Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Structure and Curriculum of Two Year Post Graduate Programme with Exit option

Postgraduate Programme of Science and Technology

M.Sc.in Biotechnology

Board of Studies

in

Biotechnology

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

w.e.f. June, 2023

(In Accordance with NEP-2020)

Review Statement

The NEP Cell reviewed the Curriculum of **M.Sc. (Honors) in Biotechnology** 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: 09/08/2023

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 Biotechnology** Programme to be effective from the **Academic Year 2023-24.**

Date: 14/07/2023

Place: Latur

(Dr. Sachin Kulkarni)
Chairperson
Board of Studies in Biotechnology
Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Members of Board of Studies in the Subject Biotechnology

Under the Faculty of Science and Technology

Sr. No.	Name	Designation	In position
1	**Dr. Sachin S. Kulkarni** Head, Department of Biotechnology, Rajarshi Shahu Mahavidyalaya, Latur (Autonomous)	Chairperson	HoD
2	**Prof. Tukaram. A. Kadam** Professor, School of Life Sciences SRTMU, Nanded.	Member	V.C. Nominee
3	**Dr. Rahul. P. Bhagat** Asst. Professor, Department ofBiotechnology, Govt. Institute of Science, Aurangabad (Autonomous)	Member	Academic Council Nominee
4	**Dr. Rajesh M. Jorgewad** Asst. Professor, Department of Biotechnology and Bioengineering, KIT college, Kolhapur (Autonomous)	Member	Academic Council Nominee
5	**Dr. Gunderao. H. Kathwate** Asst. Professor, Dept. of Biotech. S. P. P. U. Pune	Member	Expert from outside for Special Course
6	**Mr. Abhay. M. Desai** Wockhardt, Aurangabad	Member	Expert from Industry
7	**Dr. SantoshNarwade** Serum Institute Pvt.Ltd. Pune	Member	P.G. Alumni
8	**Dr. Manisha. A. Dhotre**	Member	Faculty Member
9	**Mr. Udaybhanu. P. Sirdeshmukh**	Member	Faculty Member
10	**Dr. Ravindra. B. Ade**	Member	Faculty Member
11	**Dr. Sanghapal. S. Kshirsagar**	Member	Faculty Member
12	**Mr. Suraj. D. Kadam**	Member	Faculty Member
13	**Mr. Akash. J. Waghmare**	Member	Faculty Member
14	**Miss. Swati G. Swami**	Member	Faculty Member
15	**Mr. Sanket M. Bansode**	Member	Faculty Member
16	**Miss. Karun. S. Komatwar**	Member	Faculty Member
17	**Dr. Kakasaheb. S. Raut**	Member	Member from same Faculty

From the Desk of the Chairperson…

Biotechnology as a subject is a highly interdisciplinary that combines biological sciences with engineering technologies to manipulate living organisms and biological systems to produce products that advances healthcare, medicine, agriculture, food, pharmaceuticals and environment. At its simplest, biotechnology is technology based on biology - which harnesses cellular and bimolecular processes to develop technologies and products that help to improve our lives and health of our planet.

Taking into consideration of the importance of Biotechnology, Rajarshi Shahu Mahavidyalaya, Latur (Autonomous), have taken an initiative to introduce a new emerging field as an undergraduate Programme in biotechnology under the faculty of science. B. Sc. Biotechnology is a Three-year graduate degree program which is started in the academic year 2004-05 followed by the postgraduate program started in academic year 2006-07.

National Education Policy (NEP) 2020 recognizes the relevance of biotechnology in the education system due to its interdisciplinary nature, potential for research and innovation, and its alignment with the development of 21st-century skills. By integrating biotechnology into the curriculum, the policy aims to prepare students for the challenges and opportunities of a rapidly advancing biotechnology driven world.

NEP-2020 has conceptualized the idea to develop well rounded competent individuals for making the nation a self-reliant and global leader. In the same spirit, we at Department of Biotechnology, have developed a curriculum framework to encompass the goals of NEP 2020. In the overall curriculum we have incorporated choice of courses of study, creating academic pathways having constructive combinations with exit point as well as focus on experiential learning for students by providing multidisciplinary and holistic approach to the courses taught as MMC courses along with electives of choice for equipping the students with adequate knowledge leading to the choice of better career paths.

With reference to global changes occurring in higher education in various national and foreign universities, the newly designed syllabi of M.Sc. Biotechnology as per NEP 2020 guidelines are effectively implemented from June, 2023. The committee members of Board of Studies in Biotechnology also took the local need and employability of graduate students into consideration while framing the given curriculum, keeping in view of the guidelines given in the University Grants Commission, New Delhi.

By aligning curriculum development, pedagogy, interdisciplinary connections, research opportunities, industry collaborations, teacher training, and available infrastructure with the institute, the department of biotechnology plans to integrate students with a comprehensive understanding of biotechnology, foster critical thinking and research skills, and prepare them for future careers in the field.

(Dr. Sachin Kulkarni)
Chairperson
Board of Studies in Biotechnology

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Index

Sr. No.	Content	Page No.
1	Structure of Two-Year Degree Programme	1
2	Abbreviations	2
3	Courses and Credits	3
4	Programme Outcomes (POs) for M.Sc. Programme	4
5	Programme Specific Outcomes (PSOs) for M.Sc. Physics	5
6	Curriculum: Semester-I	6
7	MMC-I : Biochemistry and Cell Biology	7
8	Lab Course –I (Based on MMC-I)	11
9	MMC-II : Microbial Physiology and Metabolism	13
10	Lab Course –II (Based on MMC-II)	17
11	MMC-III : Bioinstrumentation and Emerging Techniques	19
12	Lab Course –III (Based on MMC-III)	22
13	MEC-I (A): Bioinformatics OR MEC-I(B) : Virology	23 28
14	Lab Course –IV [Based on MEC-I (A) or MEC – I (B)]	31
15	RMC : Research Methodology	35
16	Curriculum: Semester-II	39
17	MMC-IV : Molecular Genetics	40
18	Lab Course –V (Based on MMC-IV)	43
19	MMC-V : Immunology and Immunotechniques	45
20	Lab Course –VI (Based on MMC-V)	49
21	MMC-VI : Bioprocess Engineering	51
22	Lab Course –VII (Based on MMC-VI)	55
23	MEC-II (A): Biomathematics and Biostatistics OR MEC-II (B) : Medical Biotechnology	56
24	Lab Course –VIII [Based on MEC-II (A) or MEC – II (B)]	64
25	Field Project	
26	Extra Credit Activities	69
27	Examination Framework	71

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

PG Skeleton in Accordance with NEP-2020

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

Year Level	Sem	MMC		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**	MMC I 3Cr MMC II 3Cr MMC III 3Cr	MEC I 3Cr	LC-I 1Cr LC-II 1Cr LC-III 1Cr LC-IV 1Cr						
	II	MMC IV 3Cr MMC V 3Cr MMC 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	**MMC 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**	MMC VII 3Cr MMC VIII 3Cr MMC 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 UG Degree)**
	IV	MMC X 3Cr MMC XI 3Cr MMC XII 3Cr	MEC IV 3Cr	LC-XIII 1Cr LC-XIV 1Cr LC-XV 1Cr LC-XVI 1Cr	NA	NA	RP-II 6Cr	**22Cr**		
	Total	**MMC 18Cr**	**MEC 06Cr**	**LC-8Cr**	**NA**	**NA**	**RP 10 Cr**	**42Cr**		
Cum. Total of I & II Year		**MMC 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

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

M.Sc. in Biotechnology

Year & Level	Semester	Course Code	Course Title	Credits	No. of Hrs.
I 6.0	I	601BIO1101 (MMC I)	Biochemistry and Cell Biology	03	45
			Lab Course-I	01	30
		601BIO1102 (MMC II)	Microbial Physiology and Metabolism	03	45
			Lab Course-II	01	30
		601BIO1103 (MMC III)	Bioinstrumentation and Emerging Technologies	03	45
			Lab Course-III	01	30
		601BIO1201 MEC-I (A) Or MEC-I(B)	Bioinformatics/ Virology	03	45
			Lab Course-IV	01	30
		601BIO1301 (RMC)	Research Methodology Course	04	100
	Total Credits			**20**	
	II	601BIO2101 (MMC IV)	Molecular Genetics	03	45
			Lab Course-V	01	30
		601BIO2102 (MMCV)	Immunology and Immunotechniques	03	45
			Lab Course-VI	01	30
		601BIO2103 (MMC VI)	Bioprocess Engineering	03	45
			Lab Course-VII	01	30
		MEC-I (A) Or MEC-I(B)	Biomathematics and Biostatistics/Medical Biotechnology	03	45
			Lab Course-VIII	01	30
		OJT-I/Field Project (FP)	OJT/ Field Project	04	120
	Total Credits			**20**	
Total Credits (Semester I & II)				**40**	

Programme Outcomes (POs) for M.Sc. Programme	
PO 1	
PO 2	
PO 3	
PO 4	
PO 5	
PO 6	
PO 7	

Programme Specific Outcomes (PSOs) for M.Sc. Biotechnology	
PSO No.	Upon completion of this programme the students will be able to -
PSO 1	Integrate basic principles of common analytical techniques of protein molecular structures to engage in hands-on practices for implementation of such techniques to facilitate the development of biopharmaceutical manufacturing.
PSO 2	Induce the understandings of basic principles of process units' operations of industrial products with hands-on practices for implementation of such techniques to facilitate the development of biopharmaceutical manufacturing.
PSO 3	Gain fundamental knowledge of molecular biotechnology, protein expression, and structural biology for the development of new products having clinical application.
PSO 4	Plan, conduct, execute and write-up a proposal of original research Practical skills.
PSO 5	Promote the entrepreneurship for self-growth and sustainability with the aim of promoting lab to land practices in, clinical, agriculture, food, nano, plant and animal biotechnology.
PSO 6	Integrate fundamental concepts of leadership, entrepreneurship and innovation, financial decision making and marketing to business enterprises.
PSO 7	Equip the students with the skills required for carrying out research in cutting edge areas of life sciences.
PSO 8	Make the students competent for dealing with the future problems and challenges of regional and global interest in overall development of society.

Semester - I

Course Type: MMC-I

Course Title: Biochemistry and Cell Biology

Course Code: 601BIO1101

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

Learning Objectives

LO 1. To study structure and functional importance of Carbohydrates.

LO 2. To study structure and classification of lipids.

LO 3. To understand biological importance of nucleic acids.

LO 4. To study structure and properties of amino acids.

LO 5. To understand structural organization and classification of proteins.

LO 6. To know the communication between cells and related cell signaling.

LO 7. To understand signal transduction and basics of cell cycle and cell division.

LO 8. To study apoptosis and necrosis.

Course Outcomes

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

CO 1. Describe structure and function of carbohydrates.

CO 2. Discuss Structure and classification of lipids.

CO 3. Explain biological importance of nucleic acids.

CO 4. Explain structure and properties of amino acids.

CO 5. Discuss structural organization and classification of proteins.

CO 6. Understand the cell signaling concepts and its significance.

CO 7. Explain the concept of signal transduction and cell cycle.

CO 8. Understand the concept of apoptosis and necrosis.

Unit No.	Title of Unit & Contents	Hrs.
I	**Carbohydrates, Lipids and Nucleic Acids**	**12**
	1. Classification, Structure and functions of Carbohydrates: Monosaccharides (glucose, galactose, mannose, fructose, ribose, deoxyribose), Oligosaccharides (lactose, sucrose, maltose), Polysaccharides (starch, glycogen, cellulose). 2. Classification and structure of simple, compound and derived lipids and its biological importance. 3. Structure and Biological importance of nucleic acids: Composition of nucleic acids, Structure of a polynucleotide, Structure of DNA- Watson and Crick model, Forces stabilizing DNA structure (Van-der-Waals and Hydrogen bonds, Hydrophobic interactions),RNA – Classes (m-RNA, t-RNA and r-RNA).	
	Unit Outcomes: UO 1. Describe structure and function of carbohydrates. UO 2. Discuss Structure and classification of lipids. UO 3. Explain biological importance of nucleic acids.	
II	**Amino acids and Proteins**	**10**
	1. Biological importance and Structure of amino acid 2. Classification based on polarity of 'R' group 3. Acid-base properties. 4. Titration curve (alanine) 5. Biological functions of proteins 6. Structure and organization (Primary, secondary, tertiary, and quaternary structures) 7. Forces stabilizing protein structure (Ionic, Van-der-Waals, and Hydrogen bonds, Hydrophobic interactions) 8. Classification based on structure – Fibrous (e.g., α-keratin) and Globular (e.g., myoglobin) proteins 9. Denaturation of proteins	
	Unit Outcomes: UO 1. Explain structure and properties of amino acids UO 2. Discuss structural organization and classification of proteins	
III	**Cell Signaling**	**10**

Unit No.	Title of Unit & Contents	Hrs.
	1. Cell Signaling: Introduction. 2. Stages of cell signaling. 3. Signal transduction: Concept and Pathways (GPCR and Development Pathways) 4. Factors determining signal transduction pathways. 5. Signal amplification process. 6. Receptors: Intracellular receptors and Cell surface receptors. 7. Cell Signaling in Plants.	
	Unit Outcomes: UO 1. Understand the cell signaling concepts and its significance. UO 2. Explain the concept of signal transduction.	
IV	**Cell Cycle and Cell division**	**13**
	1. Phases of the cell cycle. 2. Molecular basis of cell cycle - Cell cycle regulation 3. Molecular basis of cell cycle - Cell Cycle checkpoints. 4. Stages of Mitosis and Meiosis 5. Significance of Mitosis and Meiosis 6. Apoptosis: Mechanism of Apoptosis 7. Apoptosis vs Necrosis	
	Unit Outcomes: UO 1. Explain the process of cell division and cell cycle. UO 2. Understand the concept of apoptosis and necrosis.	

Learning Resources:

1. Molecular Cell Biology, Lodish et al. Scientific American Book, 2004.
2. The Biology of the Cell, Alberts et al. 2002.
3. The Cell – A Molecular Approach, Cooper & Hausman 2004.
4. Cell and molecular biology, De Robertis, E.D.P. and Robertis, E.M.F. Lea and Febiger, 1991.
5. Fundamentals of Biochemistry, Jain, J.L., Jain, S. and Jain, N., S. Chand and Company Ltd, 2005.
6. Fundamentals of Biochemistry, Deb, A.C., New Central Agency, Calcutta, 2016.
7. Principles of Biochemistry, Nelson, D.L., Cox, M.M. Lehninger. 5th edition Pub.WH Freeman Co., 2008.

8. Biochemistry, Berg JM, Tymoczko JL and Stryer L, 6th Edition, WH Freeman and Company, 2005.
9. Biochemistry, Voet, D., Voet J.G. 3rd Edition, John Wiley & Sons, Inc. 2004.
10. Biochemistry, The Chemical reactions of Living Cells, David E Metzler Vol. 1. 2nd Edition, Elsevier Academic Press, 2003.
11. Outlines of Biochemistry, Conn and Stump of New York Wiley, 1967.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: Lab Course

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

Course Code: 601BIO1104

Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1. To understand different cells and cell diversity.

LO 2. To understand the structures and purposes of basic components of cells.

LO 3. To understand cell division in plants and animals.

LO 4. To help in understanding the basics of cell organelles with practical experience.

LO 5. To teach how to prepare standard solutions and Buffers.

LO 6. To make understand to analyse the given Biomolecules qualitatively and quantitatively.

LO 7. To understand how to analyse biomolecules by separation techniques.

LO 8. To understand qualitative estimation of biomolecules.

Course Outcomes

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

CO 1. Separate and characterize sub-cellular components of cells.

CO 2. Use cellular techniques in research and diagnostics.

CO 3. Identify and describe the cellular structure of organs and tissues from prepared slides, and outline the principles of histochemical staining.

CO 4. Perform experimental techniques as instructed making accurate observations; record, analyze and interpret data.

CO 5. Prepare different solutions and buffers.

CO 6. Estimate the unknown concentration of biomolecules

CO 7. Use current biochemical techniques to plan and carry out experiments.

CO 8. Analyse bio-molecules by separation techniques.

Practical No.	Unit
1.	Cellular permeability
2.	Study of Mitosis (root tips)
3.	Study of Meiosis (anthers)
4.	Lipid solubility of membrane.
5.	Study of karyotypes.
6.	Isolation of chloroplast.
7.	Analysis of chlorophyll amount by Spectrophotometer.
8.	Isolation of Mitochondria.
9.	Vital staining of Mitochondria.
10.	Vital staining of lipid and glycogen bodies.
11.	Preparation of Standard solutions
12.	Preparation of buffers
13.	Determination of pK values of amino acid
14.	Determination of acid value of fatty acids
15.	Determination of Saponification number of fatty acids
16.	Determination of iodine Number of fatty acids
17.	Estimation of protein by Lowry/ Biuret/ Bradford methods.
18.	Estimation of amino acid by Ninhydrin method.
19.	Estimation of sugar by Anthrone and DNSA method.
20	Estimation of DNA and RNA by Spectrophotometric method

N.B.: Any Ten Practicals from above.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: MMC-II

Course Title: Microbial Physiology and Metabolism

Course Code: 601BIO1102

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

Learning Objectives

LO 1. To study and understand basic concept of microbial world and its diversity.

LO 2. To learn relationship of microbes to environment.

LO 3. To acquaint knowledge on basic aspects of bacterial respiration and photosynthesis.

LO 4. To get acquaint with Nutritional Categories and Transport Mechanism.

LO 5. To understand stress Physiology in microorganism.

LO 6. To understand the concept of bacterial photosynthesis and respiration.

LO 7. To describe microbial metabolism and its energetics.

LO 8. To learn about the metabolic diversity exhibited by microorganisms.

Course outcomes

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

CO 1. Describe basic structure and functions of microbes and relationship to the environment.

CO 2. Summarize the nutrients uptake system in the prokaryotes.

CO 3. Understand bacterial stress physiology.

CO 4. Elucidate bacterial transport mechanism.

CO 5. Understand and predict the various metabolic reactions in microbial cell.

CO 6. Interpret the fermentation using microbes.

CO 7. Elucidate the bioenergetics and microbial metabolic pathways

CO 8. Appreciate that the diversity of life is driven by the metabolic diversity of microbes

Unit No.	Title of Unit & Contents	Hrs.
I	**Microbial World**	**09**
	1. Bacteria: Purple and green bacteria, cyanobacteria, Homoacetogenic bacteria. Acetic acid bacteria, Budding and appendaged bacteria, Spirilla, Spirochetes, Sheathed bacteria, Pseudomonads; Lactic and propionic acid bacteria, Endospore forming rods and cocci, Mycobacterium, Rickettsias, Chlamydias and Mycoplasma. 2. Archaea: Halophiles, Methanogens, Thermoplasma, Ferroplasma and Hyper-thermophilic archaea. 3. Eukarya: Algae, Fungi, Slime molds and Protozoa. **4.** Viruses: Bacterial, Plant and Animal; Viroids and Prions	
	Unit Outcomes: UO 1. Describe basic structure and functions of microbes and relationship to the environment UO 2. Understand the basic concept of microbial world.	
II	**Microbial Nutrition and Physiology**	**10**
	1. Nutritional Categories of microorganisms based on carbon; energy and electron sources 2. Metabolite Transport: Diffusion: Passive and facilitated; Primary active and secondary active transport 3. Group translocation (phosphotransferase system) electro neutral transport; transport of Iron. 4. Stress physiology: effect of oxygen toxicity, pH, osmotic pressure, heat shock etc on bacteria Adaptations in thermophiles, halophiles, alkaliphiles, acidophiles, Extremophiles – adaptations & significance in biotechnology	
	Unit Outcomes: UO 1. Get acquainted with Nutritional Categories and Transport Mechanism UO 2. Understand the stress physiology of microorganisms.	
III	**Metabolic Diversity I**	**13**

Unit No.	Title of Unit & Contents	Hrs.
	1. Phototrophy: oxygenic-anoxygenic photosynthesis 2. Autotrophy: Fixation of CO_2 Calvin Cycle C3-C4 pathway. 3. Difference between oxygenic and anoxygenic photosynthesis 4. Chemolithotrophy - sulphur - iron - hydrogen - nitrogen oxidations 5. Respiratory metabolism – EMP, ED and PPP 6. Citric acid cycle: Branched TCA and Reverse TCA, glyoxylate cycle. 7. Comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors	
	Unit Outcomes: UO 1. Explain photosynthesis and photosynthetic bacteria UO 2. Learn about Respiratory Metabolism exhibited by microorganisms	
IV	**Metabolic Diversity II**	**13**
	1. Biosynthesis of peptidoglycan 2. Biosynthesis of biopolymers 3. Assimilation of nitrogen, sulphur, phosphorus etc. 4. Nitrogen metabolism: Metabolism of amino acids: Amino acid biosynthesis and utilization, lysine and glutamine overproduction, stringent response, polyamine biosynthesis and regulation. 5. Metabolism of lipids and hydrocarbons: Biosynthesis and degradation of lipids, Hydrocarbon utilization, PHA synthesis and degradation. 6. Fermentation Diversity (Lactic Acidand Mixed-Acid Fermentations), Fermentation without Substrate Level Phosphorylation, Concept of linear and branched fermentation pathway, Syntropy 7. Anaerobic Respiration: Methanogenesis and Acetogenesis	
	Unit Outcomes: UO 1. Learn about the metabolic diversity exhibited by microorganisms UO 2. Correlate Bacterial Physiology and Metabolic Diversity	

Learning Resources:

1. General Microbiology, Stainer, R. Y. Ingraham, E. A. Adelberg, 4th Edn, The MacMillan Press Ltd, 1999.

2. Biology of Microorganisms, M.T. Madigan, J. M. Martinko, Brock, 13th Edn, Benjamin Cummings Ltd. 2010.
3. Microbiology, Pelczar, M.J., Chan, E.C.S. and Kreig, N.R., 5th Edn, Tata McGraw Hill, 2002.
4. Bacterial metabolism, Gerhard Gottschalk, 2nd edn, Springer Science and Media Publication, 2012.
5. Microbial Physiology, Moat A. G. and Foster W., 4th Edn, John Wiley and Sons, New York, 2002.
6. Microbial Genetics, Maloy, S.R., Cronan, J.E. Jr. and Freitelder, D. Jones., 2nd Edn, Bartlett Publishers., 1994.
7. Microbiology - A Laboratory Manual, Cappuccino, J.G. and Sherman, N. Addison Wesley, 10th Edn, 2014.
8. Microbiological Applications (A Laboratory Manual in General Microbiology), Benson, H.J. WCB: Wm C., 13th Edn, Brown Publishers, 2014.
9. Brock Biology of Microorganisms, Michael Madigan, Kelly Bender, Daniel Buckley, W. Sattley, David Stahl, 14th Edn, 2014.
10. Microbial Physiology, S. Ram Reddy, S. M. Reddy, Scientific Publishers, 2008.
11. ISE Prescott's Microbiology, Loanne Willey, Kathleen Sandman, Dorothy Wood, 11th Edn, 2019.
12. Joanne M. Willey, Linda M Sherwood, Christopher J Wooolverton Prescott's Microbiology. 8thedition, Mc.Graw Hill publishers. , 2011.
13. Microbial Physiology, Moat AG and Foster JW. 4thedition. John Wiley & Sons, 2002.
14. Laboratory experiments in Microbiology, Gopal Reddy et al, Himalaya publishers, 2006.
15. Microbiology, Prescott, Harley and Klein Wim, Mc.Graw Hill Publishers ,2002

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: Lab Course

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

Course Code: 601BIO1105

Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1. To learn media preparation and sterilization.

LO 2. To study isolation and maintenance of Microorganism.

LO 3. To provides hands-on pure culture and staining techniques.

LO 4. To study growth curve of microorganisms.

LO 5. To study effect of physical and chemical factors on growth of microorganisms.

LO 6. To understand the concept of Slant and stab culture.

LO 7. To understand the technique of isolation of prototrophs and chemolithotrophs.

Course outcomes

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

CO 1. Prepare solid and liquid media.

CO 2. Isolate microbes by using pure culture techniques

CO 3. Characterize microbes morphologically and biochemically

CO 4. Perform growth kinetics

CO 5. Characterize hydrocarbon degrading microorganisms

CO 6. Characterize iron, sulphur and hydrogen oxidizing microorganisms

Practical No.	Unit
1	Culturing techniques of microbes (Slant and stab culture, tube culture, flask culture)
2	Isolation and maintenance of organisms (plating, streaking and serial dilution Methods. Storage of microorganism)
3	Enrichment culturing and isolation of prototrophs
4	Culturing and isolation of chemoautotrophs and chemolithotrophs
5	Microscopic examination of microorganisms and study of organisms (Monochrome, Negative and Gram staining)

6	Study and plot the growth curve of *E. coli* by turbidometric method
7	Determination and study of growth curve by standard plate count methods
8	Effect of temperature, pH and Salt on growth of microorganism
9	Effect of carbon and nitrogen sources on growth of microorganism
10	Demonstration of Butane-diol fermentation
11	Demonstration of Mixed acid fermentation
12	Isolation and Characterization of Hydrocarbon degrading microorganism
13	Isolation and Characterization of Iron-Sulphur Oxidizing microorganism
14	Isolation and Characterization of Hydrogen Oxidizing microorganism

N.B.: Any Ten Practicals from above.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: MMC III

Course Title: Bioinstrumentation and Emerging Techniques

Course Code: 601BIO1103

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

Learning Objectives

LO 1. To understand analytical techniques and equipment used in biological sciences.

LO 2. To understand the basic principle and applications of microscopy and centrifugation.

LO 3. To acquire knowledge on the Chromatographic and electrophoretic method for the separation of biological molecules.

LO 4. To get knowledge about the emerging techniques in the field of biological sciences.

LO 5. To understand principles and types of different chromatographic techniques.

LO 6. To acquire knowledge about the instrumentations used in spectroscopy.

LO 7. To understand radioactivity and its detection and measurement techniques.

LO 8. To learn about Circular Dichroism spectroscopy and atomic spectroscopy.

Course outcomes

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

CO 1. Apply analytical techniques in the field of biological sciences.

CO 2. Acquaint the knowledge of microscopy and centrifugations techniques.

CO 3. Get proficiency in chromatography and spectroscopy techniques.

CO 4. Get familiarize with emerging techniques.

CO 5. Understand uses and properties of spectroscopy.

CO 6. Get familiarize with different emerging techniques in biotechnology.

CO 7. Detect, estimate and recovery of proteins.

CO 8. Acquaint the knowledge of immunoblotting.

Unit No.	Title of Unit & Contents	Hrs.
I	**Microscopy and Centrifugation**	**12**
	1. Light microscopy, Fluorescence microscopy, Phase contrast microscopy, Electron microscopy, confocal microscopy. 2. Centrifugation: Principle of centrifugation.	

Unit No.	Title of Unit & Contents	Hrs.
	3. Small bench top centrifuges, large capacity refrigerated centrifuges, High speed refrigerated centrifuges. 4. Preparative and analytical ultra-centrifuge	
	Unit Outcomes: UO 1. Apply analytical techniques in the field of biological sciences. UO 2. Understand the concepts of microscopies	
II	**Chromatography and Electrophoresis**	**13**
	1. Principles of chromatography. 2. Types of Chromatography: size exclusion, Ion exchange, Affinity chromatography, High performance liquid chromatography (HPLC), Gas liquid chromatography (GLC), Reverse Phase Chromatography. 3. Electrophoresis General principles. 4. Electrophoresis of proteins: Native gels, SDS-PAGE, Gradient gel, Isoelectric focusing, 2-D gel electrophoresis (2-D PAGE), Detection, estimation and recovery of proteins. 5. Electrophoresis of nucleic acids: Agarose gel electrophoresis of DNA, DNA sequencing gels. 6. Pulse-field gel electrophoresis, electrophoresis of RNA. 7. Capillary electrophoresis.	
	Unit Outcomes: UO 1. Acquaint the knowledge of microscopy and centrifugations techniques. UO 2. Understand the concept of electrophoresis.	
III	**Spectroscopy and Radioactivity**	**11**
	1. UV and Visible Spectroscopy. 2. Infrared and Raman Spectroscopy. 3. Electron Spin Resonance Spectroscopy. 4. Nuclear Magnetic Resonance Spectroscopy. 5. Circular Dichroism Spectroscopy and Atomic Spectroscopy. 6. Lasers, Spectro fluorimetry, Luminometry, turbidometry and nephelometry. 7. Radioactivity The nature of radioactivity, detection and measurement of radioactivity.	

Unit No.	Title of Unit & Contents	Hrs.
	8. Geiger Muller counter, Liquid Scintillation counter, safety aspects, applications of radioisotopes in biological sciences.	
	Unit Outcomes: UO 1. Get proficiency in chromatography and spectroscopy techniques. UO 2. Understand the concept of radioactivity.	
IV	**Emerging Techniques**	**09**
	1. Mass Spectrometry. 2. GC-MS and LC-MS. 3. Flowcytometry. 4. ELISA 5. Immunoblotting. 6. X-ray crystallography. 7. ICP-MS (Inductively Coupled Plasma Mass Spectrometry)	
	Unit Outcomes: UO 1. Get familiarize with emerging techniques. UO 2. Explain the concept of Immunotechniques.	

Learning Resources:

1. Biophysical Chemistry Avinash Upadhyay, Kakoli Upadhyay, NirmalenduNath, Himalaya Publishing House, 2009.
2. Biophysical Chemistry by Upadhyay, Upadhyay and Nath, Himalaya Pub. House, Delhi, 2016.
3. Principles and Techniques of Biochemistry and Molecular Biology, 5th Ed., Keith Wilson and John Walker, Cambridge University press, 2005.
4. Practical Biochemistry- principles and techniques, 5th edition, Keith Wilson and John Walker. Cambridge University press, London, UK, 2000.
5. Principles and Techniques of Biochemistry and Molecular Biology, 6th Ed., Keith Wilson and John Walker, Cambridge University press, 2005.
6. Essentials of Biophysics P. Narayanan, New Age International Publications, 2000.
7. Biophysics, Dr. Gurdeep K. Chatwal, Mrs. Madhu Arora, Gurdeep R. Chatwal Himalaya Publishing House, 2007.
8. Biophysics, Mohan P Arora, Himalaya Publishing House, 2005.
9. Bioinstrumentation by Webster, Wiley,2007.
10. Bioinstrumentation by l. Veerakumari, MJP Publisher,2019.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: Lab Course

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

Course Code: 601BIO1106

Credits: 01 **Max. Marks: 50** **Hours: 3**

Learning Objectives

LO 1. To Provide Hands-on Microscopy and Centrifugation techniques

LO 2. To Provide Hands-on separation and purification of Biomolecules

LO 3. To get expertise in Western Blotting and ELISA techniques used for analysis of proteins

LO 4. To understand working principle of emerging techniques.

LO 5. To understand different separation and estimation techniques of biomolecules.

LO 6. To study different chromatographic techniques for separation of proteins.

Course outcomes

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

CO 1. Identify different specimens by using microscopy

CO 2. Separate and purify biomolecules

CO 3. Separate and identify biomolecules by using blotting techniques

CO 4. Analyze the molecules based on functional groups

CO 5. Identify isoelectric point of amino acids

Practical No.	Unit
1	To study different type Microscopy (Compound and Phase Contrast Microscopy)
2	Separation and Estimation of Biomolecules (Centrifugation and Double Beam Spectrophotometry)
3	Separation of Biomolecules by TLC
4	Separation and Purification of proteins/ pigments using column/Affinity chromatography
5	Demonstration of techniques: Gas Chromatography, High Performance Liquid Chromatography (HPLC)
6	Electrophoresis of DNA
7	Electrophoresis of proteins under native and denaturing conditions (PAGE)
8	To find out isoelectric point of amino acid

9	ELISA
10	Western blotting
11	Demonstration of FTIR

N.B.: Any Ten Practicals from above.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: MEC-I (A)

Course Title: Bioinformatics

Course Code: 601BIO1201

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

Learning Objectives

LO 1. To understand the fundamental principles and techniques of nucleic acid sequence analysis.

LO 2. To understand the process of searching and retrieving information from biological databases.

LO 3. To understand the concept and methods of pairwise sequence alignments

LO 4. To understand the principles and methods of multiple sequence alignments.

LO 5. To understand the basics of phylogenetic analysis and its applications in evolutionary studies.

LO 6. To understand the Structure and function of proteins and its prediction by using different bioinformatics tools.

LO 7. To acquire the knowledge of protein structure and function analysis by using different bioinformatics tools.

LO 8. To understand the concept of molecular docking and application of bioinformatics in omics technologies.

Course Outcomes

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

CO 1. Search and retrieve sequence information from different primary and secondary databases.

CO 2. Understand the concept of sequence alignment and its application in biological data analysis.

CO 3. Use BLAST and other tools for identification of organisms and other kind of biological analysis.

CO 4. Construct phylogenetic trees and show evolutionary relationships.

CO 5. Visualize protein structure by using tools like Pymol.

CO 6. Understand the concept of molecular docking by using Auto dock.

CO 7. Understand the significance of omics technologies in biological research.

CO 8. Know the importance and applications of bioinformatics in the biological research.

Unit No.	Title of Unit & Contents	Hrs.
I	**Fundamentals of Bioinformatics**	**12**
	1. Origin, History, and Scope of Bioinformatics 2. Importance and Use of Bioinformatics 3. Complexities in Biological systems 4. Introduction to Biological Databases 5. Sequence and Structural Databases 6. Functional and Other Databases	
	Unit Outcomes: UO 1. To acquire introductory knowledge of bioinformatics. UO 2. To know the information about various biological databases.	
II	**Sequence Alignment**	**13**
	1. Basic Concepts of Sequence Similarity and Identity 2. File Formats for Sequences 3. Sequence based parameters 4. DNA sequence analysis 5. Protein structure and functions 6. Protein sequence analysis 7. PAM matrix, Global and local alignment, BLAST: features and scores 8. Conservation score 9. Scoring Matrices 10. Multiple Sequence Alignments 11. Phylogenetic trees 12. Hydrophobicity profiles 13. Patterns and PSSM profiles	
	Unit Outcomes: UO 1 To acquire basic skills in DNA and Protein sequence alignments. UO 2 To acquire skills of application of tools in sequence alignment and analysis.	
III	**Protein Structure, Function, Prediction and Analysis**	**11**
	1. Protein secondary structure, 2. Protein secondary structure prediction-Ramachandran plot, propensity, secondary structure prediction 3. Protein tertiary structure, Protein Data Bank, visualization tools, structural classification, contact maps	

Unit No.	Title of Unit & Contents	Hrs.
	4. Protein structural analysis, protein structure prediction 5. Protein stability, energetic contributions, database, stabilizing residues, stability upon mutations 6. Protein folding rates, proteins interactions, binding site residues 7. Computer aided drug design, Molecular docking, screening, QSAR	
	Unit Outcomes: UO 1. To acquaint skill of protein structure and function prediction and analysis. UO 2. Tol acquire docking skill at primary level.	
IV	**Omics Technologies**	**09**
	1. Central Dogma and Emergence of Omics Technologies 2. Genomics 3. Transcriptomics 4. Proteomics 5. Metabolomics 6. Applications of Bioinformatics	.
	Unit Outcomes: UO1 To acquire fundamentals of omics technologies related with bioinformatics. UO 2 To apply knowledge of bioinformatics in omics analysis.	

Learning Resources:

1. Introduction to Bioinformatics Prentice Hall, Teresa Attwood, David Parry-Smith, 1999.
2. Bioinformatics: The Machine Learning Approach, Pierre Baldi, Søren Brunak MIT Press, 2001.
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, J. Wiley, Andreas D. Baxevanis, B.F. Francis Ouellette 1998.
4. Structural Bioinformatics Wiley, Philip E. Bourne, Helge Weissig Projected Pub 2003.
5. Bioinformatics for Dummies, Jean-Michel Claverie, Cedric Notredame. Wiley Pub. Projected Pub 2002.
6. Computational Molecular Biology: An Introduction, Peter Clote, Rolf Backofen Wiley, 2000.
7. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison Cambridge University Press, 1998.
8. Khan and Khanum: Fundamentals of Biostatistics (low price Third Revised edition) ;Ukaaz Publication, 2004.
9. Fundamental of Statistics: S. P. Gupta, 2007.

10. Discovering Genomics, Proteomics, & Bioinformatics. Campbell &Heyer Pearson Education, 2003.
11. Bioinformatics, Methods of Biochemical Analysis Series Baxevanis& Ouellette, Vol. 43, John Wiley & Sons, 2001.
12. Computational Molecular Biology. Pevzner, P.A. MIT Press, 2000.
13. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Andreas D. Baxevanis & B. F. Francis Ouellette 3rd Edition. Wiley & Sons, 2004.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: MEC I (B)

Course Title: Virology

Course Code: 601BIO1202

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

Learning Objectives

LO1. To illustrate morphology and replication strategy of viruses.

LO2. To acquire information on viral cultivation.

LO3. To acquire information on diseases.

LO4. To describe and review elements of viral life cycle.

LO5. To explain viral replication strategies.

LO6. To discuss principles of viral pathogenesis.

LO7. To explain vaccine strategies and mechanism of antiviral drug.

Course Outcomes

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

CO1. Facilitate conceptual understanding of classification of viruses

CO2. Acquire knowledge on basic aspects of cultivation of viruses

CO3. Acquire knowledge on basic aspects diseases.

CO4. Carryout research and development on viral diseases.

CO5. Contrast difference between virus architecture and classification.

CO6. Diagram virus transmission and replication.

CO7. Distinguish characteristics of normal cells and virus infected cells.

CO8. Study the biology of viruses.

Unit No.	Title of Unit & Contents	Hrs.
I	**Viruses**	**10**
	1. History, discovery and origin of viruses, Classification and general properties of MMC families of Viruses. 2. Morphology and ultra-structure of viruses, capsid and their arrangements,	

Unit No.	Title of Unit & Contents	Hrs.
	types of envelopes and their composition. **3.** Measurement of viruses. Viral genome; their types and structure, viral related agents-viroid and prions.	
	Unit Outcomes: UO1.Learnabout the classification of viruses. UO 2. Study morphology and ultrastructure of viruses.	
II	**Bacteriophages**	**11**
	1. Introduction to Bacteriophages, Phage Genome 2. Life Cycle of bacteriophage: Lytic pathway, Lysogenic pathway 3. Assay of viruses: Plaque assay, problems based on plaque assay, Multiplicity of infection. 4. Genetic analysis of phage: rII locus of T4 phage, Complementation, Intragenic mapping.	
	Unit Outcomes: UO1.Study life cycle of bacteriophage. UO 2. Discuss the genetic analysis of phage.	
III	**Plant Viruses**	**12**
	1. Plant viruses: Classification and structure of animal viruses. 2. Effect of animal virus on animal cells. 3. Life cycle of animal viruses: Viral adsorption or attachment to the host cell, Viral entry into the host cell, Replication of the viral genome within the host cell, Viral assembly and Viral release 4. Differences between bacteriophages and eukaryotic viruses 5. Retroviruses, HIV and AIDS, Hepatitis virus	
	Unit Outcomes: UO 1. Recognize the classification of plant viruses. UO 2. Develop knowledge about life cycle of animal viruses.	
IV	**Animal Viruses**	**12**
	1. Classification of plant viruses, Structure and pathogenicity of TMV. 2. Transmission of Plant viruses with vector (insect, nematodes and fungi) and without vector (contact, seed and pollens). Biochemical changes induced by virus in plant cell. 3. General idea about Cyanophage and Mycophage. Responsible communication of science to the public.	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1. Learn the basic types of plant viruses. UO 2. Acquire the knowledge about pathogenicity of TMV.	

Learning Resources:

1. Virology, Renato Dulbecco and Harold S. Ginsberg, Fourth edition, J. B. Lippincott Company, USA. 1980.
2. An Introduction to viruses, S. B. Biswas and Amita Biswas,4th edition, Vikas Publishing House PVT LTD New Delhi, 2007.
3. Textbook of Microbiology by Ananth Narayanan and Paniker's, eighth edition, Universities Press, 2022.
4. Microbiology; Lansing M Prescott, John P. Harley, Donald AKlein, Sixth edition, McGraw Hill Higher Education, 2002.
5. Pelczar M., Chan E.C.S. and Krieg, N.R. Microbiology. Tata Mc Grew Hill Publishing Co. Ltd., New Delhi, 1986.
6. Stainler R.V., Ingraham, JL, Wheells, M.L. and Painter P.R. The Microbial World Printice-Hall of India (Pvt.) Ltd., New Delhi, 2016.
7. Ellen Strauss, James Strauss. Viruses and Human Disease, Academic Press Christopher Burrell Colin Howard Frederick Murphy, Academic Press, 2007.
8. Principles of Virology, Bernard N. Fields Virology, Lippincott Williams & Wilkins S. Jane Flint. American Society for Microbiology, 2014.
9. Plant viruses: Diversity, Interaction and Management by Rajarshi Kumar Gaur, SMP Khurana, yuridorokhov, 2018.
10. Virology: Principles and Applications by Dr John carter, Prof Venetia Saunders, 2007.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: Lab Course

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

Course Code: 601BIO1203

Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1 To understand significance and applications of biological databases.

LO 2 To search desired sequence in primary databases.

LO 3 To do sequence alignment and phylogenetic analysis for the study of evolutionary relationships.

LO 4 To understand specific databases for PPI study and metabolic pathway study.

LO 5 To study structural and functional properties of proteins by using different

LO 6 bioinformatics tools.

LO 7 To understand molecular docking and omics tools for data analysis.

Course outcomes

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

CO 1. Do sequence alignment and phylogenetic analysis.

CO 2. Study protein structure prediction and analysis.

CO 3. Understand the concept of molecular docking.

CO 4. Know the methods of genomics, proteomics and metabolomics data analysis.

Practical No.	Unit
1.	Introduction to various online biological databases including primary and secondary databases.
2.	Sequence Alignment & Analysis (BLAST, FASTA, Gene Prediction)
3.	Multiple sequence alignment
4.	Uniport and Protein analysis
5.	Structure Databases & Visualization (PDB, PyMol)
6.	Phylogenetic tree and analysis by using MEGA and CLUSTAL Omega.
7.	Study of secondary structure of proteins and analysis by Ramachandran plot.

8.	Study of Protein-protein interaction network by String database.
9.	A Study of KEGG and REACTOME databases
10.	A demonstration of Genomics data (NGS data) by using online tools of genomics analysis.
11.	A demonstration of Proteomics data (NGS data) by using online tools of proteomics analysis.
12.	A study of molecular docking by using Autodock and other available software tools.

N.B.: Any Ten Practicals from above.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: Lab Course

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

Course Code: 601BIO1203

Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives:

LO 1. To achieve basic knowledge on virus cultivation

LO 2. To understand isolation and cultivation of bacteriophage

LO 3. To acquaint with practical aspects of plant viruses.

LO 4. To comprehend and appreciate the MMC and varied laboratory techniques and research approaches employed in the field of virology.

Course outcomes:

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

CO 1. Acquaint with the practical skills on virus cultivation.

CO 2. Get skilled in isolation and phage titration.

CO 3. Get familiarized in the instrumentation of virus diagnosis

CO 4. Know the importance of plant viruses

CO 5. Understand cultivation techniques of virus in embryonated egg.

CO 6. Learn symptoms related to plant viral diseases.

Practical No.	Unit
1	Isolation and enumeration of bacteriophage
2	Enumeration of growth phase of phage and burst size.
3	Detection of viruses using turbidometry assay
4	Study of plant viruses
5	Collection of infected plant material and identification
6	Study of morphology of lesions on infected plant
7	Laboratory detection of virus (collection and transport of virus sample)
8	Visit to diagnostic laboratory/research institute.
9	Cultivation of viruses in embryonated eggs: different routes of inoculation

10	Basic cell culture techniques and virus cultivation in cell culture.
11	Study of symptoms of local virus diseased plants through fieldwork, slides/photographs

N.B.: Any Ten Practicals from above.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: RMC

Course Title: Research Methodology Course

Course Code: 601BIO1301

Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives

LO 1 To understand the fundamental concepts and principles of research methodology.

LO 2 To develop the skills necessary for formulating and identifying research problems.

LO 3 To gain knowledge of various research designs and their applicability in different research scenarios.

LO 4 To acquire proficiency in selecting appropriate sampling techniques and determining sample sizes.

LO 5 To familiarize oneself with different data collection methods and their implementation in research.

LO 6 To develop skills in data analysis, including descriptive and inferential statistics.

LO 7 To enhance the ability to present research findings effectively through data visualization techniques.

LO 8 To gain technical skills in using Microsoft Office applications and LaTeX for research documentation and formatting.

Course Outcomes

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

CO 1 Understand the importance of research methodology and its application in various disciplines.

CO 2 Apply the research process effectively by following the steps involved in conducting research.

CO 3 Differentiate between exploratory, descriptive, and experimental research approaches and select the appropriate one for a given research problem.

CO 4 Formulate research problems and develop clear research objectives and hypotheses.

CO 5 Design appropriate research studies by selecting the suitable research design and sampling techniques.

CO 6 Collect and analyze data using various methods and techniques, ensuring data quality.

CO 7 Apply descriptive and inferential statistics to summarize and analyze research data.

CO 8 Create well-formatted research documents using latex, including complex mathematical equations and symbols.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction to Research Methodology**	**12**
	1. Introduction to Research: Definition, characteristics, and importance of research. 2. Research Process: Overview of the steps involved in the research process. 3. Types of Research: Exploratory, descriptive, and experimental research. 4. Research Problem: Identification and formulation of research problem. 5. Research Objectives and Hypotheses: Formulating clear research objectives and hypotheses.	
	Unit Outcomes: UO 1. Understand the importance of research methodology and its application in various disciplines. UO 2. Apply the research process effectively by following the steps involved in conducting research.	
II	**Research Design and Sampling**	**10**
	1. Research Design: Types of research design (experimental, quasi-experimental, non-experimental). 2. Variables: Types of variables and their measurement. 3. Sampling Techniques: Probability and non-probability sampling techniques. 4. Sample Size Determination: Factors affecting sample size and methods for determining sample size. 5. Data Collection Methods: Surveys, interviews, observation, and experiments.	
	Unit Outcomes: UO1. Differentiate between exploratory, descriptive, and experimental research approaches and select the appropriate one for a given research problem. UO2. Formulate research problems and develop clear research objectives and hypotheses.	
III	**Data Collection and Analysis**	**12**

Unit No.	Title of Unit & Contents	Hrs.
	1. Data Collection: Procedures for collecting data and ensuring data quality. 2. Data Analysis: Introduction to qualitative and quantitative data analysis. 3. Descriptive Statistics: Measures of central tendency and dispersion for summarizing data. 4. Inferential Statistics: Hypothesis testing, t-tests, chi-square tests, and ANOVA. 5. Data Presentation: Graphical representation of data using charts, graphs, and tables.	
	Unit Outcomes: UO 1. Design appropriate research studies by selecting the suitable research design and sampling techniques. UO 2. Collect and analyze data using various methods and techniques, ensuring data quality.	
IV	**Technical Skills for Research**	**11**
	1. Microsoft Office Applications: 2. Word: Formatting research documents, including tables, figures, and managing references for professional reports. 3. PowerPoint: Designing visually appealing and impactful presentations to communicate research findings effectively. 4. Excel: Organizing and analyzing research data using functions, formulas, and creating charts for data visualization. 5. LaTeX: 6. Introduction to LaTeX: Understanding the basics of LaTeX typesetting system and its advantages in academic research. 7. Document Formatting: Mastering LaTeX commands for formatting research documents, including titles, headings, and citations. **8.** Mathematical Equations and Symbols: Writing and formatting complex mathematical equations and symbols using LaTeX.	
	Unit Outcomes: UO 1. Apply descriptive and inferential statistics to summarize and analyze research data. UO 2. Create well-formatted research documents using LaTeX, including complex mathematical equations and symbols.	

Learning Resources:

1. Research Introduction, Best, J. W. and Kahn J. V., New Delhi, PHI, 2005.
2. Research Methodology, Bhattacharya, D. K., New Delhi, Excel Books, 2004.
3. Qualitative Data Analysis for Social Scientist, Brymann, Alan and Carmer, D., New York, Routledge Publications, 1994
4. Research Methodology, C. R. Kothari & Gaurav Garg, New Age International Publishers, 2019
5. Methodology of Research in Social Sciences, Krishnaswami O.R., Himalaya Publishing House, 1993.
6. Research Methodology, James V. Kahn John W. Best, PHI Limited.
7. Fundamentals of Modern Statistical Methods: Substantially Improving Power and Accuracy, Rand R. Wilcox, Springer, 2010
8. Research Methodology, Krishna Prasad Gopalakrishnan, Notion Press
9. Research Methodology, R. Panneerselvam, PHI Learning, 2014
10. Research Methodology, Upagade Vijay &Shende Arvind, S Chand, 2012
11. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, John W. Creswell, J. David Creswell, published by SAGE Publications Ltd in 2017.
12. Research Methodology: Methods and Techniques, C.R. Kothari, published, New Age International Publishers in 2004.
13. Research Methods: The Basics" by Nicholas Willman, published, Routledge in 2017.
14. Qualitative Research Methods: Collecting Evidence, Crafting Analysis, Communicating Impact, Sarah J. Tracy, published by Wiley in 2019.
15. Quantitative Research Methods for the Social Sciences, Bruce L. Babbie, published by Cengage Learning in 2019.
16. Research Methods in Psychology, Beth Morling, published by W. W. Norton & Company in 2017.
17. The Craft of Research, Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, published by University of Chicago Press in 2016.
18. Qualitative Inquiry and Research Design: Choosing Among Five Approaches, John W. Creswell, published by SAGE Publications Ltd in 2018.
19. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Creswell, John W., published by SAGE Publications Inc in 2013.

Semester - II

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: MMC- IV

Course Title: Molecular Genetics

Course Code: 601BIO2101

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

Learning Objectives

LO 1. To understand classical Mendelian genetics.

LO 2. To understand genome organization in lower and higher organisms.

LO 3. To understand chromosomal linkage and its significance.

LO 4. To understand replication, mutation and repair events in both Prokaryotic and eukaryotic organisms.

LO 5. To understand central dogma of life and gene flow.

LO 6. To know gene regulation and its application

Course outcomes

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

CO 1. Extend understanding of the molecular mechanisms via which genetic information is stored, expressed and transmitted among generations.

CO 2. Understand Medelin genetics and its extension.

CO 3. Understand the principles of inheritance at molecular level.

CO 4. Understand the synthesis, structure, and function of nucleic acids replication and eukaryotic.

CO 5. Understand concept of multiple allelism.

CO 6. Understand the flow of genetic information in populations and the relationship between genetics and evolutionary theory.

Unit No.	Title of Unit & Contents	Hrs.
I	**Principles of Genetics**	**12**
	1. Biography of Mendel and his experiments on pea plants. 2. Genetic linkage and gene mapping	

Unit No.	Title of Unit & Contents	Hrs.
	3. Chromosome theory of Sex determination: XX- XY, XX-XO, ZZ-ZW. 4. Chromosomal aberrations: Structural & Numerical: **5.** Basics of genome (gene, chromosome, DNA. RNA)	
	Unit Outcomes: UO 1. Describe basics of mediation genetics and related laws. UO 2. Understand the basic concept sex linkage, sex determination and Chromosomal aberration.	
II	**DNA replication and DNA repair**	**08**
	1. Genome Replication in prokaryote 2. Various modes of DNA replication, enzymes involved. 3. Eukaryotic organisms, Replication regulation in Eukaryotic, enzymes involved. 4. DNA Repair, Recombination: homologous, site specific, transposition	
	Unit Outcomes: UO 1. Get acquainted with DNA replication in Prokaryotic and Eukaryotic cell. UO 2. Understand the concept of DNA repair.	
III	**Transcription and Translation**	**15**
	1. Transcription in Prokaryotes and Eukaryotes (Initiation, elongation, and termination) 2. Post transcriptional processing of m-RNA, t-RNA, r-RNA. 3. Translation in prokaryotes and eukaryotes (Initiation, elongation, and termination) **4.** Post translational modifications of proteins- Chemical modification, protein folding and protein localization.	
	Unit Outcomes: UO 1. Explain transcription in prokaryotic and eukaryotes. UO 2. Learn about translation in both prokaryotic and eukaryotes'	
IV	**Gene Expression in Prokaryotes and eukaryotes.**	**10**
	1. Gene regulation in prokaryotes: -Operon concept, Lactose, Tryptophan and Arabinose. Role of cAMP and CRP in lac operon, tryptophan operon, Catabolite repression	

Unit No.	Title of Unit & Contents	Hrs.
	2. Gene regulation in eukaryotes: -Conserved mechanism, activation, and repressor role in gene regulation. **3.** Gene silencing, Signal integration.	
	Unit Outcomes: UO 1. Learn about the gene expression in lower and higher organism. UO 2. Learn the concept of gene silencing.	

Learning Resources:

1. Chromosomal Aberrations: Basic and Applied aspects by Obe. G. and A.T. Natarajan (1990)
2. Cytogenetics, Plant Breeding and evolution by U. Sinha and Sunita Sinha, Vikas Publishing House Private, Limited, 1998.
3. Cytology, Genetics and Molecular Biology by P.K. Gupta (2002), Rastogi publications.
4. Elements of Genetics by Phundan Singh, Kalyani Publishers. 2009.
5. William S. Klug and Michael R. Cummins (2005) Concepts of Genetics (International Edition) Edition: Seventh
6. T. A. Brown, John Wiley (2002) Genome 22nd Edition.
7. Lodish, Berk-Freeman (2003) Molecular Biology 7th edition Pub. Molecular Biology of the Cell
8. Benjamin A. Pierce (2010) A conceptual Approach; 6th edition Genetics:
9. Albert Bruce, (2005) Molecular Biology of the Cell, Garland Science Publication.
10. T. A Brown, John Wiley (2006) Genetics a Molecular Approach,
11. Veer Bala Rastogi (2015) Principal of Molecular Biology 2nd edition

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: Lab Course

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

Course Code: 601BIO2104

Credits: 01 **Max. Marks: 50** **Hours:30**

Learning Objectives

LO 1. To understand classical Mendelian genetics using different problems.

LO 2. To provide Hands-on isolation and purification of nucleic acids.

LO 3. To understand chromosomal linkage and its significance using different problems.

LO 4. To study quantitative analysis of nucleic acids.

LO 5. To get familiarize with practical skills of transcription and translation mechanism.

LO 6. To acquaint with genetic recombination techniques.

LO 7. To acquaint with DNA repair mechanism.

Course outcomes

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

CO 1. Apply the skill of Mendelian genetics and their experimental proof in genetic research.

CO 2. Develop skills in isolation and purification of genomic DNA , plasmid DNA and RNA.

CO 3. Separate and purify nucleic acids based on charge.

CO 4. Apply the skills of genome transformation in research.

CO 5. Develop auxotroph's by using replica plating technique.

CO 6. Apply the skills of mutation in strain development.

Practical No.	Unit
1	Problems related to monohybrid and dihybrid cross.
2	Problems related to linkages.
3	Problems based on sex determination.
4	Isolation of genomic DNA from bacteria.
5	Isolation of genomic DNA from animal and plant cells.

6	Isolation of plasmid DNA by using alkaline lysis method.
7	Agarose gel electrophoresis by using DNA markers for molecular wt. determination.
8	To study purity of DNA by Spectrophotometer.
9	Isolation of antibiotic resistant bacteria by gradient plate method.
10	Isolation of RNA from yeast cells.
11	Replica plating for transfer of bacterial colonies.
12	Genetic recombination (conjugation, transformation, transduction) in bacteria.
13	Study of mutations and DNA repair.
14	Study of invitro transcription and translation.

N.B.: Any Ten Practicals from above.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: MMC V

Course Title: Immunology and Immunotechniques

Course Code: 601BIO2102

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

Learning Objectives:

LO 1. To understand cells and organs of Immunology.

LO 2. To study basics of antigen, antibody and MHC molecules.

LO 3. To study clinical immunology with respect to various diseases.

LO 4. To study various immune-techniques of immunology.

LO 5. To understand the concept of types of innate immune system.

LO 6. To learn the concept of epitopes.

LO 7. To explain the concept of complement system.

LO 8. To explain the concept of radioimmunoassay.

Course Outcomes:

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

CO 1. Understand the working of cells and organs of immunology.

CO 2. Explain the properties of antigen, antibody and MHC molecules.

CO 3. Discuss the clinical aspects of immunology.

CO 4. Describe various antigen-antibody reactions and their significance.

CO 5. Explain the primary lymphoid organs.

CO 6. Discuss the discovery of antibody structure.

CO 7. Understand the concept of autoimmunity.

CO 8. Understand the concept of enzyme linked immunosorbent assay.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction**	**13**
	1. The history of immunology 2. Hematopoiesis and Cells of Immune system	

Unit No.	Title of Unit & Contents	Hrs.
	3. Mechanism of Innate Immune System 4. Mechanism of Adaptive Immune System: Humoral and cell-mediated Immunity. 5. Types of Innate Immune System 6. Types of Adaptive Immune System 7. Primary lymphoid organs – Thymus, Bursa of Fabricius and Bone marrow 8. Secondary lymphoid organs – Spleen and Lymph node.	
	Unit Outcomes: UO 1. Understand the working of cells and organs of immunology. UO 2. Understand the mechanism of Immune system.	
II	**Basics of Immunology**	**12**
	1. Antigen: Characteristics of antigen, types, 2. Factors that Influence Immunogenicity, 3. Epitopes, Haptens, Antigenicity and Immunogenicity, adjuvant and its types. 4. Antibody: General Structure of antibody molecule. 5. Discovery of antibody structure by chemical and enzymatic methods. 6. Antibodies Types- variation in structure of antibodies. 7. Functions of the antibody molecules. 8. Organization and Expression of Immunoglobulin Genes. 9. MHC molecules: Structure and types of MHC molecules. 10. Antigen processing and presentation: Endocytic and cytosolic pathway.	
	Unit Outcomes: UO 1. Explain the properties of antigen, antibody and MHC molecules. UO 2. Understand the functioning antibody molecule.	
III	**Clinical Immunology**	**10**
	1. Complement system: Alternative, Classical & Lectin pathway 2. Hypersensitivity: Hypersensitivity reactions and its types 3. Immunodeficiency Conditions: Primary immunodeficiency (SCID), Secondary immunodeficiency (AIDS)	

Unit No.	Title of Unit & Contents	Hrs.
	4. Autoimmunity: Organ specific autoimmune diseases and Systemic autoimmune diseases 5. Transplantation Technology**:** Types of graft (auto, Iso, Allo, and xeno graft), Autograft Acceptance vs allograft rejection 6. Vaccine Technology: Active and Passive Immunization. Type of Vaccines.	
	Unit Outcomes: UO 1. Discuss the clinical aspects of immunology. UO 2. Explain the basic concepts of vaccine technology.	
IV	**Immuno-techniques**	**10**
	1. Precipitation reactions: Precipitation reactions in gel, precipitation reactions in fluids. 2. Agglutination reactions: Mechanism with Example. 3. Radioimmunoassay: Mechanism and Applications 4. Immuno-electron microscopy: Concept and Significance 5. Complement Fixation Test, Flow cytometry: Process and Applications **6.** Enzyme Linked Immunosorbent Assay: Mechanism & Types, Western Blotting: Mechanism and Significance	
	Unit Outcomes: UO 1. Describe various antigen-antibody reactions and their significance. UO 2. Understand Radioimmunoassay.	

Learning Resources:

1. Immunology, Kuby, Judy Owen, Jenni Punt, Sharon Stanford, 7th Edn, WH Freeman Publishers, 2012.
2. Immunology, Weir DM and Stewart, J., Churchill Livingston, 10th Edn New York, 2000.
3. Immunology- An Introduction, Tizard, Ian R., Saunders College Publishing, 4th Edn, New Delhi,2000.
4. Textbook of Immunology, Sunil Kumar Mohanty, K Sai Leela, 2nd Edition, Jaypee Brothers Medical Publishers, 2014.

5. Basic and Clinical Immunology, Mark Peakman and Diego Vergani. 1st magazine, Churchill Livingstone, New York, 1997.
6. Essential Immunology, Roitt I., Blackwell Scientific Publications, 13th edn, 2017.
7. Fundamental Immunology, William E. Paul., Lippincott Williams and Wilkins; 7th edn, 2012.
8. Text Book of Microbiology, Anathanarayanan and Paniker, Orient and Longman, New Delhi, 8th edition, 2009.
9. Immunology and Immunological Techniques, Nethan Lewis, Ed-tech press, 2020.
10. Immunological techniques: Interpretations, Validation and Safety Measures, Ankita Joshi, Prof. R. S. Chauhan, Kapish Prakashan, 2022.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: Lab Course

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

Course Code: 601BIO2105

Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1. To understand cells and organs of immune system.

LO 2. To study basic immunological techniques.

LO 3. To study various antigen-antibody reactions.

LO 4. To study basics of antigen, antibody and MHC molecules

LO 5. To study various immune-techniques of immunology.

LO 6. To provide hands-on experiments of Hematology.

LO 7. To study diagnosis of diseases.

LO 8. To study Complement fixation.

Course Outcomes

CO 1. Deliberate diagnosis of disease with help of kit-based Practicals.

CO 2. Describe structure of cells and organs of immunology using microscopy.

CO 3. Identify the pattern of ag – ab interactions.

CO 4. Perform hematological experiments.

CO 5. Calculation of kinetics of enzyme catalyzed reactions

CO 6. Describe enzyme inhibitory and regulatory process.

CO 7. To identify pathogen using antigen antibody samples.

CO 8. To perform hematology experiments.

Practical No.	Unit
1	Agglutination reaction
2	Latex agglutination
3	Immunoprecipitation
4	Radial immunodiffusion
5	Ouchterlony Double diffusion

6	Immuno-electrophoresis.
7	Rocket immune-electrophoresis.
8	Crossed antigen-antibody electrophoresis.
9	Blood film preparation and identification of cells
10	Microscopic observation of lymphoid organs
11	Widal
12	VDRL
13	Determination of bleeding time
14	Determination of clotting time
15	Western blotting.
16	Immunofluorescence.
17	complement fixation test

N.B.: Any Ten Practicals from above.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: MMC-VI

Course Title: Bioprocess Engineering

Course Code: 601BIO2103

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

Learning Objectives:

LO 1. To understand the fluid statics and basic of bioprocess engineering

LO 2. To understand basic idea of designing of Bioreactor, Growth and sterilization kinetics

LO 3. To understand the measurement and control of Bioprocesses Parameters.

LO 4. To understand upstream and downstream processing techniques.

LO 5. To learn concept of material balance with reactions.

LO 6. To design sterilization cycle using kinetics of thermal death of microbes

LO 7. To learn strain improvement techniques by genetic engineering.

LO 8. To study how to measure and control bioprocess parameters.

Course Outcomes:

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

CO 1. Acquaint fluid statics and material engineering.

CO 2. Apply the knowledge to design bioreactor and study sterilization Kinetics.

CO 3. Describe and apply downstream processing techniques in research and industry.

CO 4. Explain growth kinetics and process control mechanism.

CO 5. Differentiate between Newtonian and non-Newtonian fluid.

CO 6. Explain mechanism of air and media sterilization.

CO 7. Describe different types of bioprocesses.

CO 8. Make different strategies for fermentation control.

Unit No.	Title of Unit & Contents	Hrs.
I	**Basic Chemical Engineering calculations**	**12**
	1. Material balance. Material balance with reactions. Material balance with recycle and purge. 2. Energy balance. 3. Enthalpy, specific heat, mean specific heat. Heat Balance.	

Unit No.	Title of Unit & Contents	Hrs.
	4. Heat of reaction and heat of solution. 5. Material and Energy balance together. 6. Fluid statics: Classification of fluids, concept of Reynold's number, 7. Rheological properties of fermentation process (Viscosity, cell concentration, product concentration etc), 8. Fluid mechanics. Potential flow. 9. Newtonian and non-Newtonian fluid (Bingham plastic, pseudo plastic, dilatants etc.) 10. Heat and mass Transfer.	
	Unit Outcomes: UO 1. Acquaint fluid statics and material engineering. UO 2. Describe material and energy balance and heat of reaction.	
II	**Design of Fermenters and Sterilization Kinetics**	**13**
	1. Fermenters: Ideal Properties of Bioreactor 2. Components of the fermenters & their specifications: Body Construction, Agitator, Impeller, Baffles etc. 3. Types of Bioreactors: (Packed-bed reactor, Air –lift, Trickle bed Photo bioreactors, Rotating Biological Reactors pneumatic) 4. Air & Media sterilization: Air Sterilization Principles, Mechanisms of capture of particles in Air, Depth & Screen Filters, Sizing, Testing & validation of filters for air sterilization 5. Principle of Media Sterilization, Decimal reduction 6. Design of sterilization cycle using kinetics of thermal death of microbes and equipment's used in sterilization: Batch & Continuous 7. Quality Control 8. Quality assurance 9. Standard Operating Procedures (SOP) 10. Good Manufacturing Practices (GMP)	
	Unit Outcome: UO 1. Apply the knowledge to design bioreactor and study sterilization Kinetics UO 2. Explain the concept of Air & Media sterilization.	
III	**Media for large-scale processes & their optimization**	**17**

Unit No.	Title of Unit & Contents	Hrs.
	1. Constituents of media, their estimation & quantification 2. Design of media. Costing of media 3. Strain Improvement: Isolation and Screening of microorganisms 4. Preservations and maintenance of Microorganisms, strain improvement, Mutagenesis 5. Genetic Engineering for Strain Improvement., Development of inoculum 6. Types of Bioprocesses: Biotransformation (enzyme, whole cell) 7. Batch, Fed-batch, Cell recycle & continuous fermentation processes 8. Growth Kinetics: Monod model & constitutive equations used for expressing growth, substrate consumption & product formation 9. Solid State fermentation Microbial & death kinetics.	
	Unit Outcomes: UO 1. Describe and apply downstream processing techniques in research and industry. UO 2. Understand the concept of Growth Kinetics.	
IV	**Measurement & Control of Bioprocesses Parameters**	**18**
	1. Measurement & Control of Bioprocesses Parameters: Cell growth. pH, temperature, Substrate consumption, product formation. 2. Measurement of O2/CO2 uptake, evolution. 3. Specific rates of consumption substrate & formation of product. 4. Strategies for fermentation control. 5. Computer controlled fermentations. 6. Foam & its control. 7. Scale up and Scale-down in Bioprocesses fermentations. 8. Downstream processing: Strategy for recovery 9. Harvesting of Biomass and Product, Removal of microbial cells and solid matter, foam separation, filtration, centrifugation, cell disruption. 10. Liquid -liquid extraction Ext, chromatography and membrane processes, 11. Drying and crystallization.	

Unit No.	Title of Unit & Contents	Hrs.
	12. Bioprocess Economics, Choice of process, process analysis, fixes & variable cost, Depreciation. 13. Amortized costs, Selection of Pricing, Profitability, Scales of operations etc.	
	Unit Outcomes: UO 1. Explain growth kinetics and process control mechanism. UO 2. Understand the basic concept of Downstream processing: Strategy for recovery.	

Learning Resources:

1. Principles of Fermentation Technology, Whittaker & Stan bury, 2nd Edn, Pergamon Press, 1995
2. Bioprocess Engineering Principles - Pauline Doran, Academic Press 1995
3. Operational Modes of Bioreactors, BIOTOL series - Butter worth, Heinemann 1992
4. Bioreactor Design & Product Yield, BIOTOL series - Butter worth Heinemann 1992
5. Bioprocess Engineering: Systems, Equipment & Facilities - Ed. B. Lydersen, N.A. Delia & K.M. Nelson, John Wiley & Sons Inc, 1993
6. Bio separation: Downstream Processing for Biotechnology - Paul A. Belter, E.L Cussler, Wei-Shou Hu, Academic Press, 1988
7. Solvent Extraction in Biotechnology – Larl Schuger, Spinger Verlag, 1994
8. Basic Biotechnology 3rd edition Colin Ratledge – Cambridge Publication, 2008
9. Fundamentals of Biochemical Engineering 2nd edition Bailay & ollis- Tata McGraw Hill Publication, 1986
10. Bioprocess Engineering Basic Concepts, Michael L. Shuler and Fikret Kargil, 2nd Edn, 2015.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: Lab Course

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

Course Code: 601BIO2106

Credits: 01 **Max. Marks: 50** **Hours: 30**

Leaning Objectives

LO 1. To understand working of fermenter.

LO 2. To provide Hands -On upstream and downstream processing of industrial products.

LO 3. To provide Hands-on Screening of potent microorganism.

LO 4. To learn solution for growth and sterilization kinetics.

LO 5. To understand design of bioreactor.

LO 6. To study different types of fermentation process.

Course outcomes

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

CO 1. Perform Hands-on Screening of potent microorganism

CO 2. Perform Hands -On upstream and downstream processing of industrial products

CO 3. Solve problems related to fermentation kinetics

CO 4. Design small scale Bioreactor

Practical No.	Unit
1	Study of Growth Kinetics of Bacteria and Yeast by turbidometry & SCP
2	Screening and maintenance of Industrially important microorganism (Acids, Antibiotics, Enzymes)
3	Study of scale up of fermentation
4	Study of design of bioreactor
5	Determination of TDP
6	Determination of TDT and design of sterilizer
7	Study of types of fermentation process (Surface and submerged)
8	Downstream process of industrial products (Intra & Extra cellular)
9	Problems based on: - Growth kinetics, fluid flow, Reynold's number
10	Visit to fermentation Industry

N.B.: Any Ten Practicals from above.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: MEC-II (A)

Course Title: Biomathematics and Biostatistics

Course Code: 601BIO2201

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

Learning Objectives

LO 1. To understand fundamental concepts of set theory, including sets, elements, subsets, and their operations.

LO 2. To understand determinants, their properties, and their role in solving systems of equations and matrix operations.

LO 3. To interpret and classify data, and create frequency and cumulative frequency tables for statistical analysis.

LO 4. To construct accurate and meaningful graphical representations of data, including line diagrams, bar diagrams, histograms, and more.

LO 5. To comprehend measures of central tendency, such as mean, median, mode, and their significance in data analysis.

LO 6. To calculate and analyze measures of dispersion, including range, median deviation, variance, and standard deviation.

LO 7. To understand the concept of probability and its application in real-world scenarios.

LO 8. To apply probability theorems, including those related to theoretical probability distributions (binomial, Poisson, normal).

Course Outcomes

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

CO 1. To comprehend the types of sets, perform set operations, and analyze their properties for mathematical problem-solving.

CO 2. To understand determinants, their properties, and their role in solving systems of equations and matrix operations.

CO 3. To interpret and classify data, and create frequency and cumulative frequency tables for statistical analysis.

CO 4. To construct accurate and meaningful graphical representations of data, including line diagrams, bar diagrams, histograms, and more.

CO 5. To comprehend measures of central tendency, such as mean, median, mode, and their significance in data analysis.

CO 6. To calculate and analyze measures of dispersion, including range, median deviation, variance, and standard deviation.

CO 7. To understand the concept of probability and its application in real-world scenarios.

CO 8. To apply probability theorems, including those related to theoretical probability distributions (binomial, Poisson, normal).

Unit No.	Title of Unit & Contents	Hrs.
I	**Biomathematics**	**12**
	1. Set Theory: Definition, Types of representation of sets, types of sets, operation on sets, difference set, complement of a set, union of set, intersection of set, cardinality, and its properties. 2. Determinant: introduction, The value of determinant, properties of determinants. 3. Matrices: calculation, types of matrices, addition & Multiplication of matrices	
	Unit Outcomes: UO 1. To comprehend the types of sets, perform set operations, and analyze their properties for mathematical problem-solving. UO 2. To understand determinants, their properties, and their role in solving systems of equations and matrix operations.	
II	**Basics of Biostatistics**	**07**
	1. Introduction, classification and tabulation of data. 2. Frequency and cumulative frequency table. 3. Diagrammatic representation of statistical data: Line diagrams, Bar diagram, Pie diagram. 4. Graphical representation of statistical data Histogram, frequency polygon, frequency curve, OGIVE, quartiles, deciles and percentiles.	
	Unit Outcome: UO 1 To interpret and classify data, and create frequency and cumulative frequency tables for statistical analysis. UO 2 To construct accurate and meaningful graphical representations of data, including line diagrams, bar diagrams, histograms, and more.	

Unit No.	Title of Unit & Contents	Hrs.
III	**Measures of central Tendency and Dispersion**	**07**
	1. Measures of Central Tendency: Introduction, types of central tendency: mean, median, mode, geometric mean and harmonic mean. Measures of Dispersion: Introduction, types of dispersion: Range, Medial deviation, variance and standard deviation, coefficient of variance.	
	Unit Outcomes: UO 1 To comprehend measures of central tendency, such as mean, median, mode, and their significance in data analysis. UO 2 To calculate and analyze measures of dispersion, including range, median deviation, variance, and standard deviation.	
IV	**Probability**	**07**
	1. Concept of probability. 2. Theorems of probability. 3. Theoretical probability distribution (Binomial, Poisson and normal distribution).	
	Unit Outcomes: UO 1 To understand the concept of probability and its application in real-world scenarios. UO 2 To apply probability theorems, including those related to theoretical probability distributions (binomial, Poisson, normal).	

Learning Resources:

1. Fundamentals of Biostatistics, Khan and Khanum, 5th edition, Ukaaz Publication, 2018.
2. Fundamental of Statistics, S. P. Gupta, 1st Edition, Sultan Chand & Sons Educational Publisher, New Delhi,2002.
3. Biostatistics: A Foundation for Analysis in the Health Sciences, Wayne W. Daniel and Chad L. Cross, 10th Edition, Wiley, 2013.
4. Introduction to the Practice of Statistics, David S. Moore, George P. McCabe, and Bruce A. Craig, 9th Edition, W. H. Freeman, 2017.
5. Basic Biostatistics: Statistics for Public Health Practice, B. Burt Gerstman, 2nd Edition, Jones & Bartlett Learning, 2014.

6. Biostatistics: The Bare Essentials, Geoffrey R. Norman and David L. Streiner, 4th Edition, PMPH-USA, 2014.
7. Biostatistics: A Methodology for the Health Sciences, Gerald van Belle, Lloyd D. Fisher, and Patrick J. Heagerty, 2nd Edition, Wiley, 2004.
8. Statistical Methods for Survival Data Analysis, Elisa T. Lee, John Wenyu Wang, and Ding-Geng Chen, 4th Edition, Wiley, 2013.
9. Statistics for People Who (Think They) Hate Statistics, Neil J. Salkind, 7th Edition, Sage Publications, 2020.
10. Biostatistics: A Foundation for Analysis in the Health Sciences, Wayne W. Daniel and Chad L. Cross, 10th Edition, Wiley, 2013.
11. Statistics for the Life Sciences, Myra L. Samuels, Jeffrey A. Witmer, and Andrew A. Schaffner, 5th Edition, Pearson, 2019.
12. Biostatistics: A Computing Approach, Stewart Anderson, 2nd Edition, CRC Press, 2016.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: MEC-II (B)

Course Title: Medical Biotechnology

Course Code:601BIO2202

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

Learning Objectives:

LO 1. To empower students with the knowledge of allied biomedical sciences to create a work force for advanced research and diagnostics in a medical environment.

LO 2. To familiarize the students with bacteria and viruses, diseases caused by bacteria, viruses and their control.

LO 3. To impart the knowledge of clinical research which can be used for drug discovery and development.

LO 4. To understand the relevance, basic concepts, theories of pharmacology.

LO 5. To study the preservation methods of bacterial cultures and maintenance.

LO 6. To get the knowledge about types of infections.

LO 7. To learn the general properties of viruses.

LO 8. To understand Types of Clinical Research Phases of clinical research.

Course Outcomes:

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

CO 1. Recognize (even with specific diagnostic tests) the interactions between microorganisms and humans.

CO 2. Acquaint the implications of types of drugs and their mechanisms of actions) from the subject area concepts, theory, experimental, research and health-care perspectives.

CO 3. Adopt code of ethics in professional and social context and demonstrate exemplary professional, ethical and legal behaviors in decision making.

CO 4. Recognize the MMC ethical problems related to clinical trials.

CO 5. Acquire the knowledge of role of antibiotics and chemotherapeutic agents

CO 6. Adapt the mechanisms of bacterial pathogenesis

CO 7. Acquaint the viral replication, viral genetics, classification of viruses

CO 8. Acquire the knowledge about preclinical drug testing

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction to Medical Biotechnology**	**12**
	1. Scope and history of Microbiology. Classification and identification of microorganism. Cultivation of bacteria. Culture media, preservation methods of bacterial cultures and maintenance. 2. Control of physical and chemical agents, sterilization and disinfection. 3. Role of antibiotics and chemotherapeutic agents, antiviral agents, viral agents, and antiviral drugs 4. The host-parasite relationship, Symbiotic associations, Characteristics of parasitism Entry, exit and transmission. 5. Normal flora, various sites of normal flora, list of normal flora and its beneficial and adverse effects.	
	Unit Outcomes: UO 1. Recognize (even with specific diagnostic tests) the interactions between microorganisms and humans. UO 2. Acquire the knowledge of role of antibiotics and chemotherapeutic agents.	
II	**Microbial Pathogenesis**	**10 Hrs.**
	1. Types of infections - primary, secondary, nosocomial, iatrogenic, zoonotic, etc. 2. Mechanisms of Bacterial pathogenesis – bacterial toxins, capsules, enzymes, intracellular parasitism, antigenic variations etc. leading to establishment of infections. 3. Principles of lab diagnosis of infectious diseases.	
	Unit Outcomes: UO 1. Acquire the knowledge of mechanisms of bacterial pathogenesis leading to establishment of infections. UO 2. Adapt the mechanisms of bacterial pathogenesis	
III	**Bacteriology, Mycology and Virology**	**11 Hrs.**
	1. Bacteria of medical importance: Gram Positive Cocci- *Staphylococcus, Streptococcus, Pneumococcus, Gram Negative Cocci- Neisseria*	

Unit No.	Title of Unit & Contents	Hrs.
	2. Gram Positive Bacilli- *Bacillus anthrax, C. diphtheria, Clostridium Gram Negative Bacilli- members of Enterobacteriaceae, Pseudomonadaceae, Vibrio cholera* 3. Other: Mycoplasma, Rickettsia, Chyamadia, Mycobacteria, infections produced by Fungi (Mycoses), Medical importance of fungi. 4. General properties of viruses 5. Viral replication, viral genetics, Classification of viruses 6. Pathogenesis of viral infections and Bacteriophages. 7. Laboratory diagnosis of viral infections, collection, storage and transport of specimen, viral cultivation 8. Serological methods of viral diagnosis. **Unit Outcomes**: UO 1. Acquaint the knowledge of mechanisms of serological methods of viral diagnosis. UO 2. Acquire the mechanism of viral replication, viral genetics.	
IV	**Introduction to Clinical Research**	**12 Hrs.**
	1. Introduction to Clinical Research Terminologies and definition in Clinical Research 2. Origin and History of Clinical Research Difference between Clinical Research and Clinical Practice 3. Types of Clinical Research Phases of clinical research 4. Clinical Trials in India. 5. Protocol writing, new drug discovery process- purpose, main steps involved in new drug discovery process, timelines of each step, advantages and purposes of each step, 6. Ethics in clinical research, unethical trials, Phase-I, II, III, IV trials 7. Introduction and designing -Principles of sampling -Inclusion and exclusion criteria -Methods of allocation and randomization -Informed consent process in brief -Termination of trial -Safety monitoring in clinical trials. 8. Guidelines for Care and Use of Laboratory Animals, Introduction to Preclinical Pharmacology Introductory Talk on Animal studies: present status, Pre – Clinical Toxicity, Lab Animals in Pharmacology	

Unit No.	Title of Unit & Contents	Hrs.
	9. Preclinical drug testing, Investigational New Drug Application, New Drug Application and Approval.	
	Unit Outcomes: UO 1. Adopt code of ethics in professional and social context and demonstrate exemplary professional, ethical and legal behaviors in decision making. UO 2. Acquire the knowledge about preclinical drug testing.	

Learning Resources:

1. Microbiology, Pelczer, Tata McGraw-Hill Higher Education, 1998.
2. Microbiology, Joanne Willey, Linda Sherwood, Chris Woolverton. Prescott's, 9th edition, Tata McGraw-Hill Higher Education, 2013.
3. General Microbiology, Roger Y. Stanier, 5th edition, Macmilla, 2009.
4. TextBook of Microbiology, Dr. C. P. Baweja., 6th edition, Arya Publication, 2012.
5. Textbook of Microbiology, Ananthnarayanan and Pakniker, 7th edition, Orient Blackswan, 2006.
6. Diagnostic Microbiology, Patricia M. Tille., 14th edition, Bailey and Scott's, , 2016.
7. Medical Biotechnology, Pongracz, Elsevier Health – UK, 2008.
8. Medical Biotechnology, P.K. Chakraborty, Dominant Publishers & Distributors, 2013.
9. Medical Biotechnology: Achievement Prospects and Perceptions, Albert Sasson, United Nations University, 1999.
10. Medical Biotechnology: Principles and Applications of Recombinant DNA, Bernard R. Glick, Cheryl L. Patten, Terry L. Delovitch, ASM Press, 2013.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: Lab Course

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

Course Code: 601BIO2203

Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1. To understand the principles of set operations and effectively apply them to analyse data relationships using Venn diagrams.

LO 2. To comprehend the concept of determinants and matrix operations, utilizing them to solve linear equations and practical problems.

LO 3. To gain proficiency in creating, interpreting, and utilizing a variety of graphical representations for accurate and insightful data visualization.

LO 4. To grasp the calculation, comparison, and interpretation of measures of central tendency and dispersion, enabling effective data analysis.

LO 5. To explore and analyse probability experiments, including binomial and Poisson distributions, to make informed predictions and decisions.

LO 6. To apply the concepts of geometric and harmonic means, deriving meaningful insights from data patterns and variability.

LO 7. To develop critical thinking skills by interpreting real-world data scenarios and utilizing mathematical techniques for problem-solving.

LO 8. To showcase proficiency in mathematical modelling, problem-solving, and effective communication of results for diverse applications.

Course Outcomes

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

CO 1. Utilize set operations and Venn diagrams to analyze and solve data-related problems.

CO 2. Solve linear equations using matrix techniques and determinants for various applications.

CO 3. Effectively present data using graphical representations for accurate and clear communication.

CO 4. Analyze and interpret data patterns and spread through measures of central tendency and dispersion.

CO 5. Conduct and interpret probability experiments, applying binomial and Poisson distributions to real scenarios.

CO 6. Calculate and apply geometric and harmonic means to draw insights from data sets.

CO 7. Apply critical thinking skills to interpret and solve complex real-world data challenges.

CO 8. Model and solve problems using mathematical concepts learned, showcasing problem-solving abilities.

Practical No.	Unit
1	Set Operations: a. Given sets A = {1, 2, 3} and B = {3, 4, 5}, find A ∪ B and A ∩ B. b. Calculate the difference set between sets C = {2, 4, 6} and D = {4, 6, 8}. c. Find the complement of set E = {a, b, c, d} with respect to the universal set U = {a, b, c, d, e, f}.
2	Cardinality and Venn Diagrams: Draw a Venn diagram to represent the sets A, B, and C, where A = {1, 2, 3}, B = {3, 4, 5}, and C = {2, 5, 6, 7}. Calculate the cardinality of the union and intersection of these sets
3	Determinant Calculation: a. Calculate the determinant of the matrix b. Find the determinant of a 3x3 matrix
4	Matrix Operations: a. Perform matrix addition for matrices. b. Multiply the matrix by a scalar value of k
5	Matrix Multiplication
6	Bar Diagram: a. Create a bar diagram to represent the number of patients with different blood types (A, B, AB, O). b. Represent the frequency of different types of cancer cases using a bar diagram.
7	Pie Diagram: a. Construct a pie diagram to show the proportion of different classes of diseases in a hospital dataset. b. Represent the distribution of plant species in a forest using a pie diagram.
8	Histogram: a. Draw a histogram depicting the distribution of exam scores in a class. b. Create a histogram to visualize the distribution of rainfall amounts in different months.
9	Frequency Polygon:

	a. Construct a frequency polygon to display the distribution of body mass index (BMI) in a population. b. Represent the distribution of enzyme activity levels using a frequency polygon.
10	Calculating Mean, Median, and Mode
11	Geometric and Harmonic Mean
12	Range and Median Deviation
13	Variance and Standard Deviation
14	Coin Toss Experiment
15	Dice Roll Experiment
16	Binomial Distribution
17	Poisson Distribution

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Course Type: Lab Course

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

Course Code: 601BIO2203

Credits: 02 **Max. Marks: 50** **Hours: 30**

Leaning Objectives:

LO 1 To recognize and diagnose common infectious diseases

LO 2 To impart knowledge of the basic principles of bacteriology, virology, mycology.

LO 3 To develop knowledge and skills required to practice medical microbiology.

LO 4 To differentiate between bacterial, viral, parasitic and fungal infections and to describe the mechanisms by which such microorganisms can cause disease.

LO 5 To isolate pathogens from different samples.

LO 6 To perform the antibiotic sensitivity test.

Course Outcomes:

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

CO 1 Isolate pathogens from different clinical samples.

CO 2 Identify common infectious agents and the diseases that they cause.

CO 3 Evaluate methods used to identify infectious agents in the clinical microbiology lab.

CO 4 Describe the epidemiology of infectious agents including how infectious diseases are transmitted

Practical No.	Unit
1	Isolation and identification of bacterial pathogen from clinical specimen from Urine sample
2	Isolation and identification of bacterial pathogen from clinical specimen from Pus sample
3	Isolation and identification of bacterial pathogen from clinical specimen from Blood sample
4	Antibiotic sensitivity test (Disk diffusion method and well diffusion method)
5	Widal test
6	Techniques for diagnosis of viral infections HIV b. HBs Ag c. Dengue

7	Techniques for diagnosis of parasitic infections Malaria b. Intestinal parasitic infection
8	Techniques for identification of pathogenic fungi: Germ tube test
9	LPCB preparation for molds
10	Slide culture technique
11	Visit to Pathological Labs

N.B.: Any Ten Practicals from above.

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.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

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.