scientific English: A Guide for Scientists and Other Professionals, Day, Robert; Sakaduski, Nancy (2011). Third Edition. ABC-CLI.



Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Microbiology

Course Type: MEC-
III (B)

Course Title: Clinical Microbiology

Course Code: --

Credits: 03

Max. Marks: 75

Lectures: 45 Hrs.

Learning Objectives:

- LO1. To study host parasite interactions.
- LO2. To study important Bacterial, protozoan, fungal diseases in human being
- LO3. To study important viral diseases.
- LO4: To learn methods used for diagnosis of diseases.

Course Outcomes:

After completion of course the student will be able to-

- CO1. Describe host parasite relationships, virulence of pathogen and mode of transmission of infection.
- CO2. Explain aetiology, pathogenesis, symptomatology and treatment of Bacterial, protozoan, fungal disease.
- CO3. Explain aetiology, pathogenesis, symptomatology and treatment of viral diseases.
- CO4. Understand the microbial nanotechnology
- CO5. Describe methods of diagnosis of diseases.

Unit No.	Title of Unit & Contents	Hrs.
I	Host parasite relationships.	12
	1. Early discovery of pathogenic microorganisms. 2. Development of medical microbiology as a discipline. 3. Normal microbial flora of the human body and their importance. 4. Host parasite relationships: Definitions: infection, invasion, pathogen, virulence and pathogenicity, toxigenicity, Aggressive factors of pathogen 5. Quantitative measures of virulence: minimal lethal dose (MLD), LD 50, ID 50, TCID 50. depolymerising enzymes, organotrophism. 6. Transmission and spread of infection. carrier, types of carriers. Course of infection. 7. Molecular diagnosis of diseases: basic principles and techniques involving nucleic acid in relation to laboratory evaluation of disease.	

	Unit Outcomes: UO 1. Student will be able to study Host parasite relationships.	
II	Important Bacterial , protozoan, fungal diseases of human beings	12
	(Short description of causal agent, pathogenesis, diagnosis and treatment) 1. Bacterial diseases: Staphylococcal infections , Typhoid, Cholera, Syphilis, Gonorrhoeae , Tuberculosis, Diphtheria, Tetanus, Botulism, Meningitis, Pneumonia, Enteritis. 2. Introduction to protozoan, fungal and helminthes diseases: Malaria, Kalaazar, Giardiasis, , toxoplasmosis & leishmaniasis; 3. Superficial, subcutaneous, systemic and opportunistic mycoses .	
	Unit Outcome: UO 1. Student will be able to study Important Bacterial , protozoan, fungal diseases of human beings	
III	Important viral diseases of human beings	12
	1. Study of important viral diseases with reference to causative agent, pathogenesis, 2. symptoms, transmission, control measures, epidemiology and diagnosis. 3. Hepatitis, influenza, rabies, polio, chicken pox, Mumps and Measles, herpes, dengue fever, AIDS and viral cancers. 4. An overview of emerging and re emerging viral diseases: Ebola, SARS, Hanta and 5. Chikungunya.	
	Unit Outcomes: UO 1. Student will be able to study Important viral diseases of human beings	

IV	Diagnostic tests and drug resistance	
	1. Principle of different diagnostic tests (ELISA, Immunofluorescence, agglutination based tests). 2. Modern approaches for diagnosis of infectious diseases: Basic concepts of gene probes, dot hybridization and PCR assays. 3. Antimicrobial therapy; Antibiotics and their classification, Mechanism of action of various chemotherapeutic agents (antibacterial, antifungal and antiviral). 4. Antimicrobial resistance: Multidrug efflux pumps, X- MDR M. tuberculosis, Methicillin-resistant <i>S. aureus</i> (MRSA), various methods of drug susceptibility testing. 5.	
	Unit Outcomes: UO 1. Student will be able to understand Diagnostic tests and drug resistance	

Learning Resources:

- 1) Medical Microbiology. N.C.Dey and T.K. Dey. Allied agency, Culcutta.
- 2) Microbiology by Davis, Dulbecco, Eisen Harper and Row Maryland.
- 3) Text book of Microbiology by R. Anantharayanan, C.K. Jayaram Panikar, Orient Longman, Mumbai.
- 4) Medical microbiology by Chakraborty.
- 5) Medical Microbiology: Prep Manual for Under Graduates by Nagoba, Elsevier.
- 6) Manual of Clinical Microbiology, Karen C. Carroll (Editor), Michael A. Pfaller ASM publications.
- 7) Essentials of Medical Microbiology by Apurba Sankar Sastry and Sandhya Bhat K, Jaypee Brothers Medical Publishers.
- 8) Basic Medical Microbiology E-Book, Patrick R. Murray ·2017 Elsevier Health Sciences

॥ आरोह तमसो ज्योतिः॥

Rajarshi Shahu Mahavidyalaya,
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Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Microbiology

Course Type: Lab Course

**Course Title: Lab Course –XII (Based on MEC
III-B)**

Course Code:

Credits: 01

Max. Marks: 50

Hours: 30

Learning Objectives:

- LO1. To study normal flora of host.
- LO 2. To study cultural and biochemical characteristics of pathogens
- LO 3. To study virulence factors of pathogens.
- LO 4. To learn different methods for diagnosis of diseases.

Course outcomes

After completion of course the student will be able to-

- CO 1. Design experiment for isolation of normal flora of host.
- CO 2. Perform laboratory diagnosis of diseases by culturing in the laboratory
- CO 3. Determine presence of virulence factors of pathogens.

Practical No.	Practical
1	Perform serodiagnosis of diseases to study normal micro-flora of Skin, Respiratory tract, Gastro-intestinal tract.
2	To study virulence factors of Staphylococcus aureus: Haemolysin and coagulases.
3	To study antimicrobial susceptibility of pathogens.
4	To determine the minimal inhibitory concentration (MIC) of an antibiotic on bacteria and Fungi.
5	Determination of Blood group and Rh factor.
6	Serological tests: Immuno- electrophoresis, Sandwich ELISA,
7	To perform immune diffusion test -Ochterlony double diffusion, agglutination test.
8	Haemoglobin estimation.
9	Total red blood cell count, total white blood cell count,

Learning Resources:

- 1) Medical Microbiology. N.C.Dey and T.K. Dey. Allied agency, Culcutta.
- 2) Microbiology by Davis, Dulbecco, Eisen Harper and Row Maryland.
- 3) Text book of Microbiology by R. Anantharayanan, C.K. Jayaram Panikar, Orient Longman, Mumbai.
- 4) Medical microbiology by Chakraborty.
- 5) Medical Microbiology: Prep Manual for Under Graduates by Nagoba, Elsevier.
- 6) Manual of Clinical Microbiology, Karen C. Carroll (Editor), Michael A. Pfaller ASM publications.
- 7) Essentials of Medical Microbiology by Apurba Sankar Sastry and Sandhya Bhat K, Jaypee Brothers Medical Publishers.
- 8) Basic Medical Microbiology E-Book, Patrick R. Murray ·2017 Elsevier Health Sciences

Semester - Fourth



॥ आरोह तमसो ज्योतिः ॥

Rajarshi Shahu Mahavidyalaya,
Latur (Autonomous)



Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Microbiology

Course Type: MMC-X

Course Title: FERMENTATION TECHNOLOGY

Course Code:

Credits: 03

Max. Marks: 75

Lectures: 45Hrs.

Learning Objectives:

- LO.1 To understand versatile fermentation process of microbes.
- LO.2 To understand economical importance of multiple fermentation products.
- LO.3 To understand and use of fermented products in therapies.
- LO.4 To understand importance of intellectual property rights and patents.

Course Outcomes:

After completion of course the student will be able to-

- CO1 Understand and explain different types of fermentation and industrial production of citric acid, lactic acid, enzymes, amino acid and alcoholic beverages, beer, wine.
- CO2. Understand about antibiotics and their production.
- CO3 Understand modern trends of microbial productions such as bio plastics, biopolymer, biofertilizer, bioinsecticides. Able to design and construct model of biogas production.
- CO4 Use techniques of enzyme immobilization and its application in food pharmaceutical and chemical industries. Students become aware of procedure of IPR patents trademarks, copyrights.

Unit No.	Title of Unit & Contents	Hrs
I	Microbial Fermentations	12
	1. Metabolic pathways and metabolic control mechanisms. 2. Industrial production of citric acid, lactic acid, acetic acid. 3. Industrial production of Acetone- butanol, Lysine and Glutamic acid. 4. Alcoholic beverages, distilled beverages. Industrial production of enzymes (alpha amylase, lipase, xylase, pectinases, proteases) 5. Some industrial techniques for whole cell and enzyme immobilization. 6. Application and advantages of cell and enzyme immobilization in pharmaceutical, food and fine chemical industries	
	Unit Outcomes: UO 1. Student will be able to understand Microbial Fermentations	

II	Microbial production of therapeutic compounds	12
	1. Microbial production of antibiotics Beta-Lactam Antibiotics, aminoglycosides, ansamycines (Rifamycin), 2. Industrial production of Peptide antibiotics (Quinolones), 3. Microbial Transformation and Steroids and Sterols. 4. Vit.B-12 and riboflavin fermentation.	
	Unit Outcome: UO 1. Student will be able to understand Carbohydrate Metabolism	
III	Modern trends in microbial production	12
	1. Modern trends in microbial production of bioplastics (PHB,PHA), Biopolymer (dextran, alginates, xanthan, pullulan). 2. Biofertilizer (nitrogen fixer Azotobacter, phosphate solubilising microorganisms) 3. Single cell protein production 4. Useful features of biofuels. The substrate digester and the microorganisms in the process of biogas production (Biomethanation). 5. Production of bioethanol from sugar, molasses, starch and cellulosic materials. 6. Microbial production of hydrogen gas, biodiesel from hydrocarbons.	
	Unit Outcomes: UO 1. Student will be able to understand Metabolism of Organic Nitrogenous Compounds	
IV	Intellectual Property Rights (IPR), Patents	09
	1. Intellectual Property Rights (IPR), Patents, Trademarks, copyrights, secrets, Patenting of biological materials, International co-operation, Obligations with patent applications, Trademarks and geographical indications 2. Implication of patenting, current issues, hybridoma technology etc. 3. IPR and plant genetic resources (PGRs) Patenting of higher plants and animals, transgenic organisms and isolated genes, patenting of genes and DNA sequences, plant breeders right and farmers rights.	
	Unit Outcomes: UO 1. Student will be able to understand Metabolism of lipids and hydrocarbons	

Learning Resources:

1. Annual report in fermentation processes by D. Pearlman, Academic Press
2. Biology of industrial microorganisms by A. L. Demain.
3. Biotechnology. A Text Book of Industrial Microbiology by Creuger and Creuger. Sinauer associates.
4. Fundamentals of Biochemical Engineering by Bailey and Ollis.
5. Genetics and Biotechnology of Industrial Microorganisms by C. L. Hershnergey, S.W. Queener and Q. Hegeman. Publisher ASM. Ewesis ET. Al 1998 Bioremediation Principles. Mac Graw Hill.
6. Industrial microbiology by G. Reed (ed), CBS publishers (AVI publishing comp.)
7. Manual of Industrial Microbiology and Biotechnology 2nd edition by Davis J.E. and Dmain A. L. ASM Publication.



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Rajarshi Shahu Mahavidyalaya,
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Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Microbiology

Course Type: Lab Course

Course Title: Lab Course –XIII (Based on MMC-X)

Course Code:

Credits: 01

Max. Marks: 50

Hours: 30

Learning Objectives

LO 1. To study different methods of production of different microbial ,antibiotics,enzymes, amino acids

LO 2. To understand methods of production of SCP.

LO 3. To understand methods of production of biofertilizers

Course outcomes:

CO 1. Students able to design experiments for production of valuable bioproducts in the laboratory.

CO 2 Students Also acquires skill and can design production of biofertilizers Estimate Biomolecules

Practical No.	Experiment
1	Production and characterization of citric acid using <i>A. niger</i> .
2	Microbial production of glutamic acid.
3	Production of rifamycin using <i>Nocardia</i> strain.
4	Comparison of ethanol production using various organic wastes/raw materials. (Free cells / immobilized cells).
5	Laboratory scale production of biofertilizers. (Nitrogen fixer/ Phosphate solubilizers/Siderophore producers).
6	Microbial production of dextran by <i>Leuconostoc mesenteroids</i> .
7	Microbial production of hydrogen gas by algae.
8	Enzymatic clarification of fruit juices.
9	Culturing of <i>Chlorella</i> / <i>Spirulina</i> .

Rajarshi Shahu Mahavidyalaya,
Latur (Autonomous)



Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Microbiology

Course Type: MMC-
XI

Course Title: Medical and
Pharmaceutical Microbiology

Course Code:

Credits: 03

Max. Marks: 75

Lectures: 45 Hrs.

LO 1. To understand different antimicrobial substance and their mode of action

LO 2. To understand maintenance of antimicrobial substance

LO 3. To working of biosensors and its application..

LO 4. To understand different parameters and safety measures for use of antimicrobial agents.

Course outcomes

After completion of course the student will be able to-

1. Student have the knowledge and mechanism of action of antibiotics, synthetic antimicrobial agents, chemical disinfectants, antiseptic and preservatives. Also have knowledge of antibiotic resistance in bacteria
2. Student able to evaluate microbial production and spoilage of pharmaceutical products. Design manufacturing procedure. Derive pharmaceuticals products by microbial fermentation process
3. Able to understand government regulatory practices, application of biosensor and microbial enzyme in pharmaceuticals.
4. Able to recognize good manufacturing practices and good laboratory practices. Apply quality assurance and quality management in pharmaceuticals. Use safety in microbiology.

Unit No.	Title of Unit & Contents	Hours
I	Antibiotics, synthetic antimicrobial agents	12
	1.1 Antibiotics and synthetic antimicrobial agents (Aminoglycosides, β lactams, tetracyclines, ansamycins, macrolid antibiotics). Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis). 1.2 Antifungal antibiotics, antitumour substances. Peptide antibiotics, chloramphenicol, sulphonamides and antimicrobial agents. Chemical disinfectants, antiseptics and preservatives, 1.3 Molecular principal of drug targeting, Drug delivery system in gene therapy. 1.4 Bacterial resistance to antibiotics, Penetrating defenses (cellular permeability barrier, cellular transport system and drug diffusion).	

	Unit Outcome: UO 1. Student will be able to understand Antibiotics, synthetic antimicrobial agents	
II	Microbial production and spoilage of pharmaceutical products	12
	1. Microbial production and spoilage of pharmaceutical products (sterile injectable, non-injectable, ophthalmic preparation and implants) and their sterilization. 2. Manufacturing procedure and in process control of pharmaceuticals. Other pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase). 3. New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines	
	Unit Outcome: UO 1. Student will be able to understand Microbial production and spoilage of pharmaceutical products.	
III	Regulatory practices, biosensors and applications in pharmaceuticals	12
	1 Financing R & D capital and market outlook, IP, BP, USP. 2 Government regulatory practices and policies, FDA perspective. Reimbursement of drug and biological, legislative perspective. 3 Rational drug design 4 Biosensors in pharmaceuticals..	
	Unit Outcomes: UO 1. Student will be able to understand Regulatory practices, biosensors and applications in pharmaceuticals.	
IV	Quality assurance and validation	09

	1. Good manufacturing practices (GMP) and Good laboratory practices (GLP) in pharmaceutical industry. 2. Regulatory aspects of quality control. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. 3. Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, radiation, gaseous and filter sterilization). 4. Chemical and biochemical indicators. Safety in microbiology laboratory.	
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Unit No.	Title of Unit & Contents	Hours
	Unit Outcome: UO 1. Student will be able to understand Quality assurance and validation	

Learning Resources:

1. Analytical Microbiology by Fredrick Kavanagh volume I &II. Academic Press NewYork. Biotechnology – Expanding Horizon by B.D. Singh., First Edition, Kalyani Publication, Delhi. Biotechnology by H.J. Rhem& Reed, vol 4 VCH publications, Federal Republic of Germany.
2. Drug carriers in biology & medicine by Gregory Gregoriadis. Acedemic Press NewYork.
3. Good manufacturing practices for Pharmaceuticals By Sydney H. Willing, MurrayM. Tuckerman, Willam S. Hitchings IV. Second edition Mercel Dekker NC New York.
4. Lippincott's illustrative Reviews: Pharmacology Edition: 02 Maryjnycck by Lippincott's review Publisher Pheladelphia 1997.
5. Pharmaceutical Biotechnology by S. P. Vyas& V.K. Dixit. CBS publishers & distributors, New Delhi.
6. Pharmaceutical Microbiology by W. B. Hugo & A.R. Russel Sixth Edition. Blackwell Scientific Publications.
7. Pharmacognosy by Gokhle S.D., KoKate C.K. Edition: 18, Nirali Publication.
8. Principles of medicinal chemistry Vol. 1 by Kadam S.S., Mahadik K.R., Bothra K.G. Edition: 18, Nirali Publication.
9. Quality Assurance in Microbiology by Rajesh Bhatia, Rattan LalIhphunjani. CBS publishers & distributors, New Delhi.
10. Quality control in the Pharmaceutical industry by Murray S. Cooper Vol. 2, Academic Press New York.
11. Quniolinone antimicrobial agents by David C. Hooper, John S. Wolfson. ASM Washington DC.

Rajarshi Shahu Mahavidyalaya,
Latur (Autonomous)



Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Microbiology

Course Type: Lab Course

Course Title: Lab Course –XIV (Based on MMC-XI)

Course Code:

Credits: 01

Max. Marks: 50

Hours: 30

Learning Objectives:

1. To study multiple screening procedure and statistical test for pharmaceutical substances.
2. To study production of multiple antimicrobial substances. To learn antimicrobial activity of commercially available synthetic chemicals.

Course Outcomes:

1. Students able to apply bioassay procedure to for pharmaceutical products.
2. Students Also acquire knowledge and skills to check microbial contamination of pharmaceutical products.

Practical No.	
1	Spectrophotometric/ Microbiological methods for the determination of Griseofulvin.
2	Microbial production and Bioassay of Penicillin.
3	Bioassay of Chloramphenicol/Streptomycin by plate assay method
4	Screening, Production and assay of therapeutic enzymes: Asperginase/beta lactamase.
5	Determination of MIC and LD50 of Ampicillin / Streptomycin.
6	Sterility testing by using <i>B. subtilis</i> .
7	Determination of D-value and Z-value for heat sterilization in pharmaceuticals.
8	Determination of antimicrobial activity of chemical compounds (like phenol, resorcinol and formaldehydes) Comparison with standard products.
9	Spectrophotometric/ Microbiological methods for the determination of Griseofulvin.
10	Microbial production and Bioassay of Penicillin.



Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Microbiology

Course Type: MMC-XII

Course Title: Bioinstrumentation

course code:

Credits: 03

Max. Marks: 75

Lectures: 45 Hrs.

Learning Objectives:

- To introduce the basic concept and practices of biosafety in microbiology laboratory
- To provide knowledge about principle, working and applications of various chromatography, analytical, spectroscopic and radio isotopic techniques

Learning Outcomes:

The students able to

- Explain the various separation techniques and its instrumentation
- Define and explain various fundamentals of spectroscopy, qualitative and quantitative analysis and characterize functionalities of biomolecules by using spectroscopic techniques.
- Describe the principle and working of various radiation detectors

Unit No.	Title of Unit & Contents	Hours
I	Laboratory techniques	12
	1.1 Biosafety in microbiological laboratories a. General safety measures b. Personal protection c. Chemical and Biological hazards d. Spillage and Waste disposal, First aid 1.2 Theory, Principle, Working and Applications of a. pH meter b. Laminar Air Flow 1.3 Efficacy testing protocols for a. Autoclave, b. pH meter c. Laminar Air Flow. 1.4 Centrifuge machine types and Centrifugation a. Differential b. Rate zonal c. Isopycnic d. Density gradient, 1.5 Rotor types and Ultra centrifugation. 2	
	Unit Outcome: UO 1. Student will be able to understand Laboratory techniques	

II	Chromatography Techniques	12
	1. Theory, Principle, Apparatus, Methods and Applications of - Paper Chromatography - Thin Layer Chromatography (TLC) - Gel Filtration Chromatography - Ion Exchange Chromatography - Affinity Chromatography - Gas Chromatography - HPLC.	
	Unit Outcome: UO 1. Student will be able to understand Chromatography Techniques	
III	Electrophoretic Techniques	12
	1 Theory, Principle, Apparatus, Methods and Applications of - Paper Electrophoresis, - Polyacrylamide Gel Electrophoresis (PAGE), - Agarose Gel Electrophoresis. Principle and Applications of - Iso-electric Focusing - Immuno Electrophoresis	
	Unit Outcomes: UO 1. Student will be able to understand Electrophoretic Techniques	
IV	Spectroscopic and Radio-isotopic Techniques	09
	1. Principle, Working, Instrumentation and Applications of - UV/Vis spectroscopy, - NMR spectroscopy, - Mass spectroscopy, 2. Introduction to radioisotopes and their biological applications 3. Principles and Applications of - Geiger Muller (GM) counter - Autoradiography	
	Unit Outcome: UO 1. Student will be able to understand Electrophoretic Techniques Spectroscopic and Radio-isotopic Techniques	

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Learning Resources:

1. Biochemistry. 6th Edition by Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Freeman, New York.
2. Biophysics: An Introduction by Cotterill, R. M. J. (2002). John Wiley & Sons, England.
3. Principles of protein X-ray crystallography by Drenth, J. (2007). 3rd Ed. Springer, Germany.
4. Biochemistry. 3rd edition by Garrett, R. H. and Grisham, C. M. (2004). Brooks/Cole, Publishing Company, California.
5. Understanding NMR Spectroscopy by Keeler, J. (2002). John Wiley & Sons, England.
6. Bioinformatics: sequence and genome analysis by Mount, D. W. (2001). Cold Spring Harbor Laboratory Press, New York.
7. Biophysics by Pattabhi, V. and Gautham, N. (2002). Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
8. Principles and Techniques of Biochemistry and Molecular Biology by Wilson Keith and Walker John (2005), 6th Ed. Cambridge University Press, New York.
9. Proteins NMR Spectroscopy: Principles and Practice by Cavanagh John et.al. (1995), Academic Press
10. Molecular Biophysics: Structures in Motion by Daune M. and W. J. Duffin (1999), Oxford University Press.
11. Methods in Modern Biophysics by Nalting B. and B. Nalting (2003) Springer Verlag
12. Computational Analysis of Biochemical Systems by Voit E. O. (2000) Cambridge University Press.
13. Physical Biochemistry: Applications to Biochemistry and Molecular Biology by Freilder, Freeman, San. Francisco, 1976



Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Microbiology

Course Type: Lab Course

Course Title: Lab Course –XV (Based on MMC-XII)

Course Code:

Credits: 01

Max. Marks: 50

Hours: 30

Learning Objectives

1. To provide practices of biosafety in microbiology laboratory
2. To provide hands on of various instrumental techniques used in microbiological analysis Learning Outcomes:
3. The students acquire expertise in various analytical techniques used in research and industries in the field of microbiology

Course outcomes

After completion of course the student will be able to-

CO 1. Students are enabled to isolate thermophiles, Halophiles by studying different parameters.

CO 2. Isolation of thermophiles from hot water spring (Study at least one thermo stable enzyme).

Practical No.	
1	Efficacy testing of autoclave employing chemical and biological autoclave indicators.
2	Standardization of pH meter using standard buffers.
3	Studies on pH titration curves of amino acids/acetic acid and determination of pKa values and Handerson-Hasselbach equation.
4	Separation of bacterial lipids/amino acids/sugars/organic acids by TLC and Paper Chromatography.
5	Study of UV absorption spectra of macromolecules (protein, nucleic acid, bacterial pigments).
6	Paper Electrophoresis of proteins.
7	Separation of Proteins/Nucleic acids by gel electrophoresis.

Learning Resources:

1. Biochemical Techniques: Theory and Practice by Robyt, John F.; White, Bernard J. Waveland Press, Inc., U.S.A. Published: 1990.
2. Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler, Timothy A. Nieman: (Saunders Golden Sunburst Series) published by Wadsworth Pub Co. 2007
4. Biophysical chemistry. Principles and techniques by Upadhyay A, Upadhyay K, Nath N: Himalaya Publishing House, Mumbai. 1997.
5. Brocks Biology of Microorganisms (Eleventh Edition) by Michael T. Madigan, John M. Martinko (2006), Pearson Prentice Hall.



Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)

Department of Microbiology

Course Type: MEC IV (A)

Course Title: Bioinformatics, proteomics and genomics

Course Code:

Credits: 03

Max. Marks: 75

Lectures: 45 Hrs.

Learning Objectives

1. To understand role bioinformatics in biological data analysis
2. To understand application biological database and various online tools.
3. To use of computer base software to manipulate genomic database.
4. To understand source of proteomics and genomics database.

Course outcomes

After completion of course the student will be able to-

1. understand various bioinformatics tools, databases available and sequence analysis. Gain knowledge on database concept, management, and retrieval along with utilization in gene and protein analysis.
2. Retrieve information from available databases and use them for microbial identifications and drug designing.
3. Gain ability to modify gene and protein structures in simulated systems.
4. Gain basic knowledge of statistics and tools used for several quantitative analyses in microbiology. Studying proteins. Proteomics databases.

Unit No.	Title of Unit & Contents	Hrs.
I	Basics of Bioinformatics	12
	• Introduction: Definition, history, components, and applications of bioinformatics. • Internet and bioinformatics. Data mining- Process, tasks, techniques and applications. • Database: Database management system (DBMS), • Sequence alignment: Pair wise alignment, global and local alignment. Similarity matrices (PAM, BLOSUM). Searching sequence databases using BLAST and FASTA. • Pair wise sequence alignment using dynamic programming (Needleman-Wunsch and Smith-Waterman algorithms)	

	Unit Outcome: UO 1. Student will be able to understand Basics of Bioinformatics	
II	Biological databases and Multiple sequence alignment	12
	1. Biological databases: PubMed, Metadatabase(Entrez-NCBI), Nucleic acid sequence databank (DDBJ, GenBank and EMBL). 2. Protein databases: Sequence database (PIR, Swiss-Prot, Pfam, and PROSITE), 3. Structure database (PDB), Classification database (CATH and SCOPE). 4. Molecular visualizing tool (RasMol and MOLMOL) 5. Multiple sequence alignment: Progressive and iterative alignment and tools based on these algorithms- Clustal W and Mult Align. 6. Phylogenetics: Molecular Evolution, Phylogenetic tree-types constructions and basic tools for phylogenetic analysis.	
	Unit Outcome: UO 1. Student will be able to understand biological databases and Multiple sequence alignment	
III	Microbial Genomics	12
	1. Microbial Genome Structure and organization. Principles of microbial genomics such as sequencing, assembly of microbial genomes 2. Methods for gene sequence analysis, types of genomics, analysis of gene expression, significance of genome sequencing. Microbial genome projects, Human Microbiome Project. 3. DNA analyses for repeats (Direct and inverted) 4. Benefits of Pharmacogenomics.	
	Unit Outcomes:	

	UO 1. Student will be able to understand Microbial Genomics	
IV	Microbial Proteomics	09
	1.Types of proteomics, tools for proteomics-separation and isolation of proteins. 2.Protein Structure Visualization, Comparison, Protein structure prediction. Homology or comparative modeling. 3.Protein function prediction- Introduction to the concepts of 4. molecular modeling. Structure based drug designing 5. by automated docking. Introduction to Molecular Docking 6.	
	Unit Outcome: UO 1. Student will be able to understand Microbial Proteomics	

Learning Resources:

1. Bioinformatics Methods and Protocols - Misener.
2. Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins. 2nd Edition by Baxevanis.
3. Bioinformatics - from Genomes to drug. 2 volumes by Lenganer.
4. Bioinformatics 2000 by Higgins and Taylor OUP.
5. Bioinformatics and molecular evolution-P.G. Higgs & T. K. Attwood, 2005 Blackwell Publishing.
6. Bioinformatics by David Mount.
7. Bioinformatics by Prakash S. Lohar., MJP publisher.
8. Data Mining for Genomics and Proteomics-Analysis of Gene and Protein Expression Data by D. M. Dziuda ,Willey publishers
9. Genomics-Fundamentals and Applications by Supratim Choudhary & David B., Carlson
10. Bioinformatics: Sequence, structure and Data Bank: A Practical Approach by Higgins.
11. Computer analysis of sequence data by Colte.
12. Essential Bioinformatics by Jin Xiong 2006 Cambridge University press
13. Introduction to Bioinformatics in Microbiology by Henrik Christensen 2018, Springer Nature

Switzerland AG

14. Functional Genomics. A Practical Approach Edited by Stephen P Hunt and Rick Livey (OUP) 2000.
15. Introduction to Bioinformatics by Altwood.
16. Protein Engineering: Principles and Practice by Cleland.
17. Microarray- Gene expression Data analysis by Causton, Brazma 2003 Blackwell Publishing
18. Protein Biotechnology by Felix Franks. Humana Press, Totowa, New Jersey.

Web sites for Proteomics and Genomics

- 1) www.geneprot.com.
- 2) www.hybrigenis.com
- 3) www.mdsproteomics.com
- 4) www.stromix.com



Rajarshi Shahu Mahavidyalaya, Latur

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Department of Microbiology

Course Type: Lab Course

Course Title: Lab Course –XVI, Based on MEC IV (A)

Course Code:

Credits: 01

Max. Marks: 50

Hours: 30

Learning Objectives:

1. To study data validation by using statistical analysis.
2. To study implementation of statistical formulas to different types of data.
3. To learn computer application.

Course Outcomes:

1. Students apply statistical knowledge and to correlate statistically extracted value by performing knowledge based practical.
2. Students Also acquires skill to represent data by using the Computer knowledge of MS Word, Excel and power point presentation.

Practical No.	Experiment
1	Studies of public domain databases for nucleic acid and protein sequences.
2	Determination of protein structure (PDB) by using RASMOL software
3	Genome sequence analysis by using BLAST algorithm
4	Protein sequence analysis by using BLAST algorithm

Learning Resources:

19. Bioinformatics Methods and Protocols - Misener.
20. Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins. 2nd Edition by Baxevanis.
21. Bioinformatics - from Genomes to drug. 2 volumes by Lenganer.
22. Bioinformatics 2000 by Higgins and Taylor OUP.
23. Bioinformatics and molecular evolution-P.G. Higgs & T. K. Attwood, 2005 Blackwell Publishing.
24. Bioinformatics by David Mount.
25. Bioinformatics by Prakash S. Lohar., MJP publisher.
26. Data Mining for Genomics and Proteomics-Analysis of Gene and Protein Expression Data by D. M. Dziuda, Wiley publishers
27. Genomics-Fundamentals and Applications by Supratim Choudhary & David B., Carlson
28. Bioinformatics: Sequence, structure and Data Bank: A Practical Approach by Higgins.



**Shiv Chhatrapati Shikshan Sanstha's
Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
PG First Year**

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 Tutorial 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.

शिव छत्रपती
शिक्षण संस्था
लातूर

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**Shiv Chhatrapati Shikshan Sanstha's
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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			
Research Methodology	100	10	10	20	10	-	-	40	60	100
DSC/DSE	75	05	10	15	10	-	-	30	45	75
Lab Course	50	-	-	-	-	05	20	-	25	50
Field Project	100	10	10	20	10	-	-	40	60	100

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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**Shiv Chhatrapati Shikshan Sanstha's
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Semester End Examination Paper Pattern - I

Course: 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

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