

**Kavayitri Bahinabai Chaudhari
North Maharashtra University, Jalgaon**

॥अंतरी पेटवू ज्ञानज्योत॥



'A' Grade
NAAC Re-Accredited
(3rd Cycle)

SYLLABUS

for

**Master of Science (M. Sc.)
Microbiology**

*Choice Based Credit System
(Outcome Based Curriculum)*

**Department of Microbiology, School of Life Sciences
Kavayitri Bahinabai Chaudhari North Maharashtra University
Jalgaon 425 001 (M.S.)**

2019 - 2020

**Summary of Distribution of Credits under CBCS Scheme
for
M.Sc. Microbiology
at
School of Life Sciences**

[at University Campus under Academic Flexibility w.e.f. 2019-20]

Sr. No	Type of course	Sem I	Sem II	Sem III	Sem IV
01	Core	16	16	16	12
02	Skill based	04	04	-	-
03	School Elective	-	-	04	04
04	Project	-	-	-	04
05	Audit	02	02	02	02
06	Total Credits	22	22	22	22

Subject Type	Core	Skill based	School Elective	Project	Audit	Total
Credits	60	08	08	04	08	88

Total Credits = 88

Department of Microbiology, School of Life Sciences
Kavayitri Bahinabai Chaudhari North Maharashtra University Jalgaon
M. Sc. Microbiology

Choice Based Credit System (Outcome Based Curriculum) with effect from 2019 -2020

Course credit scheme

Semester	(A) Core Courses			(B) Skill Based / Elective Course			(C) Audit Course (No weightage in CGPA)			Total Credits (A+B+C)
	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (Practical)	Total Credits	
I	4	8 + 8	16	1	4 + 0	4	1	2	2	22
II	4	12 + 4	16	1	0 + 4	4	1	2	2	22
III	4	8 + 8	16	1	4 + 0	4	1	2	2	22
IV	4	8 + 8	16	1	4 + 0	4	1	2	2	22
Total Credits		64			16			8		88

(T, Theory; P, Practical)

Structure of Curriculum

		First Year				Second Year				Total Credit Value
		Semester I		Semester II		Semester III		Semester IV		
		Credit	Course	Credit	Course	Credit	Course	Credit	Course	
(A)	Prerequisite and Core Courses									
	Theory	4	2	4	3	4	2	4	2	36
	Practical	4	2	4	1	4	2	4	2	28
(B)	Skill Based / Subject Elective Courses									
1	Theory /Practical	4	1	4	1	4	1	4	1	16
(C)	Audit Course (No weightage in CGPA calculations)									
1	Practicing Cleanliness	2	1							2
2	Personality and Cultural Development Related Course			2	1					2
3	Technology Related + Value Added Course					2	1			
4	Professional and Social + Value Added Course							2	1	2
	Total Credit Value	14	6	14	6	14	6	14	6	88

List of Audit Courses (Select any ONE course of Choice from Semester II; Semester III and Semester IV)

Semester I (Compulsory)		Semester II (Choose One)		Semester III (Choose One)		Semester IV (Choose One)	
		Personality and Cultural Development		Technology + Value Added Course		Professional and Social + Value Added Course	
Course Code	Course Title	Course Code	Course Title	Course Code	Course Title	Course Code	Course Title
AC-101	Practicing Cleanliness	AC-201A	Soft Skills	AC-301A	Computer Skills	AC-401A	Human Rights
		AC-201B	Sport Activities	AC-301B	Cyber Security	AC-401B	Current Affairs
		AC-201C	Yoga	AC-301C	Seminar + Review Writing	AC-401C	Seminar + Review Writing
		AC-201D	Music	AC-301D	Biostatistics	AC-401D	Intellectual Property Rights (IPR)

Semester-wise Course Structure of M.Sc. Microbiology

Semester I

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
MB-101	Core	Microbial Taxonomy and Diversity	4	--	4	40	--	60	--	4
MB-102	Core	Microbial Physiology and Biochemistry	4	--	4	40	--	60	--	4
MB-103	Core	Methods in Microbiology	--	4+4	8	--	40	--	60	4
MB-104	Core	Methods in Microbial Chemistry	--	4+4	8	--	40	--	60	4
MB-105	Skill Based	Bioinstrumentation	4	--	4	40	--	60	--	4
AC-101	Audit Course	Practicing Cleanliness		2	2	--	100	--	--	2
Total Credit for Semester I: 22 (T = Theory: 8; P = Practical:8; Skill Based:4; Audit Course:2)										

Semester II

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
MB-201	Core	Molecular Biology and Bioinformatics	4	--	4	40	--	60	--	4
MB-202	Core	Microbial Enzymology	4	--	4	40	--	60	--	4
MB-203	Core	Immunology	4	--	4	40	--	60	--	4
MB-204	Core	Methods in Molecular Biology and Immunology	--	4+4	8	--	40	--	60	4
MB-205	Skill Based	Methods in Enzymology	--	4+4	8	--	40	--	60	4
AC-201 A/B/C/D	Audit Course	Choose one out of Four (AC-201A/ AC-201B/AC-201C/AC-201D) from Personality and Cultural Development	--	2	2	--	100	--	--	2
Total Credit for Semester II: 22 (T = Theory: 12; P = Practical:4; Skill Based:4; Audit course:2)										

Semester III

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
MB-301	Core	Pharmaceutical Microbiology	4	--	4	40	--	60	--	4
MB-302	Core	Applied Molecular Biology	4	--	4	40	--	60	--	4
MB-304	Core	Methods in Bioinformatics	--	4+4	8	--	40	--	60	4
MB-305	Core	Methods in Applied Microbiology	--	4+4	8	--	40	--	60	4
MB-303	Elective (Select any one)	Applied and Environmental Microbiology	4	--	4	40	--	60	--	4
BC-303		Toxicology								
BT-303		Advanced Environmental Biotechnology								
AC-301 A/B/C/D	Audit Course	Choose one out of Four (AC-301A/ AC-301B/AC-301C/AC-301D) from Technology + Value Added Courses		2	2		100	--	--	2
Total Credit for Semester III: 22 (T = Theory: 8; P = Practical:8; Skill Based:4; Audit Course:2)										

Semester IV

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
MB-401	Core	Fermentation Technology	4	--	4	40	--	60	--	4
MB-402	Core	Microbial Genetics	4	--	4	40	--	60	--	4
MB-404	Core	Methods in Biotechnology	--	4+4	8	--	40	--	60	4
MB-405	Core	Laboratory Course (Project Dissertation)	--	4+4	8	--	40	--	60	4
MB-403	Elective (Select any one)	Agricultural Microbiology	4	--	4	40	--	60	--	4
BC-403		Industrial Biotechnology								
BT-403		Pharmaceutical Biotechnology								
AC-401 A/B/C/D	Audit Course	Choose one out of Four (AC-401A/ AC-401B/ AC-401C/ AC-401D) from Professional and Social + Value Added Courses		2	2		100	--	--	2
Total Credit for Semester IV: 22 (T = Theory: 8; P = Practical:8; Skill Based:4; Audit Course:2)										

Program at a Glance

Name of the program (Degree)	: M. Sc. (Microbiology)
Faculty	: Science and Technology
Duration of the Program	: Two years (four semesters)
Medium of Instruction and Examination	: English
Exam Pattern	: 60 : 40 (60 marks University exam and 40 marks continuous internal departmental exam/assessment)
Passing standards	: 40% in each exam separately (separate head of passing)
Evaluation mode	: CGPA
Total Credits of the program	: 88 (64 core credits including 4 credits of project/dissertation, 08 skill enhancement credits, 08 subject elective credits and 08 audit credits)

Program Objectives for M.Sc. Program:

1. To impart the profound theoretical and practical knowledge of the specific science discipline along with the fundamental core concepts
2. To train the students to employ modern techniques, tools, methodologies, equipment, hardware/software etc. to perform objective oriented scientific and planned experiments.
3. To groom the students for all-round development and mould them in a trained workforce to provide teaching-learning, research, business, professional supports in the various science disciplines.
4. To make the student to develop the ability to think analytically, independently and draw logical conclusions to solve real-life problems.
5. To utilize the skills and knowledge gained through the subject to deal with real life situations and problems related to society, environment, research and development etc.

Program Outcomes (PO) for M.Sc. Program:

Upon successful completion of the M.Sc. program, student will be able to:

PO No.	PO	Cognitive level
PO1	Understand the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.	2
PO2	Administer the skills in handling scientific instruments, planning and performing in laboratory experiments	3
PO3	Analyse the given scientific experimental data critically and systematically and the ability to draw the objective conclusions.	4
PO4	Develop various skills such as communication, managerial, leadership, entrepreneurship, teamwork, social, research etc., which will help in expressing ideas and views clearly and effectively	3
PO5	Model and formulate the real problems and find solution based-on knowledge acquired	6
PO6	To evaluate how developments in any science subject helps in the development of other science subjects and vice-versa and how interdisciplinary approach helps in providing better solutions and new ideas for the sustainable developments.	5

Program Specific Objectives for M.Sc. Microbiology program:

- Basic concepts, principles and methods of Microbial Diversity, microbial Systematics and Bioinstruments used in isolation and identification of microbes and structural determination of biomolecules.
- Basic and applied aspects of Genetic makeup of bacteria, algae, fungi and viruses.
- Causes, mechanisms and consequences of defect in gene/genome of microorganisms.
- Basic concepts of microbial enzymes, enzyme kinetics, regulation of enzyme activity, industrial applications of enzymes.
- Biotechnological significance of enzymes of extremophiles in agriculture, environment, medicine and industry.
- Concepts and significance of enzymes in non-aqueous environment.

Program Specific Outcomes (PSOs) for M.Sc. Microbiology program:

Students who graduate with a Master of Science in Microbiology will:

PSO No.	PSO	Cognitive level
PSO1	Demonstrate an understanding of structure and metabolism of macromolecules, understand the regulation of metabolic pathways and understand the role of microbes in industry, health and environment.	2
PSO2	Gain proficiency in laboratory techniques in both microbiology and molecular biology and be able to apply the scientific methods to the processes of experimentation and hypothesis testing.	3
PSO3	Acquire significant knowledge on various aspects related to microbiology including biochemical techniques, immunology, physiology, agriculture, environment, pharmaceutical, molecular biology, applied recombinant DNA technology and technical skills related to microbial metabolites.	4
PSO4	Learn to work as a team as well as independently to retrieve information, carry out Research investigations and result interpretations.	6
PSO5	Develop the ability to understand and practice the ethics surrounding scientific research.	5
PSO6	Realize the impact of science in society and plan to pursue research.	5

Distribution of Course papers for M. Sc. Part I Microbiology

Subject Code	Title of the Paper		Duration (Hrs./Wk)	Max. Mark	Exam. Time (Hrs.)
M.Sc. Part I Microbiology					
Semester I : Theory Courses					
MB-101	Microbial Taxonomy and Diversity	Core course	04	100	03
MB-102	Microbial Physiology and Biochemistry	Core course	04	100	03
MB-105	Bioinstrumentation	Skill based	04	100	03
Semester I : Practical Courses					
MB-103	Methods in Microbiology	Core course	04+04	100	06
MB-104	Methods in Microbial Chemistry	Core course	04+04	100	06
AC-101	Practicing Cleanliness	Audit Course	02	100	
Semester II : Theory Courses					
MB-201	Molecular Biology and Bioinformatics	Core course	04	100	03
MB-202	Microbial Enzymology	Core course	04	100	03
MB-203	Immunology	Core course	04	100	03
Semester II : Practical Courses					
MB-204	Methods in Molecular Biology and Immunology	Core course	04+04	100	06
MB-205	Methods in Enzymology	Skill based	04+04	100	06
AC-201A/B/C/D	Choose one out of Four (AC-201A/ AC-201B/ AC-201C/ AC-201D) from Personality and Cultural Development (Audit Course)	Audit Course	02	100	

M.Sc. Part I Semester I Microbiology: Core Courses

MB - 101: Microbial Taxonomy and Diversity		
	<p>Course Objectives:</p> <ol style="list-style-type: none"> To understand the ubiquitous nature of microbes to build basic concept To give basic knowledge on extremophiles To provide knowledge on characteristics of various microbes 	
Unit 1	<p>Microbial Taxonomy</p> <ul style="list-style-type: none"> Concept: Taxonomic ranks, Domain and species Introduction to Bergey's manual of Systematic bacteriology, 9th edition Current techniques used for identification: DNA fingerprinting electrophoresis, Ribotyping, DNA Fingerprinting using Pulsed Field Gel Electrophoresis (PFGE), Randomly amplified polymorphic DNA (RAPD), Fatty acid analysis, Use of NA probes Metagenomics concept, culturable and non-culturable microbial diversity 	08 L
Unit 2	<p>Extremophilic bacteria and Archea</p> <ul style="list-style-type: none"> Biotopes, Biochemistry and Physiology of adaptation to extreme environment and cultivation strategies of: Thermophile, Psychrophile, Barophile, Halophile, Acidophile, Alkaliphile, Methanogens Applications of extremophiles 	14 L
Unit 3	<p>Algae</p> <ul style="list-style-type: none"> Characteristics: Algae (Colonial Algae, Filamentous Algae, Siphonous Algae, Parenchymatous and Pseudo parenchymatous algae), Cytomorphology and Ultrastructure: algal cell (Mucilage and Sheaths, Frustule, Cell Wall, Flagella and Associated Structures, Plastids, algal movement) Nutrition: Physical and chemical requirements, Types based on nutrition Reproduction: Vegetative, Asexual Reproduction, Binary Fission or Cellular Bisection, Zoospore, Aplanospore, Autospore. Fragmentation, Resting Stages, Sexual Reproduction. 	8L

	<ul style="list-style-type: none"> • Significance of algae: Biogeochemical role, Food, Extracts (Agar, Alginate, Carrageenan), Animal Feed, Fertilizers, Cosmetics, Therapeutic Supplements, Algal pigments, Microalgae as biofertilizer, Lichens • Algal farming for biodiesel • BGA: General features, cultivation and significance • Prochloronus and cyanelles 	
Unit 4	Fungi <ul style="list-style-type: none"> • Characteristics: Fungi (Yeast, moulds and dimorphic fungi) and their Classification • Cyto-morphology and Ultrastructure: Fungal hyphae, thallus • Nutrition: Physical and chemical requirements, Types based on nutrition • Reproduction: sexual, asexual, fungal spores and parasexual • Endophytic fungi: Characteristics, cultivation and significance • Ecological significance and applications of Fungi: Biogeochemical role of fungi, Mycoses, Mycotoxins, Biocontrol, Mycorrhiza and Insect symbionts 	10 L
Unit 5	Virus <ul style="list-style-type: none"> • Virus structure: Virus proteins, Capsids, Virion membranes, Ultrastructure of HIV, plant virus (TMV) and bacterial virus (T4 virus) • Classification of viruses • Methods used in virology: Cultivation of viruses, Isolation of viruses, Centrifugation, Structural investigations of cells and virions, Electrophoretic techniques, Detection of viruses and virus components, Infectivity assays. • Detection and enumeration of viruses • Viruses in cancer: oncogenic viruses, sources and mechanism of oncogenesis, Epstein-Barr virus-linked cancers, Kaposi's sarcoma, Cell lines derived from virus-associated cancers, Prevention of virus-induced cancers, Diagnosis and treatment • Emerging viruses: Viruses in new host species and in new areas, recently discovered viruses, Re-emerging viruses, Virus surveillance • Prions: nature of prions, Prion transmission, Transmissible spongiform encephalopathy 	10 L
Suggested readings: <ol style="list-style-type: none"> 1. Carter, John B and Saunders, Venetia A. (2007) Virology: Principles and applications, John Wiley and Sons Ltd., London 2. Wagner, E. K. and Hewlett, M. J (2004) Basic Virology, 2nd Edn., Blackwell Publications, Oxford, 3. Conrat, H.F. Kimball, P.C. and Levy, J. A (1994) Virology, 3rd Edn., Prentice Hall, Eaglewood Cliff, New Jersey, USA 4. Hull, R. (2002) Matthew's Plant Virology, 4th Edn., Academic Press, London 5. Dimmock, N. J. Easton, A. J. and Leppard, K. N. (2001) Introduction to Modern Virology, 5th Edn., Blackwell Science, London 6. Laura Barsanti, and Paolo Gualtieri (2006) Algae: Anatomy, Biochemistry and Biotechnology, Taylor & Francis Group, UK 7. Becker, E. W. (1994) Microalgae- Biotechnology and Microbiology, Cambridge University Press, UK. Burnett, J. H. 8. Kevin Kavanagh (2005) Fungi: Biology and Applications, John Wiley & Sons Ltd., West Sussex, 9. Jim Deacon (2006) Fungal Biology, 4th Ed. Blackwell Publishing Ltd., West Sussex 10. Alexopoulos, C. J. and Mims, C. W. (1979) Introduction to Mycology, Wiley Eastern Ltd., Delhi 11. Griffin, D. H. (1994) Fungal Physiology, Wiley-Liss, New York 12. Kathy Talaro and Barry Chess (2012) Foundations in Microbiology, 8th Edn., The McGraw-Hill Companies, Inc., New Delhi 13. Tortora, Funke and Case (2010) Microbiology, 10th Edn., Brenjamine Cummings Inc., California 14. Moselio Schaechter (2009) Desk encyclopaedia of Microbiology, 2nd Edn., Elsevier 15. Prescott, Harley and Klein's (2002) Microbiology, 5th Edn. The McGraw-Hill Companies, Inc., 16. Ulhas Patil, JS Kulkarni, AB Chaudhari and SB Chincholkar (2017) Foundations in Microbiology, 9th Edn., Nirali Prakashan, Pune 17. Fred A. Rainey and Aharon Oren (2006) Extremophiles, Methods in Microbiology, Volume 35, Elsevier and Academic Press, London 		

18. Martin Dworkin (Editor) (2006) The Prokaryotes: A Handbook on the Biology of Bacteria, Volume 2, Ecophysiology and Biochemistry, Springer-Verlag, New York

19. Michael T. Madigan, John M. Martinko, Paul V. Dunlap, David P. Clark, (2009) Brock Biology of Microorganism, Benjamin Cummings, California, USA.

20. Bergey's Manual of Systematic Bacteriology (2001) Editor-in-chief: Garrity, George M. Boone, David R.; Castenholz, Richard W. (Eds.), (4 Volumes) Springer/ Williams and Wilkins, USA

21. Kushner, D.J. eds. (1978) Microbial life in extreme environments. Academic Press, London.

22. Horikoshi, K., Grant, W.D. eds. (1998) Extremophiles, Microbial Life in Extreme Environments. Wiley-Liss Publishers, New York.

23. Willey, J., Sherwood, L., Woolverton, C.J. and Prescott, L.M. (2017) Prescott's Microbiology, 10th edn., NY: McGraw-Hill Education, New York

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C101.1	Differentiate various groups of microbes and microbial taxonomy	2
C101.2	Acquire knowledge on adaptability of extremophiles and microbial diversity	3
C101.3	Acquaint with the scope of microbiology in different diversified areas.	4

MB-102: Microbial Physiology and Biochemistry		
	Course Objectives: 1. To know the structural organization, characteristics and metabolism of biomolecules 2. To learn microbial metabolic pathways and its enzymatic regulation 3. To acquire knowledge on transport of solute and energy metabolism	
Unit 1	Structure and properties of Biomolecules <ul style="list-style-type: none"> • Classification, Structure and function of: carbohydrates, lipids, proteins, nucleic acids and vitamins. • Conformation of proteins: Primary, secondary, tertiary and quaternary structure; Ramachandran plot, domains; motif and folds • Structural stability: protein and nucleic acid 	10 L
Unit 2	Transport and Energy metabolism <ul style="list-style-type: none"> • Cell membrane and its ultrastructure • Types of cellular transport: passive, facilitated, active, translocation, liposomes for transduction, Na/K⁺ ATPase, ABC transporter • Response to stress. • Energy metabolism: Free energy, Bacterial and Mitochondrial ETC, ATP Synthase complex, inhibitors of ETC and energetics of ETC 	10 L
Unit 3	Metabolism of carbohydrates <ul style="list-style-type: none"> • Metabolic pathway, bioenergetics and regulation of: EMP, HMP, TCA, Glyoxylate pathway, C3 and C4 pathway • Alternative glycolytic pathways 	12 L
Unit 4	Metabolism of Lipids <ul style="list-style-type: none"> • Metabolic pathway, Bioenergetics and regulation of: Fatty acid synthesis, Catabolism of lipids • FAS Complex 	06 L
Unit 5	Amino acid and Nucleotide metabolism <ul style="list-style-type: none"> • Metabolic pathway, Bioenergetics and regulation of: amino acid degradation • Metabolic fates of amino groups • Metabolic pathway, Bioenergetics and regulation: Purines and Pyrimidine biosynthesis: De novo pathway and Salvage pathway, ribonucleotide reductase 	12 L
Suggested readings:		
1. White, D. (2000) The Physiology and Biochemistry of Prokaryotes, Oxford University Press, New		

York, USA

- White, D., Drummond, J. and Fuqua, C. (2011) *The Physiology and Biochemistry of Prokaryotes*, 4th edn., Oxford University Press, New York
- Cohen, G.N. (2014) *Microbial Biochemistry*, 2nd edn., Springer
- Gottschalke, G (2004) *Bacterial Metabolism*, Springer, Weinheim
- Moat, A. G., Foster, J. and Spector, M.P. (2002) *Microbial Physiology*, 4th edn., Wiley Interscience Publ., New York
- Nelson, D.L. and Cox, M.M. (2000) *Lehninger's Principles of Biochemistry*, CBS Publications, New Delhi
- Stryer, L. (2002) *Biochemistry*, 5th Edn., W.H. Freeman and Co., New York, USA
- Price, N.C. and Stevens, L. (2000) *Fundamentals of Enzymology*, 3rd edn., Oxford University Press, NY, USA.
- Voet, D., Voet, J.G. and Pratt C.W. (1999) *Fundamentals of Biochemistry*. John Wiley and Sons, Inc., Chichester, UK
- Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2003) *Harper's Biochemistry*. Appleton and Lange, Stamford, Connecticut.
- Jain, J.L., Jain, S. and Jain, N. (2009) *Fundamentals of Biochemistry*, S Chand, New Delhi
- Doelle, H.W. (1975) *Microbial Metabolism*, 2nd Edn, Academic Press, London

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C102.1	Acquire knowledge on metabolism of biomolecules	3
C102.2	Familiarise with amino acids, proteins, lipids, nucleic acids and enzymes	4
C102.3	Understand biochemical reactions in microbial cells and metabolic pathway diversity	2

MB-103: Methods in Microbiology

	Course Objectives: 1. To familiarize in General Microbiology techniques 2. To learn the basic microbial techniques used for characterization of microbial system 3. To know about effect of environmental condition on microbes
1	Biosafety: Safe Laboratory techniques, Equipment related hazards, Biosafety cabinets, Transport of infectious material/cultures, Waste disposals, Fire and electricity hazards, Immunisation to staff.
2	Growth Curve of yeast by Turbidity (Spectrophotometer/ Nephelometer) and Dry mass (Centrifugation) measurement
3	Isolation and cultivation of cyanobacteria/ Algae
4	Study on fungal hyphal growth and study on isolation, morphology of Actinomycetes
5	Isolation of Bacteriophage by plaque assay and enumeration
6	Isolation and partial characterisation of Acidophile/ Alkalophiles/ Halophile/ Thermophile/ Psychrophile bacteria from acidic/alkaline/high salt/high/low temperature environments
7	Cultivation of cancer cell lines (HeLa/ CHO/---)
8	SDS PAGE of protein
9	Agarose gel electrophoresis of DNA
10	Gel Permeation Chromatography/Affinity chromatography
11	16S rRNA gene sequence analysis using BLAST and preparation of phylogenetic tree
12	Demonstration of HPLC/ GC/AAS
Suggested readings:	
1. Norris, J. R. Ribbons D. W. (Ed) (1969) <i>Methods in Microbiology</i> , Volume 1, Academic Press Inc. Ltd., London	

2. Harley, J. P., Lansing, M. Prescott, H. (2002) 5th Edn., Laboratory Exercises in Microbiology, The McGraw–Hill Companies, New York
3. Benson, H.J. (2001) Microbiological Applications Lab Manual, 8th Edn. The McGraw–Hill Companies, New York
4. Aneja, K.R. (1996) Experiments in Microbiology, 3rd edn., Wishwa Prakashan, New Delhi.
5. Parija, S.C. (2005) Text Book of Practical Microbiology, Ahuja Publishing House, New Delhi.
6. Dubey, R.C. and Maheshwari, D.K. (2004) Practical Microbiology, S. Chand and Co. New Delhi.
7. Cappuccino, J.G. and Sherman, N. (2014) Microbiology: A Laboratory Manual. 10th Edition, Pearson Education Inc., San Francisco.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C103.1	Develop expertise in basic analytical techniques of microbiology.	3
C103.2	Get knowledge in the analysis of biomolecules	3
C103.3	Carry out microbial techniques related to isolation, identification of algae, fungi, archaea	4

MB - 104: Methods in Microbial Chemistry

	Course Objectives: 1. To familiarize the student in biochemical techniques and learn basic microbial biochemistry 3. To utilize bioinformatics software tool to understand the biomolecule
1	Basic biochemical techniques: Use of hand glove, Use of pipette aid, Preparation of standard solutions and buffers, Dilution approaches.
2	Determination of pKa value of amino acid
3	Quantitative analysis reducing sugar by DNSA method
4	Quantitative analysis of total carbohydrate by Phenol sulphuric acid method
5	Quantitative analysis of protein by Folin-Ciocalteu / Biuret method and UV absorption method
6	Quantitative analysis of amino acids by ninhydrin method
7	Quantitative estimation of fatty acids by titration method
8	Determination of Iodine number and acid number of lipid sample
9	Detection of changes in the conformation of bovine serum albumin by viscosity measurement
10	Identification of the C-terminal amino acid of Protein
11	Quantitate estimation of DNA by Diphenyl Amine method
12	Quantitate estimation of RNA by Orcinol method
13	Study of biomolecules using RasMol/ SPDBV software
14	Demonstration of TLC for detection of biomolecules: Sugars and amino acids
	Suggested readings: 1. Thomas, G.M. and Shalkhammer, (2004) Analytical Biotechnology, Springer, New Delhi 2. Thimmaiah, S.R. (2006) Standard Methods of Biochemical Analysis, Kalyani Publishers, New Delhi. 3. Plummer, D.T. (2001) An Introduction to Practical Biochemistry, 3 rd edn., McGraw Hill Ltd. New Delhi 4. Sawhey, S.K. and Singh, R. (2002) Introductory Practical Biochemistry, Narosa Publication House, New Delhi. 5. Jayaraman, J. (2008) Laboratory Manual in Biochemistry, New Age International, New Delhi. 6. Schmauder, H.P, Schweizer, M. and Schewizer, L.M. (2003) Methods in Biotechnology, Taylor and Francis Ltd., London

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C104.1	Acquire expertise in basic biochemical techniques	3
C104.2	Get knowledge in the analysis and estimation of biomolecules	4
C104.3	Carry out biochemical analysis	5

M.Sc. Part I Semester I Microbiology: Skill Based Course

MB - 105: Bioinstrumentation		
	<i>Course Objectives:</i> 1. To introduce the student to the variety of biophysical and biochemical techniques 2. To make them familiar with various approaches of analytical techniques	
Unit 1	Principles of biophysical chemistry • pH, pOH, pka, Isoelectric pH, Henderson-Hasselbalch equation, buffer, colligative properties.	05 L
Unit 2	Separation techniques • Chromatography: Principle, design and applications of TLC, HPTLC, GC, HPLC, Gel filtration, • Electrophoresis and electrofocusing: Principle, design and applications of Agarose gel and capillary electrophoresis, PAGE, Iso-electric focusing. • Centrifugation and Ultracentrifugation	16 L
Unit 3	Biophysical methods • Analysis of biomolecules: UV/visible spectrophotometer, fluorescence, circular dichroism, IR, NMR and ESR spectroscopy, • Structure determination: X-ray diffraction and NMR; analysis using light scattering, different types of mass spectrometry.	16 L
Unit 4	Radiolabeling techniques • Properties of different types of radioisotopes used in biology, • Detection and measurement of radioactivity • Incorporation of radioisotopes in biological tissues and cells, • Safety guidelines for Radiolabeling techniques	08 L
Unit 5	Microscopic techniques • Scanning and transmission microscopes, different fixation and staining techniques for Electron microscope, freeze-etch and freeze-fracture methods for Electron microscope, • Image processing methods in microscopy.	05 L

Suggested readings:

1. Cantor, C.R. and Schimmel, P.R. (2008)
2. Upadhyay, A., Upadhyay, K. and Nath, N. (2000) **Biophysical Chemistry**, Himalaya Publisher, Nagpur.
3. Friefelder A, D. (1993) **Physical Biochemistry**, 2nd Edn. W. H. Freeman & Co., USA.
4. Van Holde, K. E. (1985) **Physical Biochemistry**, 2nd Edn., Prentice Hall Inc. New Jersey.
5. Skoog, D.A., Hollier, F.J. and Nieman, I.A. (1998) **Principles of Instrumental Analysis**, Harcourt Brace College Publishers, Orlando
6. Wilson, K. and Walker, J. (2000) **Practical Biochemistry: Principles and techniques**, 5th Edn., Cambridge University Press, Cambridge,
7. Willard, H.H. and Merrit, Jr. L.L. (1986) **Instrumental Methods of Chemical Analysis**, CBS Publishers, New Delhi
8. Wilson, K. and Goulding, K.H. **Biologists Guide to Principle and Techniques of Practical Biochemistry**, ELBS Publications, London
9. Mikkelsen, S.R. and Corton, E. (2004) **Bioanalytical Chemistry**, Wiley Interscience, New York
10. Sivasankar, B. (2005) **Bioseparations Principles and Techniques**, Prentice Hall of India Pvt. Ltd.,

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C105.1	Acquire knowledge on basic biophysical and biochemical aspects	3
C105.2	Learn purification of molecules, analytical tools, electrophoretic separation	4
C105.3	Learn how to interpret protein mobility on page under native and SDS	3

M.Sc. Part I Semester I Microbiology: Audit Courses

AC-101: Practicing Cleanliness (Compulsory; Campus-level Audit Course; Practical; 2 Credits)		
Course Objectives (COs):		
<ul style="list-style-type: none"> • To make students aware of Clean India Mission and inculcate cleanliness practices among them. 		
	<ul style="list-style-type: none"> • Awareness program on <ul style="list-style-type: none"> ○ Swachh Bharat Abhiyan (Clean India Mission) ○ Clean Campus Mission ○ Role of youth in Clean India Mission • Cleaning activities inside and surroundings of Department buildings. • Tree plantation and further care of planted trees • Waste (Liquid/Solid/e-waste) Management, Japanese 5-S practices • Planning and execution of collection of Garbage from different sections of University campus • Role of youth in power saving, pollution control, control of global warming, preservation of ground water and many more issues of national importance. • Cleanest School/Department and Cleanest Hostel contests • Painting and Essay writing competitions 	

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC101.1	Identify need at of cleanliness at home/office and other public places.	2
AC101.2	Plan and observe cleanliness programs at home and other places.	4
AC101.3	Practice Japanese 5-S practices in regular life.	3

M.Sc. Part I Semester II (Microbiology): Core Courses

MB – 201: Molecular Biology and Bioinformatics		
	<p>Course Objectives:</p> <ol style="list-style-type: none"> To extend the knowledge on structure and functions of genetic material To introduce genome organization, transcription and translation process in Prokaryotes and study various tools to understand molecular mechanisms. To introduce the basic principles of bioinformatics 	
Unit 1	Basics molecular biology	10 L
	<ul style="list-style-type: none"> DNA: topological properties (linking, writhing, twisting number), Structure of super helix, Base flipping, Palindrome, Inverted repeats and stem and loop. Overview of DNA replication RNA: Structure, types and functions Denaturation and renaturation kinetics of nucleic acids Proteins: Domain and motifs Histone proteins, DNA-Protein interactions: helix-loop-helix, helix-turn-helix, leucine zipper, Zinc finger motifs, 	
Unit 2	Transcription	10 L
	<ul style="list-style-type: none"> Types of RNA polymerase (prokaryotic & eukaryotic), Process of transcription mRNA processing, editing: capping, adenylation, splicing, RNA transport Transcriptional regulation: transcriptional bursting/pulsing, specificity factors, enhancers, repressors, activators and general transcription factors Post-transcriptional modifications, RNA degradation, nuclear transport, mRNA localization, anti-sigma factors, RNAi (siRNA, miRNA and CRISPR mechanism) 	
Unit 3	Translation	10 L
	<ul style="list-style-type: none"> Ribosome (structure and composition), Activation of tRNA, tRNA synthetase Genetic code and its properties Steps: Initiation: factors and their regulation, Elongation, Termination Inhibitors Post translational modification of proteins and protein degradation Translational regulation: Cytoplasmic polyadenylation, UTR sequence elements, RNA binding proteins, ribosomal regulation, non-sense mediated RNA decay, 5' decapping 	
Unit 4	Protein targeting and degradation	10 L
	<ul style="list-style-type: none"> Signal hypothesis Signal sequences in bacteria Membrane and Lysosomal protein targeting HSP and Chaperons Protein degradation 	
Unit 5	Basic Bioinformatics	10 L
	<ul style="list-style-type: none"> Biological databases: Nucleic acid databases (GenBank, EMBL, DDBJ) Protein sequence data base (UniProt, PDB) Scoring matrices, local. global and multiple sequence alignment Database search for homologous sequences, BLAST Phylogenetic analysis: Overview and tree construction methods 	
<p>Suggested Readings:</p> <ul style="list-style-type: none"> Lewin B. (2013) Gene XI, Pearson Prentice Hall, Pearson Education, Inc., NT, USA (ISBN: 0-13-123826-4) Malacinski GM (2003) Essentials of Molecular Biology, 4th edn., Jones and Batielt, London. (ISBN: 0-7637-2133-6) Watson JD, Baker JA, Bell SP, Gann A, Lewin M, Losick R (2007) Molecular Biology of the Gene, 6th edn., Benjamin Cummings- CSHL Press, USA Stryer, Lubert (2002) Biochemistry 5th edn. W. H. Freeman and Co. New York Wink M. (2006) An Introduction to Molecular Biotechnology, Wiley-VCH Verlag Gmbh and Co., 		

Weinheim, Germany (ISBN: 978-3-527-31412-6/3-527-31412-1)

- Weaver, RF (1999) Molecular Biology, WCB McGraw-Hill Co. Inc., NY (ISBN: 0-697-14750-9)
- Brown, TA (1995) Essential Molecular Biology, Vol. I, A Practical Approach, IRL Press, Oxford, UK
- Nelson DL & Cox MM (2005) Lehninger's Principles of Biochemistry, 4th edn., McMillan Worth Publ. Inc. NY
- Russell, PJ (1998) Genetics, 5th edn, Benjamin-Cummings Publ. Co. Inc., NY (ISBN: 0-321-0038-2)
- Oliver, RP and Schweizer, M. (1999) Molecular Fungal Biology, Cambridge University Press, Cambridge, UK (ISBN: 0-521-56784-X)
- Klug, WS and Cummings, MR (2003) Concepts of Genetics, 7th edn., Pearson Education Inc., (ISBN: 81-7808-884-3)
- Bates, AD and Maxwell, A (2006) DNA Topology, Indian Edn., Oxford University Press, New Delhi (ISBN: 0-19-56831-X)
- Turner, PC, McLennan, AG, Bates AD and White, MRH (2002) Instant Notes: Molecular Biology, 2nd edn., Viva Books Pvt. Ltd., New Delhi (ISBN: 81-7649-215-9)
- Lesk, AM (2002) Introduction to Bioinformatics, Oxford University Press, UK (ISBN:0-19-925196-7)
- Korf, I, Yandell, M and Bedell, J (2003) An Essential Guide to the Basic Local Alignment Search Tool-BLAST, O'Reilly Network Publishers, Tokyo (ISBN:)
- Baxevanis, A. D. and Ouellette, B. F. F. (2001) Bioinformatics: A practical guide to the analysis of genes and proteins. Second Edition. John Wiley & Sons, New York.
- Mount, D. W. (2001) Bioinformatics: sequence and genome analysis. Cold Spring Harbor Laboratory Press, New York.
- Zoe L. and Terence C. (2004) Bioinformatics: Managing Scientific Data, Morgan Kaufmann Publishers, New Delhi.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C201.1	Receive elaborate knowledge on nucleic acids and molecular mechanisms in bacteria	3
C201.2	Understand gene expressions and signal sequences in bacteria	2
C201.3	Get thorough knowledge about fundamental aspects on bioinformatics	5

MB - 202: Microbial Enzymology		
	<i>Course Objectives:</i> 1. To understand basic aspects of microbial enzyme 2. To learn the kinetics of enzyme catalysed reactions and applications of enzymes 3. To introduce what kind of catalytic mechanism is adopted in enzyme	
Unit 1	Basic Enzymology <ul style="list-style-type: none"> • General Characteristics of enzyme, Ribozyme, Abzyme and Coenzymes • Enzyme Nomenclature, classes of enzymes, enzyme activity, Specific activity, katal, Substrate specificity, Active site • Effects of pH, temperature, substrate concentration, activator on enzyme activity • Enzyme turnover: Concept and significance. • Isoenzyme: concept and properties, ex. LDH • Multienzyme complexes: pyruvate dehydrogenase and fatty acid synthetase, advantages of multienzyme complex 	10 L
Unit 2	Enzyme Kinetics <ul style="list-style-type: none"> • Elementary reactions, Reversible reactions, Rates of reactions, Transition state, • Equilibrium and steady state theory • The Michaelis–Menten Equation, Concept of Km and Vmax, Double reciprocal plot, Analysis of Kinetic Data. 	10 L

	<ul style="list-style-type: none"> Enzyme Inhibition: Competitive Inhibition, Non-competitive, Uncompetitive Inhibition and Mixed Inhibition, Bi-substrate, and Multi substrate reactions 	
Unit 3	Catalytic Mechanisms and regulation <ul style="list-style-type: none"> Acid–Base Catalysis, Covalent Catalysis, Metal Ion Catalysis, Electrostatic Catalysis, Catalysis through Proximity and Orientation Effects, Catalysis by Preferential Transition State Binding Serine Proteases: Kinetics and Catalytic Groups, X-Ray Structures, Catalytic Mechanism, Testing the Catalytic Mechanism, Zymogens Enzyme regulation: feedback inhibition, feed forward stimulation, enzyme reparation, induction and degradation, enzyme regulation by cAMP, covalent modification, allosteric regulation of enzymes w.r.t. ATCase 	10 L
Unit 4	Industrial applications of Enzymes <ul style="list-style-type: none"> Perspective of use of enzyme in industry Source, Significance and biotechnological applications of Cellulases, Proteases in dough/Flour and protein hydrolysate, Amylases in starch industry, Lipases in oil industry, Pectinases in fruit industry, Laccases 	10 L
Unit 5	Extremozymes <ul style="list-style-type: none"> Microbial source, characteristics and biotechnological significance of extremozymes of thermophiles, psychrophiles, acidophiles, alkalophiles, halophiles Non-aqueous enzymology 	10 L

Suggested readings

- Stryer, L. (2004) **Biochemistry**, 5th Edn., W. H. Freeman & Co., New York
- Palmer, T. (2004) **Enzymes: Biochemistry, Biotechnology and Clinical Chemistry**, Affiliated East-West Press Pvt. Ltd., New Delhi
- Price, N. C. and Stevens, L. (2000) **Fundamentals of Enzymology**, Oxford University Press, New York.
- Dixon, M. Webb, E. C., Throne, C.J.R. and Tipton, K. F., **Enzymes**, Academic Press, NY.
- Cook, Paul, F. and Cleland, W.W. (2007) **Enzyme Kinetics and Mechanism**. Garland Science, New York.
- Nooralabettu, K. P. (2011) **Enzyme Technology Pacemaker of Biotechnology**, PHI Learning Pvt. Ltd., New Dehli
- Shanmugam, S. and Sathishkumar, T. (2009) **Enzyme Technology**, I K International, Delhi
- Satyanaryana, T. (1999) **Biochemistry**, Books and Allied Pvt. Ltd., Calcutta
- Nelson, D.L. and Cox, M.M. (2000) **Lehninger's Principles of Biochemistry**, CBS Publications, New Delhi.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C202.1	Understand fundamental as well as kinetics of enzyme catalysed reactions	2
C202.2	Apply the knowledge to explore applications of various enzymes	3
C202.3	Identify how extremophiles act as a source of extremozyme.	5

MB - 203: Immunology		
	Course Objectives: <ol style="list-style-type: none"> To understand various components of host immune system, its structure and function To acquaint with operational mechanisms of the host defence system, allergy, GVR 	
Unit 1	Overview of the Immune System <ul style="list-style-type: none"> Cells and organs of the immune system Cytokines and Interleukins Characteristics and Types: Antigen, Immunogen, Allergen. Antibody: Types, structure, Antibody diversity (Somatic gene recombination, 	10 L

	Genesis of light and heavy chain) <ul style="list-style-type: none"> Major Histocompatibility Complex: properties of MHC genes, structure, properties and cellular distribution of MHC molecules, binding of peptides to MHC 	
Unit 2	Immune Response <ul style="list-style-type: none"> Cell mediated Immune response: T cell, Types of T cells, T cell activation Humoral Immune response: B cell, Plasma cell, B cell activation (T dependent and T-independent pathway), regulation of humoral immune responses by Fc receptors Complement system and Opsonisation Inflammatory response Immunologic tolerance: General features of immunologic tolerance, T and B lymphocyte tolerance, tolerance induced by foreign protein antigens 	12 L
Unit 3	Hyper immune response <ul style="list-style-type: none"> Graft rejection: Immunological basis, First set and second set of reaction, Significance of HLA and MHC, Immunological Tolerance Hypersensitivity: types and mechanism with example 	08 L
Unit 4	Immune response to infections and diseases <ul style="list-style-type: none"> Immunity against viral and protozoal infections Cancer immunology: Types of tumours, oncogenesis and tumour antigens (TATAs, TSTA) Autoimmune diseases: Mechanisms for induction of autoimmunity, Organ-specific and systemic, Treatment of autoimmune diseases Immunodeficiency diseases (e.g. SCID, CVI, AIDS) 	10 L
Unit 5	Histochemical and immunotechniques <ul style="list-style-type: none"> Production of monoclonal and polyclonal antibodies, detection of molecules using ELISA, RIA, western blot, immunoprecipitation and immuno-fluorescence microscopy, <i>in situ</i> localization by FISH and GISH 	10 L

Suggested readings:

1. Goldsby, R.A., Kindt, T.J. and Osborne, B. and Kuby, A. (2003) **Immunology**, 5th edn., W. H. Freeman and Company, New York.
2. Roitt, I. (2000) **Essentials of Immunology**, 5th edn., Blackwell ELBS Science Publication, Oxford.
3. Paul, W. E (2013) **Fundamental Immunology**, 7th edn., Lippincott Williams and Wilkins Publishers, USA
4. Tizard, I. R. (1995) **Immunology: An Introduction**, Saunders College Publishing, Philadelphia
5. Banerjee, A. K. and Banerjee, N. (2006) **Fundamentals of Microbiology and Immunology**, New Central Book Agency (Pvt.) Ltd., Kolkata
6. Coleman, R.M., Lombard, M.F. and Sicard, R.E. (2000) **Fundamental Immunology**, 4th edn., WmC Publications, London
7. Barrett, James T. (1998) **Microbiology and Immunology Concepts**, Lippincott Williams & Wilkins, Philadelphia, PA
8. Janeway, Charles, Travers, Paul, Walport, Mark and Shlomchik, Mark (2004) **Immunobiology**, Garland Science,
9. Owen, J.A., Punt, J. and Stranford, S.A. (2013) Kuby Immunology, 7th edn, WH Freeman, USA

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C203.1	Understand fundamental basis of immune system and immune response	2
C203.2	Apply host defence, allergy, organ transplant and immunological diseases	3
C203.3	Use various immunochemical techniques for diagnosis of diseases.	5

MB - 204: Methods in Molecular Biology and Immunology

	Course Objectives:	
	1. To impart hands on training in molecular biology and immunochemical techniques	
	2. To familiarize the student with bacterial gene transfer and immunodiagnostic tools	
1	To study bacterial transformation	
2	To study bacterial conjugation	
3	Isolation and detection of bacterial/ Fungal DNA	
4	Plasmid isolation and curing	
5	Restriction digestion by endonucleases	
6	PCR amplification of DNA	
7	To study the spontaneous mutation by Fluctuation test	
8	Immuno-diffusion by Ouchterlony double diffusion	
9	Immuno-electrophoresis	
10	Bacterial gene expression using IPTG inducible promoter	
11	ELISA	
12	Western/Southern/Northern blot	
	Suggested readings:	
	1. Schmauder, H. P., Schweizer, M. and Schweizer, L. M. (2003) Methods in Biotechnology , Taylor and Francis, London	
	2. Joe Sambrook (2001) Molecular Cloning: A Laboratory Manual , 3rd Edn., (3 volume set) Cold Spring Harbor Laboratory Press,	
	3. Sawhey, S.K. and Singh, R. (2002) Introductory Practical Biochemistry , Narosa Publication House, New Delhi.	
	4. Thimmaiah, S.R. (2006) Standard Methods of Biochemical Analysis , Kalyani Publishers, Delhi.	
	5. Davis, L.G., Dibner, M.D. and Battey, J.F. (1986) Basic Methods in Molecular Biology , Appleton and Lange, Norwalk.	

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C204.1	Undertake gene transfer in different bacteria and make use of PCR amplification of DNA.	5
C204.2	Apply molecular diagnostic and immunodiagnostic techniques.	3

M.Sc. Part I Semester II (Microbiology): Skill Based Course

MB - 205: Methods in Enzymology

Course Objectives:	
1. To introduce qualitative and quantitative tools to search for enzyme from microbes	
2. To learn enzyme characteristics and identify use of enzyme	
Important note: Use any ONE suitable enzyme from microbial source: Amylase/ Protease/ Phytase/ Laccase/ Lipase/ β -Galactosidase/ Xylanase/ Cellulase for the following experiments	
1	Qualitative assay of enzyme detection in microbial source
2	Quantitative assay of enzyme (activity and specific activity)
3	Effect of pH and temperature on enzyme activity
4	Effect of activator and inhibitor on enzyme activity
5	Partial Purification of enzyme by ammonium sulphate precipitation and dialysis or solvent Purification fold and purified enzyme yield calculations of enzyme purification procedures

6	Enzyme Purification by Ultrafiltration/
7	Determination of K_m and V_{max} of enzyme
8	Kinetic study of Inhibitors on K_m and V_{max}
9	Native PAGE
10	Enzyme stabilization by immobilization technique: gel entrapment/ crosslinking
11	Production of maltodextrin using amylase or blood stain removal / gelatinolysis of X-ray film by protease
12	Structural prediction using ExPaSy server
13	Determination of enzyme activity in organic solvent media
Suggested readings:	
1. Thimmaiah, S.R. (2006) Standard Methods of Biochemical Analysis , Kalyani Publishers, Delhi.	
2. Bisswanger, Hans (2011) Practical Enzymology , Wiley-VCH, Germany	
3. Robert Eienthal and Michael Danson (2002) Enzyme Assays: A Practical Approach , 2 nd Edn. Oxford University Press, USA	
4. Plummer, D.T. (2001) In introduction to Practical Biochemistry , 3 rd edn., McGraw Hill Ltd. Delhi	
5. Sawhey, S.K. and Singh, R. (2002) Introductory Practical Biochemistry , Narosa Publication House, New Delhi.	
6. Jayaraman, J. (2008) Laboratory Manual in Biochemistry , New Age International, New Delhi	

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C205.1	Isolate, purify enzyme of interest from microbial system, characterize the enzyme and trace out application(s) of that enzyme	5
C205.2	Use the technique of enzyme assay to determine its specific activity, pH and temperature optima, K_m , V_{max} , K_{cat} of enzyme and activation energy using Arrhenius plot.	4
C205.3	Immobilize enzyme for particular application and familiarize with algorithm for protein	5

M.Sc. Part I Semester II (Microbiology): Audit Courses

AC-201(A): Soft Skills (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)		
	Course Objectives (COs):	
	<ul style="list-style-type: none"> To inculcate different soft skills among students. 	
Unit 1	Introduction to soft skills Formal definition, Elements of soft skills, Soft vs. Hard skills, Emotional quotient, Goal setting, life skills, Need for soft skills, Communication skills, Etiquettes & Mannerism.	2 hrs.
Unit 2	Self-Assessment Goal setting, SWOT analysis, attitude, moral values, self-confidence, etiquettes, non-verbal skills, achievements, positive attitude, positive thinking and self-esteem. Activity: The teacher should prepare a questionnaire which evaluate students in all the above areas and make them aware about these aspects.	4 hrs.
Unit 3	Communication Skills Types of communication: Verbal, Non-verbal, body language, gestures, postures, gait, dressing sense, facial expressions, peculiarity of speaker (habits). Rhetoric speech: Prepared speech (topics are given in advance, students get 10 minutes to prepare the speech and 5 minutes to deliver, Extempore speech (students deliver speeches spontaneously for 5 minutes each on a given topic), Storytelling (Each student narrates a fictional or real-life story for 5 minutes each), Oral review (Each student orally presents a review on a story or a book read by them)	8 hrs.

	Drafting skills: Letter, Report & Resume writing, business letters, reading & listening skills Activity: The teacher should teach the students how to write the letter, report and build resume. The teacher should give proper format and layouts. Each student will write one formal letter, one report and a resume.	
Unit 4	Formal Group Discussion, Personal Interview & Presentation skills Topic comprehension, Content organization, Group speaking etiquettes, driving the discussion & skills. Preparation for personal interview: dress code, greeting the panel, crisp self-introduction, neatness, etiquettes, language tone, handling embarrassing & tricky questions, graceful closing. Activity: Each batch is divided into two groups of 12 to 14 students each. Two rounds of a GD for each group should be conducted and teacher should give them feedback. Mock interview are to be conducted.	4 hrs.
Unit 5	Aptitude and analytical skills Quantitative aptitude, Numerical reasoning, verbal reasoning, diagrammatic test, situational tests, logical thinking. Analytical skills: Definition, Types, problem solving	8 hrs.
Unit 6	Life skills Time management, critical thinking, sound and practical decision making by dealing with conflicts, stress management, leadership qualities Activity: The teacher can conduct a case study activity to train students for decision making skills. The teacher should conduct a session on stress management and guide students on how to manage stress. The teacher may conduct a stress relieving activity in the class. He/she may counsel students individually to know their problems and guide them on dealing with them effectively.	4 hrs.

Suggested readings:

1. Basics of Communication In English: Francis Sounderaj, MacMillan India Ltd.
2. English for Business Communication: Simon Sweeney, Cambridge University Press
3. An Introduction to Professional English and Soft Skills: Das, Cambridge University Press
4. Quantitative Aptitude: R.S. Agrawal

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201A.1	Identify their lacunas about some soft skills and try to overcome the same.	2
AC201A.2	Practice learned soft skills in real life and do their jobs more effectively.	3

AC-201(B): Practicing Sports Activities (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)				
Course Objectives (CObs):				
<ul style="list-style-type: none"> To motivate students towards sports and provide them required training. 				
SR NO.	NAME OF THE SPORT/GAME (Select ONE of the Following)	SYLLABUS OF THE COURSE	TIMING (02 Hours in a Week)	SEMESTER
1	Volleyball	<ul style="list-style-type: none"> General Fitness Basic Fitness Specific Fitness History of the Game Basic Skill of the Game Major Skill of the Game 	Morning : 07 to 09 AM OR Evening :	Total 30 Hours in Each Semester
2	Athletics			
3	Badminton			
4	Cricket			
5	Basketball			
6	Handball			
7	Kabaddi			

8	Kho-Kho	<ul style="list-style-type: none"> • Technique & Tactics of the Game • Game Practice 	05 to 07 PM	
9	Table-Tennis			
10	Swimming			

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201B.1	Identify one or more sports of their choice and develop more interest to participate at University/National level sport events.	2
AC201B.2	Practice the learned sports activities regularly in real life.	3

AC-201(C): Practicing Yoga (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	<p>Course Objectives:</p> <ul style="list-style-type: none"> • To motivate students towards yoga and provide them required training.
	<ul style="list-style-type: none"> • Yog: Meaning, Definition & Introduction, Objectives • Primary Introduction of Ashtanga Yoga • Preparation of Yogabhyas • Omkar Sadhana, Prayer, Guru Vandana • Sukshma Vyayamas • Suryanamaskar (12 Postures) • Asanas : <ul style="list-style-type: none"> ▪ Sitting (Baithaksthiti) - Vajrasana, Padmasana, Vakrasana, Ardha-Pashchimotanasana ▪ Supine (Shayansthiti) - Uttan Padaasan(Ekpad/Dwipad), Pavanmuktasana, Viparitakarani Aasan, Khandarasan, Shavasana ▪ Prone (Viparitshayansthiti) - Vakrahasta, Bhujangasana, Saralhasta Bhujangasana, Shalabhasana(Ekpad/Dwipad), Makarasana ▪ Standing (Dhandsthiti) - Tadasana , TiryakTadasana, Virasana, Ardh Chakrasana • Primary Study of Swasana: Dirghaswasana, Santhaswasana, JaladSwasana - 6 Types • Pranayama : Anuloma-viloma, Bhramari

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201C.1	Identify and practice some Yoga asanas regularly in their life to remain healthy.	2
AC201C.2	Provide guidance and practice about Yoga to their friends, parents and relatives.	3

AC-201(D): Introduction to Indian Music (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	<p>Course Objectives:</p> <ul style="list-style-type: none"> To motivate students towards Indian music and provide them minimum required training.
	<ul style="list-style-type: none"> Definition and brief about generation of Swar, Saptak, Thaata, Raaga, Aavartan, Meend, Khatka, Murkee, Taal, Aalaap etc. Taal and its uses - Treetaal, Daadraa, Zaptaal, Kervaa. Information of Badaakhyaal, Chhotaakhyaal (one), Sargam, Lakshangeet (information) Detailed information of Tambora Detailed information of Harmonium and Tablaa. Five filmy songs based on Indian Classical Music (Theory and Presentation) Sound Management - Basic information of Sound Recording (including Practicals) Composition of Music as per the Story Preparing news write-ups of the Seminars, Library Musical Programmes held at the nearest Akashwani, by personal visits.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201D.1	Identify different types of Indian music.	3
AC201D.2	Develop more interest to learn and practice Indian music.	4

Distribution of Course papers for M.Sc. Part II (Microbiology)

Subject Code	Title of the Paper		Duration (Hrs./Wk)	Max. Mark	Exam. Time (Hrs.)
M.Sc. Part II (Microbiology)					
Semester III : Theory Courses					
MB-301	Pharmaceutical Microbiology	Core course	04	100	03
MB-302	Applied Molecular Biology	Core course	04	100	03
MB-303	Applied and Environmental Microbiology	Elective course	04	100	03
BC-303	Toxicology				
BT-303	Advanced Environmental Biotechnology				
Semester III : Practical Courses					
MB-304	Methods in Bioinformatics	Core course	04+04	100	06
MB-305	Methods in Applied Microbiology	Core course	04+04	100	06
AC-301A/B/C/D	Choose one out of Four (AC-301A/ AC-301B/ AC-301C/ AC-301D) from Technology + Value Added Courses	Audit course	02	100	
Semester IV : Theory Courses					
MB-401	Fermentation Technology	Core course	04	100	03
MB-402	Microbial Genetics	Core course	04	100	03
MB-403	Agricultural Microbiology	Elective course	04	100	03
BC-403	Industrial Biotechnology				
BT-403	Pharmaceutical Biotechnology				
Semester IV : Practical Courses					
MB-404	Methods in Biotechnology	Core course	04+04	100	06
MB-405	Laboratory course (Project Dissertation)	Skill based	04+04	100	06
AC-401A/B/C/D	Choose one out of Four (AC-401A/ AC-401B/ AC-401C/ AC-401D) from Professional and Social + Value Added Courses	Audit course	02	100	

M.Sc. Part II Semester III (Microbiology): Core Courses

MB – 301: Pharmaceutical Microbiology		
	<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To introduce knowledge about antibiotics, biopharmaceuticals and GMP, ICH process 2. To familiarize the students with spoilage and regulatory aspects as well as quality control issues in pharmaceuticals. 	
Unit I	<p>Antibiotics and Synthetic antimicrobial agents</p> <p>Mechanism of action, microbial resistance, therapeutic, prophylactic usage and adverse reactions</p> <ul style="list-style-type: none"> • Antibiotic and Synthetic antimicrobial agents: β-lactam, aminoglycosides, tetracyclines, ansamycins, macrolides • Antifungal antibiotics: Griseofulvin • Antiviral drugs: Amantidines, Nucleoside analogues, Interferons • Peptide antibiotics • Synthetic antibiotics: Sulphonamides, Chloramphenicol, Quinolone 	10 L
Unit II	<p>Microbial aspects of pharmaceutical products</p> <ul style="list-style-type: none"> • Microbial contamination • Microbial spoilage (Types and factors) and preservation • Sterilization of pharmaceuticals (survivor curve, D, Z, F value) <ul style="list-style-type: none"> ○ Methods: Heat, Gaseous, Radiation, Filtration and method of validation ○ Disinfectants 	10 L
Unit III	<p>Regulatory aspects and quality assurance in pharmaceuticals</p> <ul style="list-style-type: none"> • GMP in pharmaceuticals • FDA regulation and pharmacopeia • Design of sterile product manufacturing unit • Quality control in pharmaceuticals: In-process and final product control and ICH process • Sterilization control and sterility validation 	10 L
Unit IV	<p>Production of Biopharmaceuticals</p> <ul style="list-style-type: none"> • Asparaginase, and Clinical dextran • Vaccines (DNA/ multivalent subunit/ bacterial) • Viral vaccines: Live attenuated, Inactivated, Live recombinant Virion subunit vaccines, production of viruses for vaccines, Virus-like particles, Synthetic peptide vaccines, • Immunoserum and toxoid 	10 L
Unit V	<p>Drug design</p> <ul style="list-style-type: none"> • Rational drug design <ul style="list-style-type: none"> ○ Concepts and steps in drug design ○ Lead drug and Pro-drug ○ Structure based and combinatorial approach ○ Computer aided drug design and softwares ○ Peptidomimetic and strategies for drug discovery • Drug delivery: Concept and approaches 	10 L
<p>Suggested Readings:</p> <ul style="list-style-type: none"> • Hugo, WB and Russell, AD (2003/1998) Pharmaceutical Microbiology, 6th edn, Blackwell Science, Oxford, UK (ISBN: 0-632-04196-X) Reprinted • Krogsgaard-Larsen, P., Lilijefors, T. and Madsen, U. (2004) Textbook of Drug Design and Discovery, 3rd edn., Taylor and Francis, London (ISBN: 0-415-28288 PB) • Haider, SI (2006) Validation Standard Operating Procedures, 2nd edn., CRC Press Taylor and Francis Group, NY (ISBN: 0-8493-9529-1) • Dutton CJ, Haxell MA, McArthur HAI and Wax RG (2002) Peptide Antibiotics, Marcel Dekker Inc., NY, USA (ISBN: 0-8247-0245-X) • Seth SD (2004) Textbook of Pharmacology, 2nd edn., Elsevier, New Delhi (ISBN: 81-8147-553-4) 		

- Bhatia R and Ichhpujani RL (1995) Quality Assurance in Microbiology, CBS Publishers, New Delhi (ISBN: 81-239-0387-1)
- Chakraborty C and Bhattacharya A (2004) Pharmacogenomics: An approach to New Drug Development. Biotech Books, New Delhi (ISBN: 81-7622-105-8)

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C301.1	Get in-depth knowledge on different categories of antibiotics and biopharmaceuticals.	4
C301.2	Understand drug design, quality control and regulatory elements of pharmaceuticals.	2
C301.3	Discriminate conventional and combinatorial tools used in drug discovery.	4

MB – 302: Applied Molecular Biology

	<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To learn about the various enzymes involved in rDNA Technology 2. To know the principles of cDNA construction and amplification methods. 3. Making aware of synthesis of recombinant products 	
Unit I	<p>Tools of molecular biology (or rDNA technology)</p> <ul style="list-style-type: none"> • Enzymes: Restriction endonucleases and its types, DNA methylases, DNA polymerase, DNA ligases, Kinases, Phosphatases, topoisomerase • Cloning vectors: Choice and its properties, Bacterial vectors: plasmid, Bacteriophage, Cosmids, Phagmids, BACs. Eukaryotic vectors: YACs, Ti, SV40 • Cloning hosts: Prokaryotic and eukaryotic hosts: properties 	10
Unit II	<p>Methods in rDNA technology</p> <ul style="list-style-type: none"> • Vector mediated and chromosomal integration • Genomic and cDNA library construction • Gene transfer techniques: Transfection, Electroporation, Microinjection, Biolistic • Screening, analysis and confirmation of rDNA <ul style="list-style-type: none"> ○ Genetic methods ○ Hybridization techniques – Dot Blot, Colony, Dip stick, Plaque ○ Immunochemical methods ○ Plus, and minus screening, HRT and HART ○ Analysis – Restriction mapping, Blotting techniques ○ Confirmation by genetic marker and reporter genes • Applications of genetic engineering 	10
Unit III	<p>Microbial Genomics</p> <ul style="list-style-type: none"> • Concept of - Genome density, GC content, CPG Islands, Isochores, codon usage bias, cDNAs and ESTs, Contigs, epigenomics • Structural, Functional, Application and Comparative Genomics: <ul style="list-style-type: none"> ○ Methods for whole genome sequencing, gene annotation ○ Gene and SNP identification ○ Genome mapping (Conjugation, Recombination and complementation) and map integration • Genome editing using CRISPR-<i>cas</i> system 	10
Unit IV	<p>Protein Engineering and Proteomics</p> <ul style="list-style-type: none"> • Protein identification and Expression Mapping: 2D-gel electrophoresis, Mass Spectrophotometry and isotope labelling • Protein-ligand docking • Experimental approach to Protein-Protein interaction mapping: <ul style="list-style-type: none"> ○ Yeast and Bacterial 2-hybrid systems ○ Protein-ligand interactions 	10

	<ul style="list-style-type: none"> ○ Protein fragment complement assays ● Protein arrays and chips: Antibody and peptide arrays 	
Unit V	Techniques in Molecular biology	10
	<ul style="list-style-type: none"> ● DNA Sequencing: Sanger, Maxam Gilbert and high throughput [Polony, 454 pyrosequencing, Illumina (Solexa), Massively parallel signature sequencing (MPSS), SOLiD, Ion Torrent semiconductor, single molecule, Single molecule real time (SMRT)] ● PCR: Basics, Reverse transcriptase PCR, Real time PCR, Applications ● Analysis of polymorphism: RFLP, RAPD, AFLP, SSCP, DGGE ● Analysis of gene expression: SAGE, Microarray 	
Suggested Readings:		
<ul style="list-style-type: none"> ● Nicholl, D.S.T. (2002) An Introduction to Genetic Engineering, 2nd edn., Cambridge University Press, Cambridge, UK (ISBN: 81-7596-101-5 paperback) ● Malacinski, G.M. (2003) Essential of Molecular Biology, 4th edn, Jones & Barlett Publishers, Boston (ISBN: 0-7637-2133-6) ● Alcamo, IE (2001) DNA Technology, Academic Press, London, UK (ISBN: 0-12-048920-1) ● Brown, TA (1995) Essential Molecular Biology, Vol. I (A Practical Approach), IRL Press, Oxford ● Terence A. Brown (2015) Gene Cloning and DNA Analysis: An Introduction, 7th Edn. John Wiley and Sons Ltd, UK. ISBN: 9781405181730 ● Primrose, SB and Wardlow, AC (1982) Source Book for Experiments for the Teaching of Microbiology, Academic Press, London (ISBN: 0-12-565680-7) ● Sambrook and Russell Molecular Cloning Vol. I, II and III, CSHL Press, USA ● Weaver, RF (1999) Molecular Biology, WCB McGraw Hill Co., Inc., NY (ISBN: 0-321-0038-2) ● Timothy, Palzkill (2002) Proteomics. Springer US, ISBN 978-0-7923-7565-4 ● Channarayappa (2006) Molecular Biotechnology: Principles and Practice, Universities Press (India) Pvt. Ltd, Hyderabad (ISBN: 81-7371-501:7) 		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C302.1	Learn basic ideas on cloning vehicle.	2
C302.2	Know more about cDNA and amplification products.	4
C302.3	Understand the construction of recombinant DNA and molecular biology tools.	2

MB-304: Methods in Bioinformatics

	Course Objectives:
	<ol style="list-style-type: none"> 1. To impart training about elementary aspects of statistics used in microbiology 2. To introduce student to the variety of computational methods currently available for predicting functional behaviour of biological system 3. To analyse the output data to predict a biologically relevant function
1	Calculate mean, median, mode, range, variance, standard deviation, standard error, confidence interval using MS-Excel/suitable software
2	Plot straight Line (Linear Least squares) using LINEST Function of MS-excel/ suitable software
3	Plot - line, scatter graphs, bar graphs, error bars using MS-Excel/suitable software
4	Determine: linear regression, Correlation and their coefficients using MS-Excel/suitable software
5	Compute paired and unpaired, F-test, t-test, using MS-Excel/suitable software
6	Compute ANOVA, χ^2 -test using MS-Excel/suitable software
7	Biological databases – NCBI, Protein Data Bank and ExPaSy
8	Primary and tertiary structure analysis of protein/ DNA using BLAST

9	Multiple sequence alignments using Clustal W
10	Phylogenetic tree analysis using MEGA 5.
11	Primer designing using biological software
12	Demonstration of Microplate Reader
13	Demonstration of HPLC for analysis of microbial metabolite

Suggested Readings:

- Bailey, N.T.J (1959) *Statistical Methods in Biology*, ELBS and The English Universities Press Ltd., UK
- Irfan Ali Khan and Atiya Khanum (2004) *Fundamentals of biostatistics*, Ukaaz Publication, Hyderabad.
- Gupta, S. C. *Fundamentals of Statistics*, Himalaya Publishing House, New Delhi.
- Bliss, C. I. K. (1967) *Statistics in Biology*, Vol. 1, McGraw-Hill, New York.
- Baxevanis, A. D. and Ouellette, B. F. F. (2001) *Bioinformatics: A practical guide to the analysis of genes and proteins*. Second Edition. John Wiley & Sons, New York.
- Ewens Warren J. and Gregory R. Grant. (2004) *Statistical Methods in Bioinformatics, An Introduction*, Springer, New York.
- Lacroix, Z. and Critchlow, T. (Eds.) (2003) *Bioinformatics. Managing Scientific Data*. Morgan Kaufmann Publishers.
- Misener, S. and Krawetz, S. A. (Eds.). (2000) *Methods in Molecular Biology*, Volume 132. *Bioinformatics: Methods and Protocols*. Humana Press, New Jersey.
- Mount, D. W. (2001) *Bioinformatics: Sequence and Genome analysis*. Cold Spring Harbor Laboratory Press, New York.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C304.1	Access information from databases and interpret phylogenetic tree to gain insight into evolutionary path.	3
C304.2	Understand various algorithm.	4
C304.3	Practice biostatistics for interpretation of experimental data.	5

MB-305: Methods in Applied Microbiology

	<p>Course Objectives:</p> <p>1. To impart training to students about various quality control analysis carried out for pharmaceuticals</p> <p>2. To familiarize the students with quality activities required in pharmaceutical industry</p>
1	Survivor curve for Ultraviolet light/Heat /ethylene oxide
2	Validation of autoclave using chemical and biological indicator
3	Phenol coefficient (Rideal Walker Test/ Chick Martin Test),
4	Sterility testing of in-process materials and finished products
5	Evaluation of carcinogenicity using Ames test
6	Microbial Limit Test (analysis of water, raw material, finished product, packaging material, Excipients)
7	Evaluation of quality of media/reagents for Growth promotion tests.
8	Endotoxin/pyrogen using LAL (water, in-process, final product)
9	Validation of efficiency of laminar air flow
10	Biodegradation of pesticide and evaluation of CO ₂ as well as metabolites by suitable method
11	Pretreatment of lignocellulosic feedstock for saccharification using physico-chemical method, assessment of saccharification using suitable method and preparation for SSF/SHF
12	Production of biogas from feedstock and detection using water displacement method
13	Demonstrations: Lyophilization
14	Demonstration of LCMS for analysis of microbial product

Suggested Readings:

- White, D (2000) The Physiology and Biochemistry of Prokaryotes, Oxford University Press, Oxford
- Mudili, J (2007) Introductory Practical Microbiology, Narosa Publ. House Pvt. Ltd., New Delhi (ISBN: 978-81-7319-744-4)
- Primrose, SB and Wardlow, AC (1982) Source Book for Experiments for the Teaching of Microbiology, Academic Press, London (ISBN: 0-12-565680-7)
- Sawhney, SK and Singh, R. (2001) Introductory Practical Biochemistry, Narosa Publ. House, Chennai

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C305.1	Undertake quality control tests of pharmaceutical products.	5
C305.2	Carry out sterility testing and maintain sterility in the production area of pharma products.	4
C305.3	Understand various types of regulatory approvals required for pharmaceutical products.	2

M.Sc. Part II Semester III (Microbiology): Elective Course (Select only one)

MB - 303: Applied and Environmental Microbiology		
	<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To understand offline/ online strategies adopted for microbial analysis of food 2. To learn about role of microbes in wastewater treatment, as well as liquid and solid waste management 3. To impart knowledge about removal of recalcitrant from contaminated environment 	
Unit I	<p>Food Microbiology</p> <ul style="list-style-type: none"> • Methods of sampling and investigation • Preparation of dilutions • Offline and online approach of microbial analysis • Detection and enumeration of indicator bacteria, pathogenic and toxigenic microbes • Mycotoxins • Microbiological examination of specific foods <ul style="list-style-type: none"> ➤ Meat and meat products ➤ Milk and milk products • Food intoxications: Causes, pathogenesis and prevention and control 	10
Unit-II	<p>Microbiological treatment of waste water</p> <ul style="list-style-type: none"> • Principles and need for biological waste water treatment • Conventional treatment process <ul style="list-style-type: none"> Primary- Sedimentation or settling Biological treatment process: Aerobic suspended-growth, Aerobic attached-growth (TF, RBC, PBR), Anaerobic suspended growth and Anaerobic attached growth • Advanced Tertiary Process: <ul style="list-style-type: none"> Solids removal, Biological nitrogen removal, Biological phosphorus removal and Disinfection • Waste water treatment for distillery and antibiotic industries • Solid waste management <ul style="list-style-type: none"> ➤ Composting: Principle, chemistry and biology of composting, technology of composting, criteria of compost maturity, applications of compost ➤ Biomethanation: Feedstocks, BMP, Microbiology of biomethanation, biochemistry of methane synthesis. 	10

Unit- III	Biological conversion of Lignocellulosic waste	10
	<ul style="list-style-type: none"> • Composition, structure of lignocelluloses and issues • Pre-treatment of lignocellulosic material: Physical, Chemical and Biological • Fermentation: Submerged, SSF, SHF, SScF • Applications in lignocellulosic ethanol production 	
Unit- IV	Bioremediation and biodegradation of xenobiotics	10
	<ul style="list-style-type: none"> • Concept of biodegradability and bioconversion • Principles for measuring biodegradability • Mechanism of biodegradation / bioremediation • Methods for bioremediation: Intrinsic, Biostimulation, and Bioaugmentation • Impediments to microbial degradation of compounds • Biodegradation of xenobiotics <ul style="list-style-type: none"> ➤ Biochemical/ physiological approach ➤ Molecular techniques ➤ Toxicological risk assessments 	
Unit- V	Biomarkers and Bioreporters	10
	<ul style="list-style-type: none"> • Concept and approaches to metagenomics analysis, ecological inference • Biomarker gene (antibiotic and heavy metal resistance genes, ice-nucleation, bioluminescence genes, green fluorescent genes) • Bioreporter genes and Biosensor 	
Suggested Readings:		
<ul style="list-style-type: none"> • Singh, A. and Ward, O. P. (2004) Biodegradation and Bioremediation, Springer-Verlag, Berlin (ISBN: 3-540-21101-2) • Hurst, C.J. (2002) Manual of Environmental Microbiology, ASM Press, Washington D.C. (ISBN: 1-55581-199-x) • Demain, A. L. and Davies, J. E. (1999) Manual of Industrial Microbiology and Biotechnology, ASM Press, Washington D.C. (ISBN: 1-55581-128-0) • Martin, A. M. (1998) Bioconversion of waste materials to Industrial Products, Blackie Academic and Professional, London (ISBN: 0-7514-0423-3) • Harrigan, W. F. and McCance, M.E. (1994) Laboratory Methods in Food and Dairy Microbiology. Academic Press, London • Mossel, D.A.A., Correy, J.E.L., Struijk, C.B. and Baird, R. M. (1995) Essentials of the Microbiology of Foods, John-Wiley and Sons Inc., New York. • Hobbs, B & Roberts, D. (1993) Food Poisoning & Food Hygiene, Edward Arnold, London • Baker, K.H. and Herson, D. S. (1994) Bioremediation, Mc-Graw Hill Inc., New York. • Rehm, R. G. and Reed, G. (1984) Biotechnology, Vol.1-8, Verlag-Chemie, Weinheim. • Forster, C. F. (1985) Biotechnology and Wastewater Treatment, Cambridge University Press, Cambridge. • Maier, R. Pepper, I. L. and Gerba, C. P. (2009) Environmental Microbiology, 2nd edn., Academic Press, London 		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C303.1	Understand significance of microbes in food, wastewater treatment and clean-up	2
C303.2	Describe use of microbes in solid and liquid waste treatment as well as bioremediation of toxicants, thereby acquire knowledge about microbial potentials	4
C303.3	Understand the relevance of microbial standards for food quality assurance.	3

M.Sc. Part II Semester III Microbiology: Audit Courses

AC-301(A): Computer Skills		
(Technology + Value added Audit course; Practical; 2 Credits)		
(Optional: Campus + Program level)		
Course Objectives (COs):		
<ul style="list-style-type: none"> • To inculcate different daily useful computer skills among students. 		
Unit 1	Elements of Information Technology 1.1 Information Types: Text, Audio, Video, and Image, storage formats 1.2 Components: Operating System, Hardware and Software, firmware 1.3 Devices: Computer, Mobile Phones, Tablet, Touch Screen, Scanner, Printer, Projector, smart boards 1.4 Processor & Memory: Processor functions, speed, Memory types: RAM /ROM /HDD /DVD-ROM/Flash drives, memory measurement metrics	2 hrs
Unit 2	Office Automation-Text Processing 2.1 Views: Normal View, Web Layout View, Print Layout View, Outline View, ReadingLayout View 2.2 Working with Files: Create New Documents, Open Existing Documents, Save Documents to different formats, Rename Documents, Close Documents 2.3 Working with Text: Type and Insert Text, Highlight Text, Formatting Text, Delete Text, Spelling and Grammar, paragraphs, indentation, margins 2.4 Lists: Bulleted and Numbered Lists, 2.5 Tables: Insert Tables, Draw Tables, Nested Tables, Insert Rows and Columns, Move and Resize Tables, Moving the order of the column and/or rows inside a table, Table Properties 2.6 Page Margins, Gutter Margins, Indentations, Columns, Graphics, Print Documents, 2.7 Paragraph Formatting, Paragraph Attributes, Non-printing characters 2.8 Types of document files: RTF, PDF, DOCX etc.	5 hrs
Unit 3	Office Automation-Worksheet Data Processing 3.1 Spreadsheet Basics: Adding and Renaming Worksheets, Modifying Worksheets, 3.2 Moving Through Cells, Adding Rows, Columns, and Cells, Resizing Rows and Columns, Selecting Cells, Moving and Copying Cells 3.3 Formulas and Functions: Formulas, Linking Worksheets, Basic Functions, AutoSum, Sorting and Filtering: Basic Sorts, Complex Sorts, Auto-fill, Deleting Rows, Columns, and Cells 3.4 Charting: Chart Types, drawing charts, Ranges, formatting charts	5 hrs
Unit 4	Office Automation- Presentation Techniques and slide shows 4.1 Create a new presentation, AutoContent Wizard, Design Template, Blank Presentation, Open an Existing Presentation, PowerPoint screen, Screen Layout 4.2 Working with slides: Insert a new slide, Notes, Slide layout, Apply a design template, Reorder Slides, Hide Slides, Hide Slide text, Add content, resize a placeholder or textbox, Move a placeholder or text box, Delete a placeholder or text box, Placeholder or Text box properties, Bulleted and numbered lists, Adding notes 4.3 Work with text: Add text and edit options, Format text, Copy text formatting, Replace fonts, Line spacing, Change case, Spelling check, Spelling options 4.4 Working with tables: Adding a table, Entering text, Deleting a table, Changing row width, Adding a row/column, Deleting a row/column, Combining cells, Splitting a cell, Adding color to cells, To align text vertically in cells, To change table borders, Graphics, Add clip art, Add an image from a file, Save & Print, slide shows, slide animation/transitions.	6 hrs
Unit 5	Internet & Applications: 5.1 Computer Network Types: LAN, PAN, MAN, CAN, WAN, Defining and describing the Internet, Brief history, Browsing the Web, Hypertext and hyperlinks, browsers, Uniform resource locator 5.2 Internet Resources: Email, Parts of email,	4 hrs

	5.3 Protecting the computer: Password protection, Viruses, Virus protection software, Updating the software, Scanning files, Net banking precautions. 5.4 Social Networking: Features, Social impact, emerging trends, issues, Social Networking sites: Facebook, Twitter, linkedin, orkut, online booking services 5.5 Online Resources: Wikipedia, Blog, Job portals, C.V. writing 5.6 e-learning: e-Books, e-Magazines, e-News papers, OCW(open course wares): Sakshat(NPTEL) portal, MIT courseware	
Unit 6	Cloud Computing Basics 6.1 Introduction to cloud computing 6.2 Cloud computing models: SAS, AAS, PAS 6.3 Examples of SAS, AAS, PAS (DropBox, Google Drive, Google Docs, Office 365 Prezi, etc.)	3 hrs
Suggested readings:		
1. TCI, "Introduction to Computers and Application Software", Publisher: Jones & Bartlett Learning, 2010, ISBN: 1449609821, 9781449609825 2. Laura Story, Dawna Walls, "Microsoft Office 2010 Fundamentals", Publisher: Cengage Learning, 2010, ISBN: 0538472464, 9780538472463 3. June Jamrich Parsons, Dan Oja, "Computer Concepts Illustrated series", Edition 5, Publisher Course Technology, 2005, ISBN 0619273550, 9780619273552 4. Cloud computing online resources		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301A.1	Identify their lacunas about some computer skills and try to overcome the same.	2
AC301A.2	Practice the learned computer skills in real life and do their jobs more effectively.	3

AC-301(B): Cyber Security (Technology + Value added Audit course; Practical; 2 Credits) (Optional: Campus + Program level)		
Course Objectives (COs):		
<ul style="list-style-type: none"> To make students aware of different daily useful cyber security skills/rules. 		
Unit 1	Networking Concepts Overview Basics of Communication Systems, Transmission Media, ISO/OSI and TCP/IP models, Network types: Local Area Networks, Wide Area Networks, Internetworking, Packet Formats, Wireless Networks: Wireless concepts, Advantages of Wireless, Wireless network architecture, Reasons to use wireless, Internet	3 hrs
Unit 2	Security Concepts Information Security Overview, Information Security Services, Types of Attacks, Goals for Security, E-commerce Security, Computer Forensics, Steganography. Importance of Physical Security, Biometric security & its types, Risk associated with improper physical access, Physical Security equipments. Passwords: Define passwords, Types of passwords, Passwords Storage – Windows & Linux.	7 hrs
Unit 3	Security Threats and vulnerabilities Overview of Security threats, Hacking Techniques, Password Cracking, Types of password attacks, Insecure Network connections, Wi-Fi attacks & countermeasures, Information Warfare and Surveillance. Cyber crime: e-mail related cyber crimes, Social network related cyber crimes, Desktop related cyber crimes, Social Engineering related cyber crimes, Network related cyber crimes, Cyber terrorism, Banking crimes	7 hrs

Unit 4	Cryptography Understanding cryptography, Goals of cryptography, Types of cryptography, Applications of Cryptography, Use of Hash function in cryptography, Digital signature in cryptography, Public Key infrastructure	5 hrs
Unit 5	System & Network Security System Security: Desktop Security, email security: PGP and SMIME, Web Security: web authentication, Security certificates, SSL and SET, Network Security: Overview of IDS, Intrusion Detection Systems and Intrusion Prevention Systems, Overview of Firewalls, Types of Firewalls, VPN Security, Security in Multimedia Networks, Fax Security.	3 hrs
Unit 6	OS Security OS Security Vulnerabilities updates and patches, OS integrity checks, Anti-virus software, Design of secure OS and OS hardening, configuring the OS for security, Trusted OS.	2 hrs
Unit 7	Security Laws and Standards Security laws genesis, International Scenario, Security Audit, IT Act 2000 and its amendments.	3 hrs
Suggested readings:		
<ol style="list-style-type: none"> 1. Skills Factory, Certificate in Cyber Security, Text Book Special edition, Specially published for KBC NMU, Jalgaon 2. BPB Publication, “Fundamentals of Cyber Security”, Mayank Bhushan, Rajkumar Singh Rathore , Aatif Jamshed 3. CreateSpace Independent Publishing Platform, “Cyber Security Basics”, Don Franke, ISBN-13: 978-1522952190 ISBN-10: 1522952195 4. Online references 		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301B.1	Practice learned cyber security skills/rules in real life.	3
AC301B.2	Provide guidance about cyber security skills/rules to their friends, parents and relatives.	2

AC-301(C): Seminar + Review Writing

(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)

Course Objectives (COs):

- To motivate students to develop skills to search, retrieve, interpret, organize, and present relevant biological information.

Writing a Scientific Literature Review:

- Choosing a topic, Deciding the scope of topic, Significance and impact of scientific problem being addressed, Relevance to subject, current issues and social relevance, Strengths and limitations of the study, Enticing broad audience.
- Literature Survey and Information to consider in the review:
 - Literature search using authentic library resources (print and non-print, digital and virtual) for Almanacs, Encyclopaedia, Dissertations, Theses, Research papers, Review articles, Reference/ Textbooks, and Popular articles (INFLIBNET, Google Scholar, PubMed, Highwire, Google patents, Indian patent database, etc.)
 - Analyzing the literature quality (indexing, peer review, citations, journal impact factor, etc.)
- Deciding a writing approach (theoretical, experimental, interpretive, clinical, etc.), prepare the highlights and drawing important conclusion from literature
- Sections to include and tips for writing them: Abstract, Introduction, Body, Discussion, Conclusion, References
- Reference styles (MLA, APA, etc.), Use of bibliography/ reference/ citation managers and generators

<p>(Reference Manager, EndNote, RefWorks, Mendeley, Zotero, Qiqqa, etc.)</p> <ul style="list-style-type: none"> Ethics of publication: Approval and consent, Data ethics (accuracy, falsification, fabrication, and confidentiality), Plagiarism and self-plagiarism, collaborative authorship, conflict of interest, legal consequences Content similarity detection, Use of anti-plagiarism services (Urkund, iThenticate, Turnitin, Copyscape, Grammarly, etc.)

Seminar Activity:

- Students are encouraged to deliver seminars on the topics of research, preferably published research paper in a reputed and indexed journal to develop presentation skills and enable to build confidence which will lead them to read different themes and enhance their scientific approach and knowledge assimilation abilities.
- Presentations must be created and presented by students using digital platform using a suitable software in the presence of student audience and faculty for evaluation

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301C.1	Retrieve, analyse, comprehend the scientific information on a given topic and derive logical inferences.	4
AC301C.2	Compile the scientific information on a topic, verify for similarity index or plagiarism.	2
AC301C.3	Deliver the interactive presentation of scientific data before audience and participate in open discussion with confidence.	2

AC-301(D): Biostatistics		
(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)		
<i>Course Objectives (COs):</i>		
<ul style="list-style-type: none"> To learn basic statistical concepts/methods and their applications in biological processes and experiments. 		
Unit 1	<p>Descriptive Statistics and Presentation of Data</p> <ul style="list-style-type: none"> Types of Data: qualitative and quantitative data; nominal and ordinal data; discrete and continuous data; frequency and non-frequency data, Different types of scale - nominal, ordinal, ratio and interval. Analysis of univariate Quantitative Data: Concepts of central tendency or location, dispersion, skewness and kurtosis, measures of dispersion: range, quartile deviation, variance, standard deviation. Analysis of bivariate Data: measures of association, correlation. Presentation of Data: construction of tables with one or more factors of classification, diagrammatic and graphical representation of non-frequency data, frequency distributions, histogram. Graphical presentation of data through bar graph, line graph, pie chart, histogram, dot plot, box-plot, multiple line/bar graphs etc. 	8 hrs
Unit 2	<p>Correlation and regression</p> <ul style="list-style-type: none"> Bivariate data: scatter diagram, coefficient of determination, rank correlation: Spearman's rank correlation coefficient. Meaning and concept of regression, fitting of simple linear regression and quadratic regression in single predictor variable. Multivariate data: multiple regression, coefficient of determination, R-square and its interpretation, testing significance of predictor variables. 	8 hrs
Unit 3	<p>Testing of hypothesis and basic statistical designs</p> <ul style="list-style-type: none"> Introduction of methods of sampling. 	8 hrs

	<ul style="list-style-type: none"> • Statistical hypothesis, problem of testing of hypothesis, simple and composite hypothesis, types of errors, p-value, conclusions in hypothesis testing. • Statistical tests: one sample t-test, paired t-test, test for proportions, chi-square test for testing independence/association of attributes. • Design of experiments: introduction to basic terms of design of experiments, standard designs: Completely Randomized Design (CRD), Randomized Block Design(RBD), concept of ANOVA, F-test in ANOVA, interpretation of results from ANOVA. 	
Unit 4	PRACTICALS (Emphasis on examples from Biological Sciences) <ul style="list-style-type: none"> • Based on graphical Representation • Based on measures of Central Tendency & Dispersion • Based on Distributions Binomial Poisson Normal • Based on t, f, z and Chi-square • Based on basic statistical designs 	6 hrs
Suggested readings: <ol style="list-style-type: none"> 1. Le CT (2003) Introductory Biostatistics. 1st edition, John Wiley 2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia. 3. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press. 4. Danial W (2004) Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc. 5. Design and Analysis of Experiments by Montgomery D.C. (2001), John Wiley. 		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301D.1	Describe and identify data generated from biological processes and experiments.	1
AC301D.2	Use summary statistics: measures of central tendency, measures of dispersion with their interpretations for explain the data more effectively through graphical tools.	3
AC301D.3	Apply knowledge of correlation, regression analysis and testing of hypothesis to real life data and understand their interpretation.	3

M.Sc. Part II Semester IV (Microbiology): Core Courses

MB – 401: Fermentation Technology		
	<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To introduce microbial fermentation, product recovery and bioreactor design 2. To familiarize the student with separation techniques used for fermentation products 3. To introduce the microbial process adopted for production of various metabolites 	
Unit I	<p>Upstream processing</p> <ul style="list-style-type: none"> • Microbial growth kinetics and measurement of cell growth • Metabolic pathways and control mechanisms • Fermentation- kinetics of batch and continuous culture • Designing of medium and strain improvement • Stoichiometry of microbial growth and product formation 	10
Unit II	<p>Bioreactors (Design and Application) bioreactor operation</p> <ul style="list-style-type: none"> • Design and construction materials of bioreactor • Parameters involved in fermentation process monitoring • Aeration and agitation for mass transfer • Strategy for medium sterilization, maintenance of aseptic/axenic condition • Control of process parameters and overview of process automation • Scale up and production economics 	10
Unit III	<p>Downstream processing and IPR</p> <ul style="list-style-type: none"> • Biomass harvesting: centrifugation, filtration • Cell disruption: ultrasonication, thawing, enzymatic. • Product extraction: Liquid –liquid, supercritical fluid extraction, ultrafiltration, Three phase partitioning • Product purification and characterization: Chromatography: adsorption, size exclusion, affinity, ion exchange, reverse phase, HPLC, • Quality practices: concept of SOP, GLP and Biosafety aspects of handling infectious organisms • Intellectual Property Right (IPR): Patents, copyrights, trademarks, geographical indications Patenting biological materials, transgenic materials Patent regulatory bodies at National and International level 	10
Unit IV	<p>Microbial Products I</p> <ul style="list-style-type: none"> • Enzymes: Protease, asparaginase • Organic acids: citric acid, lactic acid • Amino acids: Lysine, aspartic acid • Polysaccharides: Alginate, Hyaluronic acid 	10
Unit V	<p>Microbial Products II</p> <ul style="list-style-type: none"> • Antibiotics: Penicillin, streptomycin • Ethanol: 1st, 2nd and 3rd generation • Vaccines production: DPT, MMR • Nucleotides: IMP, GMP • Recombinant proteins: Insulin, Monoclonal antibodies • Fermented milk: Kefir and Yoghurt 	10
<p>Suggested Readings:</p> <ul style="list-style-type: none"> • Mukhopadhyay, S.N. (2004) Process Biotechnology Fundamentals, 2nd edn., Viva Books, Mumbai, (ISBN: 81-7649-496-8) • Shuler M. L. and Kargi F (2008) Bioprocess Engineering-Basic Concepts, 2nd Edn. Prentice-Hall, USA • The Indian Environmental Protection Act (EPA), 1986 • Food Safety and Standards act (Government of India), 2006 • El-Mansi, EMT, Bryce, CFA, Demain, AL and Allman, AR (2007) Fermentation Microbiology and 		

Biotechnology, 2nd edn., CRC Taylor & Francis Group, Boca Raton, Florida (ISBN: 0-8493-5334-3)

- Lodish, MR (2001) Bioseparation Engineering, Wiley Interscience, NY (ISBN: 0-471-24476-7)
- SreeKrishna, V. (2007) Bioethics and Biosafety in Biotechnology, New Age International (P) Ltd., Publ., Mumbai (ISBN: 81-224-2085-0)
- Moo-Young, MC (2011) Comprehensive Biotechnology, Vol. I, II and III, Elsevier, ISBN:978-0-08-088504-9
- Goodfrey, T. and Reichelt, JR (1997) Industrial Enzymology, 2nd edn., McMillan Publ. Co., London
- Rhem, HJ, Reed, G, Puhler, A. and Stadler, P. (1997) Biotechnology, 2nd edn., VCH Pub. Germany
- Singh, KC (2004) Intellectual Property Rights on Biotechnology, BCIL, New Delhi
- Stanbury, Peter F.; Whitaker, Allan; Hall, Stephen J. (1994) Principles of Fermentation Technology. II Edn, Butterworth-Heinemann Publishers
- Okafor Nduka (2007) Modern Industrial Microbiology and Biotechnology, Science Publishers, USA

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C401.1	Learn industrially relevant microbial products and their production process	2
C401.2	Get knowledge about bioreactor configuration, recovery of fermentation products	3
C401.3	Understand IPR and regulatory procedures required for final product.	4

MB - 402: Microbial Genetics		
	<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To extend the knowledge on molecular basis of mutation and repairs in microbes 2. To understand different modes of gene regulation and expression mechanisms in bacteria 3. To understand the principle role of plasmids, gene transfer methods and DNA replication 	
Unit 1	<p>Genome organization</p> <ul style="list-style-type: none"> • General features of genome: viruses, prokaryotes, archea and eukaryotes, • Genome: Phage (T4), <i>E. coli</i>, <i>Saccharomyces</i> and <i>Neurospora</i> • Genome vocabulary: Operon, interrupted genes, gene families, structure of chromatin and chromosomes, unique and repetitive DNA, heterochromatin, euchromatin, allele, transposons. 	05 L
Unit 2	<p>Virus genome replication</p> <ul style="list-style-type: none"> • General aspects of viral genome replication: in Prokaryotic and eukaryotic cells, Polymerases • Replication: DNA replication (Initiation, elongation and termination), Double-stranded RNA replication, Single-stranded RNA replication • Reverse transcription 	10 L
Unit 3	<p>DNA Damage and Repair</p> <ul style="list-style-type: none"> • Mutation: Spontaneous and induced (Physical and Chemical mutagens), Molecular mechanisms of mutations: Point mutations, base substitution-transition and transversion (frameshift mutations, deletion, and addition), mutation rates, mutation probability, inversion. • Effects of mutation on the gene product: loss of the function of mutants (null, leaky mutations), gain of function of mutants, random or adaptive mutations, • Significance of mutants: Uses of bacterial and fungal mutants in Strain improvement, Bacteriophage mutants in viral genetics. • DNA protection and repair: Role of restriction-modification system in DNA protection and repair 	15L
Unit 4	<p>Plasmids</p> <ul style="list-style-type: none"> • Characteristics of bacterial plasmid: size, conformation, replication origin of replication, replication proteins, regulation of plasmid copy number, amplification 	10 L

	and compatibility. Curing of plasmids, <ul style="list-style-type: none"> • Plasmid segregation: Random diffusion, par regions, post-segregational killing • Types of plasmid in: bacteria and Saccharomyces • Plasmid isolation: isolation and purification techniques for bacterial plasmids 	
Unit 5	Gene regulations <ul style="list-style-type: none"> • Gene regulation in bacteria and Viruses: Lac operon, Quorum sensing, Riboswitch, gene regulation by repressor in Lysogenic cycle of bacteriophage • Gene regulation in eukaryotes: DNA Rearrangements, Chromatin Modification, Cis-acting site, RNA Silencing 	10 L
Suggested readings:		
<ol style="list-style-type: none"> 1. Streips, U.N. and Yasbin, R.E. (2002) Modern Microbial Genetics, 2nd Edn., Wiley-Liss, New York 2. Maloy, S. and Freifelder, D. (1994) Microbial Genetics, Jones & Barlett Publishers, London 3. Dale, J. W. (1994) Molecular Genetics, John Wiley & Sons, Hoboken, NJ, USA 4. Upadhyay, A., and Upadhyay, K. (2005) Molbio: Fundamentals of Molecular Biology, Himalya Publication House, Mumbai 5. Trun, N.J. and Trempy, J.E. (2006) Fundamental Bacterial Genetics, Blackwell Publishers, New York 6. Larry, Snyder and Wendy, Champness (2007) Molecular Genetics of Bacteria, 3rd Edn, ASM Press, Washington, USA. 7. Malacinski, G.M. (2005) Freifelder's Essentials of Molecular Biology, 4th Edn., Narosa Publishing House, New Delhi 		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C402.1	Receive elaborate knowledge on mutation analysis, genome and its replication	2
C402.2	Understand about gene regulation and repair mechanisms in DNA damage	2
C402.3	Get in-depth knowledge on gene transfer mechanisms in microbes and able to explain how plasmid copy number is regulated.	4

MB - 404: Methods in Biotechnology

	Course Objectives:	
	<ol style="list-style-type: none"> 1. To train the student in basic molecular biology tools 2. To learn gene transfer and gene expression 3. To introduce microbial interaction with plant 	
1	Isolation and estimation of RNA / mRNA from bacteria/ yeast/ fungi	
2	Determination of T _m and % (G+C) of DNA	
3	DNA fingerprinting through southern blotting	
4	Gene transfer using electroporation	
5	Demonstration of GFP marker cloning and expression	
6	Fermentative production / biotransformation of antibiotic/ steroid	
7	Estimation of penicillin/ streptomycin by microbiological and chemical assay	
8	Analysis of biogas digested slurry for organic C, COD, lignin, Fatty acids and N	
9	Nodulation of legume by Rhizobium using Leonard Jar/ Pot assay	
10	Production and detection of siderophore produced by bacteria / fungi	
11	Isolation of VAM spores from soil	
12	Isolation of microbes from Rhizosphere / Phyllo-plane/ PGPR	
13	Demonstration of Acetylene Reduction Assay for nitrogen fixation	
Suggested Readings:		
<ul style="list-style-type: none"> • Sawhney, SK and Singh, R. (2001) Introductory Practical Biochemistry, Narosa Publ. House, Chennai • Aneja, KR (2005) Experiments in Microbiology, Plant Pathology and Biotechnology, International Publishers, New Delhi (ISBN: 81-224-1494-X) • Tablot, N. (2005) Molecular and Cellular Biology of Filamentous Fungi, Practical Approach, Indian Edn., Oxford University Press, New Delhi (ISBN: 0-19-567943-1) 		

- Hewitt, W (1977) Microbiological Assay, Academic Press, New York
- McMei, B. and Harvey, L. (1986) Fermentations: Practical Approach, IRL Press, Oxford
- Kalaichelvan, PT (2006) Microbiology and Biotechnology: A Laboratory Manual, MJP Publ., Chennai (ISBN: 81-8094-008-X)
- IMTECH Laboratory Manual for Bacterial Genetics, Institute of Microbial Technology, Chandigarh
- Cappucino, J and Sherman, N.C. (2015) Microbiology-A Laboratory Manual, The Benjamin-Cummings Publ. Co., Inc.
- Sambrook and Russell Molecular Cloning Vol I, II and III, CSHL Press, USA
- Janarthanan, S. and Vincent, S. (2007) Practical Biotechnology, Universities Press (India) Pvt. Ltd., Hyderabad (ISBN: 13-978-81-7371-582-2)
- Schmauder, H.P, Schweizer, M and Schewizer, L.M (2003) Methods in Biotechnology, Taylor and Francis Ltd., London (ISBN: 0-7484-0430-9)
- Davis, L.G., Dibner, MD and Battey, JF (1986) Basic Methods in Molecular Biology, Appleton and Lange, Norwalk (ISBN: 0-8385-0582-1)

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C404.1	Perform gene transfer, GFP gene cloning and carry out southern blotting	6
C404.2	Understand plant microbe relations	4

M.Sc. Part II Semester IV (Microbiology): Skill Based Courses

MB – 405: Laboratory course (Project Dissertation)

Course Objectives:

1. To give exposure to the students to research culture and technology
2. To introduce students how to select a research topic, plan, perform experiments, collect data and analyse the data
3. To foster self-confidence and self-reliance in the students as he/she learns to work and think independently

The project is allotted during the Forth semester. The students will get an opportunity to become a part of ongoing research activities in the respective supervisor's laboratory and can explore experience in different areas of microbiology viz. agriculture, food, medicine and pharmaceutical, etc. The students will acquire skill to write, compile and analyze data, and present the detailed technical/scientific report. At the end of successful project semester training, potentially the students become employable in the industries/organizations.

It is expected that the students will design experiments and collect experimental data to deduce conclusions. At the end, they will submit a detailed thesis for evaluation. The students should be introduced to research methodology in the beginning through few lectures.

The systematic approach towards the execution of project should be as follows:

1. Selection of topic relevant to priority areas of biotechnology.
2. Collection of literature on the topic of research from libraries, internet, on-line journals, Planning of research experiments
3. Performing the experiments with scientific and statistical acceptability.
4. Presentation of observations and results.
5. Interpretation of results and drawing important conclusions.
6. Discussion of obtained results with respect to literature reports.
7. Writing monthly progress report
8. Preparation of report (Dissertation) containing introduction, materials and methods, results and discussion, conclusions, bibliography and submission of at least 3 copies (1 copy retained in the department and after examination submitted to Library, 1 copy submitted to the guide and 1 copy kept with the candidate).
9. Presentation of research data during university examination and submission of project dissertation in a bound form.

<p>1. Internal examination (40 marks): Components of continuous internal assessment: Submission of monthly progress report and signed by supervisor (at least 4 reports) (2 marks per report = 8 marks), Literature collected, experiment planning and design (10 marks), Experiments conducted (10 marks), outcome of the experiments and viva (8 marks) and regular attendance (4 marks) recorded: Research Supervisors</p> <p>2. External examination (60 marks) and Components of external assessment: Subject matter (5 marks), Review of literature (10 marks), Writing of dissertation submitted in bound form at the time of examination (Title page, Certificate, Plagiarism report, Main content: Abstract, Introduction, Literature, Materials and methods, results and discussion and conclusion with relevant references) (15 marks), Presentation structure (PPT format) (8 marks), Overall presentation reflecting contribution of work (4 marks), Response to questions (15 marks).</p>
<p>Suggested readings: Refer the topic in research papers, review articles published in peer reviewed and SCI indexed journals, reference books, abstracts, etc. related to topic of project dissertation</p>

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C405.1	Conceive a problem based on published research and carry out comprehensive survey of literature	4
C405.2	Plan and carry out task in given framework of dissertation and present the work in written and viva	6
C405.3	Use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.	6
C405.4	Learn handling of instruments, use of chemicals and how to conduct the experiments	3
C405.5	Learn how to present the project in power point and answer the queries to examiners as well as science of writing	6

M.Sc. Part II Semester IV (Microbiology): Elective Course

MB – 403: Agricultural Microbiology		
	<p>Course Objectives:</p> <ol style="list-style-type: none"> To introduce various attributes of microbial ecology and plant microbe interactions To learn the student about how plant elicit defence against pathogens To know biocontrol, biofertilizers for plant nutrition, remediation of salt-affected soils 	
Unit I	<p>Microbial ecology</p> <ul style="list-style-type: none"> Basic microbial ecology and its components Microbial interactions: Positive and Negative interactions with examples Microbial communities: Concept, Elements and methods of analysis (CLPP, PLFA, DGGE, SSCP, ARDRA and FISH) Methods to quantitative microbial ecology 	10 L
Unit II	<p>Microbial interactions with plant roots</p> <ul style="list-style-type: none"> Rhizosphere and its anatomy Mycorrhizae: VAM, OM, Endo- and Ecto-mycorrhiza Plant Growth Promoting Rhizobacteria (PGPR) Strategies for rhizosphere and mycorrhizae community study <p>Microbial interaction with aerial plant structure</p> <ul style="list-style-type: none"> Phylloplane, Stems/ flowers, leaf buds Strategies for microbial interaction studies with aerial plant structures <p>Leguminous root nodules</p> <ul style="list-style-type: none"> Nodulation process and mechanism of nitrogen fixation Strategies to study infection process, root nodulation and N₂ fixation 	10 L

Unit III	Pathogenic interactions with plants <ul style="list-style-type: none"> Plant defence mechanisms (structural, biochemical, HR, SAR) Microbial pathogenicity mechanisms in virus, bacteria, fungal pathogens Genetic basis of plant-pathogen interactions Methods of plant disease detection: Traditional and innovative Region-specific plant diseases (Etiology, symptoms and control): Red rot of sugarcane, Sigatoka disease of banana, Banana bunchy top, Tikka disease of groundnut, Powdery mildew, Smut and Rust of Jawar 	10 L
Unit IV	Microbial control for plant diseases <ul style="list-style-type: none"> Plant disease control: Strategies, principles, IDM Biopesticides: BT, Siderophore and <i>Trichoderma</i>; <i>Pseudomonas</i>, <i>Beauveria bassiana</i> and NPV Biocontrol of post-harvest diseases Control of plant pathogens by genetic engineering 	10 L
Unit V	Current microbial interventions in agriculture <ul style="list-style-type: none"> Integrated Plant Nutrition through biofertilizers Phytoremediation: Rhizodegradation Rhizosphere engineering Microbiome Microbial reclamation of saline and sodic soils Genetically modified microbes and crops 	10 L

Suggested Readings:

- Stanier, RY, Ingraham, JL, Wheelis, ML and Painter, PR (1993) General Microbiology, 5th edn., The McMillan Press Ltd., London (ISBN: 0-333-41768-2)
- Atlas, RM and Bartha, R (1998) Microbial Ecology-Fundamental and Applications, Addison Wesley Longman Inc.
- Lynch and Poole (1984) Microbial Ecology- A Conceptual Approach, Blackwell Scientific Publ.
- Streips, UN and Yasbin, RE (2002) Modern Microbial Genetics, 2nd edn., Wiley-Liss, USA (ISBN: 0-471-38665-0)
- Coyne, MS (2004) Soil Microbiology: An Explanatory Approach, Delmar/Thomson Asia Pvt. Ltd., Singapore (ISBN: 981-240-203-9)
- Kumar, HD and Kumar, S (2004) Modern Concepts of Microbiology, 2nd edn., Vikas Publishing House Pvt. Ltd., New Delhi (ISBN: 81-259-1000-X)
- Hurst, CJ, Crawford, RL, Knudsen, GR, McInerey, MJ and Stetzenbach, LD (2002) Manual of Environmental Microbiology, 2nd edn., ASM Press, Washington (ISBN: 1-55581-199-X)
- Ciancio, A and Mukerji, KG (2007) General Concepts in Integrated Pest and Disease Management, Springer, The Netherlands (ISBN: 978-1-4020-6060-1)
- Buchanan, BB, Gruissem, W and Jones, RL (2000) Biochemistry and Molecular Biology of Plants, IK International Pvt. Ltd., New Delhi (ISBN:81-88237-11-6)
- Boland, GJ and Kuykendall, LD (1998) Plant-Microbe Interactions and Biological Control, Marcel Dekker Inc., NY, USA (ISBN: 0-8247-0043-0)
- Chincholkar, SB and Mukerji, KG (2007) Biological Control of Plant Diseases, Haworth Press Inc., London (ISBN: 1-56022-328-6)
- Ben Lugtenberg (2015) Principles of Plant-Microbe Interactions: Microbes for Sustainable Agriculture. Leiden: Springer. ISBN: 978-3-319-08574-6

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C403.1	Understand ecology and how plant microbe interaction occurs	2
C403.2	Describe pathogenic interactions with plant and how biocontrol arrest pathogens	2
C403.3	Gain insight into genetics of host pathogen relation, plant resistance to pathogens.	4

M.Sc. Part II Semester IV (Microbiology): Audit Courses

AC-401(A): Human Rights (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Campus-level)		
	<p><i>Course Objectives (CObs):</i></p> <ul style="list-style-type: none"> To make students aware about human rights and human values. 	
Unit 1	<p>Introduction to Human Rights</p> <p>1.1 Concept of Human Rights 1.2 Nature and Scope of Human Rights 1.3 Fundamental Rights and Fundamental Duties 1.4 Interrelation of Rights and Duties</p>	6 hrs.
Unit 2	<p>Human Rights in India</p> <p>2.1 Meaning and Significance of : 1) Right to Equality 2) Right to Freedom, 3) Right against Exploitation, 4) Right to Freedom of Religion, 5) Cultural and Educational Rights, and 6) Right to Constitutional Remedies. 2.2 Constitutional Provisions for Human Rights 2.3 Declaration of Human Rights 2.4: National Human Rights Commission</p>	8 hrs.
Unit 3	<p>Human Values</p> <p>3.1: Meaning and Definitions of Values 3.2: Importance of values in the life of Individual 3.3: Types of Values 3.4: Programmes for conservation of Values</p>	8 hrs.
Unit 4	<p>Status of Social and Economically Disadvantaged people and their rights</p> <p>4.1: Rights of women and children in the context of Social status 4.2: The Minorities and Human Rights 4.3: Status of SC/ST and other Indigenous People in the Indian Scenario 4.4: Human rights of economically disadvantaged Society</p>	8 hrs.
<p>Suggested readings:</p> <ol style="list-style-type: none"> Human rights education – YCMOU, Nasik Value education – SCERT, Pune Human rights reference handbook – Lucille whare 		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401A.1	Practice the learned issues under human rights and human values in real life.	3
AC401A.2	Provide social justices to people around them and provide guidance about human rights to their friends, parents and relatives.	5

AC-401(B): Current Affairs (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Campus-level)			
Course Objectives (COs):			
<ul style="list-style-type: none"> To make students updated about current affairs of India and world. 			
	Title	Content	Hours
Unit 1	Politics & Economy	<ul style="list-style-type: none"> National & International Political Activity, Organization. Economy & Business, Corporate world 	08
Unit 2	Awards and recognitions	<ul style="list-style-type: none"> National & International Awards and recognitions Books and authors 	07
Unit 3	Science & Technology	<ul style="list-style-type: none"> Software, Automobile, Space Research New inventions and discoveries 	07
Unit 4	Environment & Sports	<ul style="list-style-type: none"> Summit & conference, Ecology & Climate, Organization. National & International Games, Olympics, commonwealth etc. 	08
Suggested readings (Use recent years' data and current literature):			
<ol style="list-style-type: none"> India 2019, by Publications Division Government of India Manorama Year Book by Philip Mathew, India 2019, Rajiv Maharshi Quick General Knowledge 2018 with Current Affairs Update, Disha Experts General Knowledge 2018: Latest Who's Who & Current Affairs by RPH Editorial Board. 			

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401B.1	Identify important issues currently/ recently happening in India or world.	5
AC401B.2	Summarize current affairs regularly.	6

AC-401(C): Seminar + Review Writing (Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)	
Course Objectives (COs):	
<ul style="list-style-type: none"> To motivate students to develop skills to search, retrieve, interpret, organize, and present relevant biological information. 	
Writing a Scientific Literature Review:	
<ul style="list-style-type: none"> Choosing a topic, Deciding the scope of topic, Significance and impact of scientific problem being addressed, Relevance to subject, current issues and social relevance, Strengths and limitations of the study, Enticing broad audience. Literature Survey and Information to consider in the review: <ul style="list-style-type: none"> Literature search using authentic library resources (print and non-print, digital and virtual) for Almanacs, Encyclopaedia, Dissertations, Theses, Research papers, Review articles, Reference/ Textbooks, and Popular articles (INFLIBNET, Google Scholar, PubMed, Highwire, Google patents, Indian patent database, etc.) Analyzing the literature quality (indexing, peer review, citations, journal impact factor, etc.) Deciding a writing approach (theoretical, experimental, interpretive, clinical, etc.), prepare the highlights and drawing important conclusion from literature Sections to include and tips for writing them: Abstract, Introduction, Body, Discussion, Conclusion, References Reference styles (MLA, APA, etc.), Use of bibliography/ reference/ citation managers and generators (Reference Manager, EndNote, RefWorks, Mendeley, Zotero, Qiqqa, etc.) Ethics of publication: Approval and consent, Data ethics (accuracy, falsification, fabrication, and 	

confidentiality), Plagiarism and self-plagiarism, collaborative authorship, conflict of interest, legal consequences

- Content similarity detection, Use of anti-plagiarism services (Urkund, iThenticate, Turnitin, Copyscape, Grammarly, etc.)

Seminar Activity:

- Students are encouraged to deliver seminars on the topics of research, preferably published research paper in a reputed and indexed journal to develop presentation skills and enable to build confidence which will lead them to read different themes and enhance their scientific approach and knowledge assimilation abilities.
- Presentations must be created and presented by students using digital platform using a suitable software in the presence of student audience and faculty for evaluation

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401C.1	Retrieve, analyse, comprehend the scientific information on a given topic and derive logical inferences.	4
AC401C.2	Compile the scientific information on a topic, verify for similarity index or plagiarism.	2
AC401C.3	Deliver the interactive presentation of scientific data before audience and participate in open discussion with confidence.	2

AC-401(D): Intellectual Property Rights (IPR) (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Program-level)		
	<i>Course Objectives (COs):</i> <ul style="list-style-type: none"> • To provide basic knowledge on intellectual property rights and their implications. • To understand ethical issues relevant to biology from the perspective of national and international law. 	
Unit 1	History and Introduction to Intellectual Property Rights: Evolution of patent Laws, History of Indian Patent System, Concept of IPR, Designs, Trademarks TM, Trade Secret (TS), Domain Names, Geographical Indications, Copyright	6 hrs.
Unit 2	Classification of patents and ownership: Classification of patents in India, Classification of patents by WIPO, Categories of Patent, Special Patents Ownership of patent, Rights of patent holder and co-owners, Duties of patent holder and co-owners, Transfer of patent Rights, Limitations of patent Rights, Restoration of Patents, Infringement of patent Rights and Offences, Actions against Infringement and Remedies and Relief	6 hrs.
Unit 3	Protection of biological materials and Biodiversity Methods of protection of plant and plant products, Essentialities of plant protection, Plant variety protection and Farmers' Right Act, UPOV convention (plant Varieties) 1961, National Biodiversity Act- 2002, Protection of environment and biodiversity	6 hrs.
Unit 4	Biosafety and good laboratory practices Overview of biosafety, Risk assessment, Cartagena protocol on Biosafety, Biosafety Levels, GMOs and LMOs, Gene flow and environmental impact, opportunities and challenges Roles of Institutional Biosafety Committee, RCGM, GEAC in food and agriculture Risk analysis, assessment and management, International regulatory bodies Importance of good laboratory practices, General good laboratory practices	6 hrs.

Unit 5	Bioethics Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies etc Bioethics in research – cloning and stem cell research in human, animal rights/welfare in experimentation Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations, biopiracy	6 hrs.
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Suggested readings:

1. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.
2. Deepa Goel, Shomini Parashar (2013) IPR, Biosafety and Bioethics Always learning, Pearson Education India, ISBN 9332514240, 9789332514249
3. Department of Biotechnology <http://dbtindia.gov.in/guidelines-biosafety>
4. Ganguli, P. (2001). Intellectual property rights: Unleashing the knowledge economy. New Delhi: Tata McGraw-Hill Pub.
5. International Union for the Protection of New Varieties of Plants. <http://www.upov.int>
6. Kuhse, H. (2010). Bioethics: An anthology. Malden, MA: Blackwell.
7. National Biodiversity Authority. <http://www.nbaindia.org>
8. National Portal of India. <http://www.archive.india.gov.in>
9. Office of the Controller General of Patents, Design & Trademarks; Government of India. <http://www.ipindia.nic.in/>
10. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F. (2009). Problem formulation in the environmental risk assessment for genetically modified plants. *Transgenic Research*, 19(3), 425-436. doi:10.1007/s11248-009-9321-9
11. World Intellectual Property Organisation. <http://www.wipo.int>
12. World Trade Organisation. <http://www.wto.org>

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401D.1	Understand to classify, identify advantages of intellectual property and IPR	3
AC401D.2	Understand the need to protect biological diversity and follow bioethical practices in research work, awareness to protect intellectual property relevant to biology	2
