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 (IIndYear)

Approved by

Board of Studies in Microbiology

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

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
Rajarshi Shahu
Mahavidyalaya, Latur
(Autonomous)

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 Rajarshi Shahu
Mahavidyalaya, Latur (Autonomous)

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

Shiv Chhatrapati Shikshan Sanstha's

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Department of Microbiology

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Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

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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:	
PO1	**Disciplinary Masters Knowledge** Comprehensive in-depth relevant scientific knowledge and its execution in the specific area of study.
PO2	**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
PO3	**Problem Solving Skills** Analytical skills to solve problems, evaluate situations and act responsibly to communicate, cooperate and lead the team.
PO4	**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.
PO5	**Self-Directed Life-long Learning** Ability to prepare for NET, SET, GATE and other national and international competitive examinations.
PO6	**Professional Competence** Ability to apply the knowledge independently for continuous personal and professional development and identify business opportunities and initiate action to achieve it.
PO7	**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.

Shiv Chhatrapati Shikshan Sanstha's

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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

Shiv Chhatrapati Shikshan Sanstha's

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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 Major II 3Cr Major III 3Cr	MEC I 3Cr	LC-I 1Cr LC-II 1Cr LC-III 1Cr LC-IV 1Cr						
	II	Major IV 3Cr Major V 3Cr Major VI 3Cr	MEC II 3Cr	LC-V 1Cr LC-VI 1Cr LC-VII 1Cr LC-VIII 1Cr	NA	OJT-I 4Cr /FPI 4Cr	NA	**20Cr**	OJT/FP: 1Cr=25M	
	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 Major VIII 3Cr Major IX 3Cr	MEC III 3Cr	LC-IX 1Cr LC-X 1Cr LC-XI 1Cr LC-XII 1Cr	NA	NA	RP-I 4Cr	**20Cr**	RPI & RPII: 1Cr=25M	**PG Degree (After 03 Year B.Sc. Degree)**
	IV	Major X 3Cr Major XI 3Cr Major XII 3Cr	MEC IV 3Cr	LC-XIII 1Cr LC-XIV 1Cr LC-XV 1Cr LC-XVI 1Cr	NA	NA	RP-II 6Cr	**22Cr**		
	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									

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.
II 6.5	III	602MIB3101 MMC-VII	Immunology	03	45
		602MIB3104	Lab Course-VI	01	30
		602MIB3102 MMC-VIII	Advanced Molecular Biology	03	45
		602MIB3105	Lab Course-VII	01	30
		602MIB3103 MMC-IX	Bioprocess Engineering	03	45
		602MIB3106	Lab Course-VIII	01	30
		602MIB3201 MEC-III (A) OR 602MIB3202 MEC-III(B)	Quantitative Biology OR Clinical Microbiology	03	45
		602MIB3203 OR 602MIB3204	Lab Course-IX OR Lab Course-X	01	30
		AP	Academic Project	04	
	Total Credits			**20**	
	IV	602MIB4101 MMC-X	Fermentation Technology	03	45
		602MIB4104	Lab Course-XI	01	30
		602MIB4102 MMC-XI	Medical and Pharmaceutical Microbiology	03	45
		602MIB4105	Lab Course-XII	01	30

		602MIB4103 MMC-XII	Bioinstrumentation	03	45
		602MIB4106	Lab Course-XIII	01	30
		602MIB4201 MEC- IV(a) OR 602MIB4202 MEC-IV(b)	Bioinformatics, proteomics and genomics OR Marine Microbiology	03	45
		602MIB4203 OR 602MIB4204	Lab Course-XIV OR Lab Course-XV	01	30
		RP	Research Project	06	
	Total Credits			**22**	
Total Credits (Semester III & IV)				**42**	

Semester - Third

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Course Type: MMC VII
Course Title: Immunology
Course Code: 602MIB3101

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 morrow- 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 - maturations, 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. Idiotype 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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Course Type: Lab Course
Course Title: Lab Course –IX (Based on MMC- VII)
Course Code: 602MIB3104
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, GoodMicrobiological 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 performdifferent immunological reactions.
CO2. Apply skills to perform serological diagnosis of diseases

Practical No.	Experiment
1	Antigen – Antibody reactions 1.Agglutination – Widal test A. SlideTest – 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 *S. typhi* by Craigie's tube method.
6	Preparation of 'O' antigen of *S. typhi* 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.
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Department of Microbiology

Course Type: MMC- VIII
Course Title: Advanced Molecular Biology
Course Code: 602MIB3102
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 ingenetic 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 (Polynucleotidekinase, 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 andpUC18). Bacteriophage lambda (λ), Cosmids, Phasmids and Phagemids as vectors. SV40vaccina/bacculo 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, somaticcell 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 bygain 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 dignosis. 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 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 byBernard 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.

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Microbiology

Course Type: Lab Course

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

Course Code: 602MIB3105

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 it's 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. DavidH., Gelfand John J. Sninsky, Academic Press.
2) PCR technology- principles and application for DNA amplification by Henry AErilch (Ed) Stockton Press. 1989.
3) Route maps in gene technology by M.R. Walker and R. Rapley, Blackwellscience, 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. JohnWiley and Sons Inc. Thomas F. Budinger and Miriam D. Budinger. 2006.

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Course Type: MMC-IX
Course Title: Bioprocess Engineering
Course Code: 602MIB3103
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 Kla 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

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Department of Microbiology

Course Type: Lab Course

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

Course Code: 602MIB3106

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	Screenig of Industrialy 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, Pergam on Press.
3. Peppler and Perlmen, 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: 602MIB3201
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 o give curves, Box plot, Scatter plot, survival curves) and diagrammatic (Simple bar diagram, percentage bar diagram, multiple bar diagram, sub - divided bar diagramand 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 ofvariance. 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 RandomizedDesign, 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. Essentials featuresof 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 (5^{th}) 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:602MIB3203

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 valueby performing knowledge based practical.
- Students Also acquires skill to represent data by using the computerknowledge 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	Prepration 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 MichaelJay 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: 602MIB3202
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 S. aureus (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 Chakraborthy.
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 Els,evier Health Sciences

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Microbiology

Course Type: Lab Course

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

Course Code:602MIB3204

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 Chakraborthy.
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 Els,evier Health Sciences

Semester - Fourth

Rajarshi Shahu Mahavidyalaya, Latur

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Department of Microbiology

Course Type: MMC-X

Course Title: FERMENTATION TECHNOLOGY
Course Code: 602MIB4101
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 ofcitric 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 ofbiogas production.

CO4 Use techniques of enzyme immobilization and its application in food pharmaceuticaland 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.Sinaeur 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 BioremediationPrinciples.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. andDmain A. L. ASM Publication.

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Department of Microbiology

Course Type: Lab Course
Course Title: Lab Course –XIII (Based on MMC-X)
Course Code: 602MIB4104
Credits: 01 **Max. Marks: 50** **Hours: 30**

Leaning 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 thelaboratory.

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

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

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Microbiology

Course Type: MMC- XI
Course Title: Medical and

Pharmaceutical Microbiology
Course Code:602MIB4102
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

LO 1. To understand different antimicrobial substance and their mode of action
LO 2. To To understand maintenance of antimicrobial substance
LO 3. To To working of biosensors and its application..
LO 4. To understand different parameters and safety measures for use of antimicrobialagents.

Course outcomes

After completion of course the student will be able to-

CO1.Student have the knowledge and mechanism of action of antibiotics, synthetic antimicrobial agents, chemical disinfectants, antiseptic and preservatives. Also haveknowledge of antibiotic resistance in bacteria

CO2.Student able to evaluate microbial production and spoilage of pharmaceutical products. Design manufacturing procedure. Derive pharmaceuticals products bymicrobial fermentation process

CO3.Able to understand government regulatory practices, application of biosensor and microbial enzyme in pharmaceuticals.

CO4.Able to recognize good manufacturing practices and good laboratory practices. Apply quality assurance and quality management in pharmaceuticals. Use safety inmicrobiology.

Unit No.	Title of Unit & Contents	Hours
I	Antibiotics, synthetic antimicrobial agents	12
	1.1 Antibiotics and synthetic antimicrobial agents (Aminoglycosides, β lactums, 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, multivalentsubunit 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 ofdrug 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.	
	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 byLippincott'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 LalIhhpunjani. CBSpublishers & 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. ASMWashington DC.

Rajarshi Shahu Mahavidyalaya, Latur

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Department of Microbiology

Course Type: Lab Course

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

Course Code:602MIB4105

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 antimicrobialactivity 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 *B. subtilis*.
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.

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Department of Microbiology

Course Type: MMC-XII

Course Title: Bioinstrumentation

Course code: 602MIB4103

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**
	1.1Biosafety in microbiological laboratories a. General safety measures b. Personal protection c. Chemical and Biological hazards d. Spillage and Waste disposal, First aid 1.2Theory, Principle, Working and Applications of a. pH meter b. Laminar Air Flow 1.3Efficacy testing protocols for a. Autoclave, b. pH meter c. Laminar Air Flow. 1.4Centrifuge 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 a. Paper Chromatography b. Thin Layer Chromatography (TLC) c. Gel Filtration Chromatography d. Ion Exchange Chromatography e. Affinity Chromatography f. Gas Chromatography h. HPLC.	
	Unit Outcome: UO 1. Student will be able to understand Chromatography Techniques	
III	**Electrophoretic Techniques**	**12**
	1Theory, Principle, Apparatus, Methods and Applications of a) Paper Electrophoresis, b) Polyacrylamide Gel Electrophoresis (PAGE), c) Agarose Gel Electrophoresis. Principle and Applications of a. Iso-electric Focusing b. 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 a. UV/Vis spectroscopy, b. NMR spectroscopy, c. Mass spectroscopy, 2. Introduction to radioisotopes and their biological applications 3. Principles and Applications of a. Geiger Muller (GM) counter b. Autoradiography	
	Unit Outcome: UO 1. Student will be able to understand Electrophoretic Techniques Spectroscopic and Radio-isotopic Techniques	

Learning Resources:

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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, NewYork 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 UniversityPress.
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: 602MIB4106
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
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Department of Microbiology

Course Type: MEC IV (A)
Course Title: Bioinformatics, proteomics and genomics
Course Code: 602MIB4201
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 microbialidentifications 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 inmicrobiology. 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 andapplications. • 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 andSmith-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 onthese 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 ofgene 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 Editionby 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 ExpressionData by D. M. Dziuda ,Willey publishers
9. Genomics-Fundamentals and Applications by SupratimChoudhart& David B., Carlson
10. Bioinformatics: Sequence, structure and Data Bank: A Practical Approach by Higgis.
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, SpringerNature

Switzerland AG

14. Functional Genomics. A Practical Approach Edited by Stephen P Hunt and RickLiveey (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 Jarsey.

Web sites for Proteomics and Genomics

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

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Department of Microbiology

Course Type: Lab Course
Course Title: Lab Course –XVI, Based on MEC IV (a)
Course Code: 602MIB4203
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 usingthe 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 Editionby 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 ExpressionData by D. M. Dziuda ,Willey publishers
27. Genomics-Fundamentals and Applications by SupratimChoudhart& David B., Carlson
28. Bioinformatics: Sequence, structure and Data Bank: A Practical Approach by Higgis.

Shiv Chhatrapati Shikshan Sanstha's

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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.

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.

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