CHOICE BASED CREDIT SYSTEM (CBCS)

SEMESTER PATTERN

M.Sc. Microbiology (PG) Program under Faculty of Science

(Affiliated Colleges)

(w.e.f. Academic Year 2014-15)

Name of the Faculty	Total credit	Average credits per semester
Science	**100**	**25**

Note:

- Assessment shall consist of Continuous assessment **(CA)** and End of Semester Examination **(ESE).**
- **Weightage:** 75% for ESE & 25% for CA
- **Paper- (Elective):** Transfer of Credit as per Student choice

Eligibility conditions:

- Admission to M. Sc. Microbiology shall be made on the basis of aggregate percentage of three years Microbiology as an optional subject at graduate level (B. Sc).

- B. Sc. Microbiology as one of the optional subject only shall eligible for the admission to M. Sc. Microbiology.

Distribution of Credits for M.Sc. Microbiology under Science faculty (All Affiliated Colleges)

	Paper No. & Code	Title of the subject	External (ESE)	Internal (CA)	Total
Sem. I	Paper-I: MB-101	Cell Biology And Microbial Physiology	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper-II: MB-102	Advances In Virology	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper-III: MB-103	Food, Dairy And Agricultural Microbiology	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	*Paper-IV (Elective): MB-104	Bioinstrumentation	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper –V (Seminar) MB-105	Based on theory paper MB-101, 102, 103 & 104	Credit: 1 (25 marks)		Credit: 1
				Total for Sem: I	**Credit: 17**
Sem. II	Paper-VI: MB-201	Microbial Metabolism	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper-VII: MB-202	Molecular Biology And Microbial Genetics	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper-VIII: MB-203	Bioprocess Engineering	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	*Paper-IX (Elective): MB-204	Enzyme Technology	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper –X (Seminar) MB-205	Based on theory paper MB-201, 202,203 & 204	Credit: 1 (25 marks)		Credit: 1
				Total for Sem: II	**Credit: 17**
Lab Course Work (Annual Practical)	LAB –I	Based on theory paper MB-101 & MB-102	(75 marks)	(25 marks)	Credit: 4 (100 marks)
	LAB –II	Based on theory paper MB-103 & MB-104	(75 marks)	(25 marks)	Credit: 4 (100 marks)
	LAB –III	Based on theory paper MB-201 & MB-202	(75 marks)	(25 marks)	Credit: 4 (100 marks)
	LAB –IV	Based on theory paper MB-203 & MB-204	(75 marks)	(25 marks)	Credit: 4 (100 marks)
	Total for Lab Course work(Annual)				**Credit: 16**
	Total for M.Sc. I Year: Sem. I + Sem. II + Lab Course work (Annual)				**Credit: 50**

Semester	Paper No. & Code	Title of the subject	External (ESE)	Internal (CA)	Total
Sem. III	Paper-XI: MB-301	Molecular Immunology	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper-XII: MB-302	Recombinant DNA Technology	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper-XIII: MB-303	Microbial Diversity And Extremophiles	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	*Paper-XIV (Elective): MB-304	Biostatistics, Computer Applications And Research Methodology	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper –XV (Seminar) MB-305	Based on theory paper MB-301, 302, 303 & 304	Credit: 1 (25 marks)		Credit: 1
				Total for Sem: III	**Credit: 17**
Sem. IV	Paper-XVI: MB-401	Fermentation Technology	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper-XVII; MB-402	Medical And Pharmaceutical Microbiology	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper-XVIII: MB-403	Environmental Microbiology	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	*Paper-XIX (Elective): MB-404	Bioinformatics, Proteomics And Genomics	(75 marks)	(25 marks) (2Test : 15 marks+ Assignments :10 marks)	Credit: 4 (100 marks)
	Paper –XX (Seminar) MB-405	Based on theory paper MB-401, 402, 403 & 404	Credit: 1 (25 marks)		Credit: 1
				Total for Sem: IV	**Credit: 17**
Lab Course Work (Annual Practical)	LAB –V	Based on theory paper MB-301 & MB-302	(75 marks)	(25 marks)	Credit: 4 (100 marks)
	LAB –VI	Based on theory paper MB-303 & MB-304	(75 marks)	(25 marks)	Credit: 4 (100 marks)
	LAB –VII	Based on theory paper MB-401, 402, 403 & 404	(75 marks)	(25 marks)	Credit: 4 (100 marks)
	LAB –VIII (Dissertation) *(Elective)	----	(75 marks)	(25 marks)	Credit: 4 (100 marks)
	Total for Lab Course work(Annual)				**Credit: 16**
	Total for M.Sc. II Year: Sem. III + Sem. IV + Lab Course work (Annual)				**Credit: 50**
	Total for M.Sc.(I Year + II Year):				**Credit: 100**

Practical Examination:

The outline of the distribution of maximum marks for various aspects/mechanisms towards ESE is as follows:

- Journal – **10 marks**
- Experimental Performance – **50 marks**
- Viva-voce & Group discussion of 5/6 students for testing the understanding level of a student – **15 marks**

- At least three experiments should be asked for the full course of 4/5 credits and at least two for 2/3 credits.
- Certified Journal would be compulsory to appear for the ESE practical course.
- There shall be two experts from the parent Department and two examiners (one of which will be external) per batch.
- If a student failed to obtain a grade other than F in a course then such a course will not be taken into account for calculating (C) GPA and overall grade. In fact, all the courses in which a student has passed will be taken into account for calculating the (C) GPA and overall grade.

INFRASTRUCTURE, INSTRUMENTAL, LIBRARY AND OTHER FACILITES REQUIRED FOR M.Sc. COURSE IN MICROBIOLOGY

(For 30 Students INTAKE CAPACITY).

1. Two Laboratories (For Part I and II) each measuring at least 1000 sq.ft with sufficient number of tables and stools. Labs should be provided with basic instruments, such as autoclave, Incubator, oven, pH meter, hot plates, Cyclo-mixers, water bath shakers, colorimeter, fridge, distillation plant, etc.
2. A culture room with a laminar air- flow measuring 300 sq. ft
3. An instrumentation room with double door, air conditioner and inverter, power generator for sophisticated instruments measuring 500 sq. ft.

4. Two lecture halls (For Part I and Part II) with overhead projector facility and measuring 400 sq. ft with tables and chairs.
5. A media preparation and storeroom measuring at least 400 sq. ft.
6. A computer and Bioinformatics laboratory with four to five computers (PIV) with printer and Internet facility.

LIST OF BASIC INSTRUMENTS REQUIRED FOR M.Sc. PRACTICALS.

1. Laminar Air Flow
2. Compound Microscope
3. Autoclave
4. Incubator
5. Hot Air ovens
6. BOD incubator
7. pH meter
8. Water bath incubator shaker
9. Colorimeter
10. Spectrophotometer
11. Hot plates
12. Cyclomixer
13. Electrophoretic Apparatus
14. Orbital Incubator Shaker
15. High Speed centrifuge (10,000rpm)
16. Distillation Apparatus (single and Double)
17. Refrigerators
18. Paper Chromatography cabinet
19. Rough Balances
20. Bacterial filter assembly
21. General purpose centrifuge
22. Vortex mixers.

23. Magnetic stirrers
24. UV cabinet
25. TLC apparatus
26. Dissolved oxygen meter
27. Mettler balance
28. Digital balances
29. Water bath shaker
30. Colony counter
31. Rotary shaker
32. Columns for chromatography
33. Fraction collector
34. Gas Burners
35. LPG cylinders
36. Distillation apparatus

LIST OF SOPHISTICATED INSTRUMENTS REQUIRED FOR THE PRACTICALS

1. UV Visible spectrophotometer
2. Gas chromatography
3. Sonicator
4. High speed refrigerated centrifuge
5. Microprocessor based pH analyzer
6. Horizontal paper electrophoresis unit
7. Vertical electrophoresis
8. Submarine electrophoresis
9. Immuno-electrophoresis
10. Power pack with constant voltage/current adjustment
11. PAGE electrophoresis unit
12. DNA sequencer
13. ELIZA reader

14. PCR (Thermal cycler)
15. Gel documentation unit
16. Semidry transfer apparatus
17. Deep freezer (-30 ^{0}c)
18. Fermenter
19. Atomic absorption spectrophotometer
20. COD and BOD analyzer
21. Phase contrast microscope
22. Binocular microscope
23. HPLC
24. Lyophilizer
25. Pentium IV computer with printer
26. Micropipettes
27. CO_2 incubator

OTHER REQUIREMENTS:

The Department should have required **chemicals, Dehydrated Media, Stains, Acids, Solvents, Fine Chemicals, Enzymes, Antisera, Immunodiagnostic Kits, Specific Microbial Cultures With Known Genetic Markers and Glassware** to conduct the prescribed syllabus. Cold room facility is preferred.

LIBRARY FACILITY

The Library should have ample number of prescribed textbooks, reference books, recommended in the prescribed syllabus and the library should also subscribe national and international journals and scientific magazines.

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

CBCS Syllabus for M.Sc. (MICROBIOLOGY)

(Effective progressively from July 2014)

FIRST SEMESTER

MB-101: CELL BIOLOGY AND MICROBIAL PHYSIOLOGY (Four Credits)

Unit-I: Cell Biology and Bacterial chemolithotrops (09)

Structure and function of cells and intracellular organelles (of both prokaryotes and eukaryotes): Mechanism of cell division including (Mitosis and Meiosis and cell differentiation: Cell-cell Interaction;

Physiological groups of chemolithotrops, ammonia oxidation by membrane of Genus Nitro groups, Nitrate oxidation by nitro group of genera. Oxidation of molecular hydrogen by Hydrogenomonas species. Ferrous and sulfur/sulfide oxidation by Thiobacillus species.

Unit-II: Bacterial Photosynthesis (09)

Photosynthetic microorganisms, photosynthetic pigments and generation of reducing power by cyclic and non cyclic photophosphorylation, electron transport chain in photosynthetic Bacteria. Carbon dioxide fixation pathways.

Unit –III: Bacterial respiration (09)

Bacterial aerobic respiration, components of electron transport chain free energy changes and electron transport, Oxidative phosphorylation and theories of ATP formation, inhibition of electron transport chain. Electron transport chain in some heterotrophic and chemolithotrophic bacteria.

Bacterial anaerobes respiration: Introduction .Nitrate, carbonate and sulfate as electron acceptors. Electron transport chain in some anaerobic bacteria. Catalase, super oxide dismutase, mechanism of oxygen toxicity.

Unit –IV: Bacterial permeation (09)

Structure and organization of membrane: (Glyco-conjugants and proteins in membrane system), fluid mosaic model of membrane. Methods to study diffusion of solutes in bacteria, passive diffusion, facilitated diffusion, different mechanisms of active diffusion (Proton motive

force, PTS, role of permeases in transport, different permeases in *E.Coli*. Transport of amino acids and inorganic ions in microorganisms and their mechanisms.

Unit –V: Bacterial Sporulation (09)

Sporulating bacteria, molecular architecture of spores, induction and stages of Sporulation, Influence of different factors on sporulation .Cytological and macromolecular changes during sporulation. Heat resistance and sporulation.

PRACTICAL LAB-I MB-101: CELL BIOLOGY AND MICROBIAL PHYSIOLOGY (Two Credits)

1. Isolation of photosynthetic bacteria
2. Glucose uptake by *E. coli / Sacchromyces cerevisiae* [Active and Passive diffusion]
3. Effect of UV, gamma radiations pH, disinfectants, chemicals and heavy metal ions on spore germination of *Bacillus SP.*
4. Determination of Iron Oxidation Rate of *Thiobacillus ferrooxidans.*
5. Determination of Sulfur Oxidation Rate of *Thiobacillus thiooxidans.*
6. Microbial degradation, decolorization and adsorption of organic dyes (by free and immobilized cells).
7. Estimation of calcium ions present in sporulating bacteria by EDTA method.
8. Demonstration of utilization of sugars by oxidation and fermentation techniques.

REFERENCES

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

MB-102: ADVANCES IN VIROLOGY (Four Credits)

Unit I: Foundations of Virology (08)

Virus prehistory, Discovery of Viruses., Definitive properties of Viruses, Cataloging of Viruses through Virus classifications scheme of ICTV ICNV, Morphology and ultra structure of Viruses.

Unit II: Virus cultivation, Detection & Genetics. (10)

Introduction, Cultivation of viruses, Cell culture, embryonated egg, laboratory animals, Detection of viruses in the host, measurement of infectious units, measurement of virus particles and their components, the one step growth cycle, assay of viruses, physical and chemical methods (Electron microscopy and protein and nucleic acid studies), infectivity assay, genetic analysis of Viruses. Classical genetic methods, engineering mutations in to viruses, engineering viral genomes, viral vectors.

Unit III: Virus attachment & Entry into host cell (10)

Introduction, Architecture of cell surfaces, Interaction of Viruses with cell receptors, uptake of macromolecules by cells, Mechanism of Virus entry into cells, Transport of Viral genome into the cell nucleus .Genomic replication of Viruses (DNA/RNA).mRNA production by animal viruses, mechanism of RNA synthesis, transcription mechanism and post transcriptional processing. Translation of viral protein, assembly, exit and maturation of progeny virions, multiplication of bacteriophages.

Unit IV: Viral pathogenesis (08)

Host and virus factors involved in pathogenesis, patterns of infection, pathogenesis of animal viruses, Adenovirus, Herpes virus, Hepatitis virus, Picorna virus, Poxivirus and Orthomyxovirus, pathogenesis of plant (TMV) and insect viruses (NPV). Host cell transformation by viruses and oncogenesis of DNA and RNA viruses.

Unit V: Prevention and control of viruses. (09)

Introduction, Vaccines, proven best defence against virus, preparation of vaccine, New vaccine Technology, Antiviral drugs, small molecules that block viral replication. Virus evolution and emergence of new viruses.

PRACTICAL LAB-I MB-102: RECENT TRENDS IN VIROLOGY (Two Credits)

1. One step growth curve for determination of virus titer.
2. Phase typing of *E.coli* bacteriophages.
3. Induction of lambda lysogen by UV radiations.
4. Studies on Specialized transduction.
5. Isolation of lambda DNA and their characterization.
6. Amplification of lambda DNA by PCR
7. Cultivation and assay of virus using embryonated eggs and tissue culture Technique.
8. Study of symptoms of plant/animal virus.

REFERENCE:

1. *An Introduction to Viruses* by S. B. Biswas & Amita Biswas (2009), Vikas Publishing House PVT LTD.
2. *Applied Virology Research: New Diagnostic Procedures* by Edouard Kurstak, R. G. Marusyk, F. A. Murphy (1984), Academic press Inc.
3. *Brocks Biology of Microorganisms* (Eleventh Edition) by Michael T. Madigan, John M. Martinko (2006), Pearson Prentice Hall.
4. *Clinical Virology Manual* by Steven C. Specter, Richard L. Hodinka, Danny L. Wiedbrauk, Stephen A. Young (2009), ASM Press.
5. *Introduction to Modern Virology 4th Edition* by N. J. Dimmock & S. B. Primrose (1994), Blackwell Scientific publications, Oxford.
6. *Notes on Medical Virology, 10th Edition* by Morag C. Timbury (1994).
7. *Principles of Virology: Molecular Biology, Pathogenesis and Control* by S. J. Flint, L. W. Enquist, V. R. Racaniello, A. M. Skalkaj (2009), ASM Press, Washington.
8. *Principles* of *Molecular Virology* (4th edn.), Edward Arnold & A. J. Cann (2005). Academic Press, London.
9. *Text Book on principles of bacteriology, Virology and Immunology* by Topley and Wilsons (1995).
10. *Virology 3rd Edition* by H. F. Conrat, P.C. Kimball and J.A. Levy (1994). Prentice Hall, Englewood Cliff, New Jersey.

MB 103: FOOD, DAIRY & AGRICULTURE MICROBIOLOGY (Four Credits)

UNIT-I: Food & Dairy Fermentations (10)

Starter cultures & biochemical activities production and preservation of

1) Soy Sauce 2) Saurkraut 3) Sausages 4) Vinegar 5) Beer 6) Wine 7) Cheese 8) Fermented milk products. 9) Tea and coffee 10) Pickles 11) Indian fermented foods (Dosa, Idli and Jilebi).

UNIT – II: Quality Assurance in foods (08)

Quality assurance: Microbiological quality standards of food

Government regulatory practices and policies. FDA, EPA, HACCP, ISI.

Food borne infections and intoxications: Bacterial with type of infection and toxicity-

1) *Clostridium* 2) *Salmonella* 3) *Shigella*,4) *Staphylococcus* 5) *Campylobacter* 6) *Listeria*

-Mycotoxin- Rubratoxin and Alfa Toxins

- Phycotoxins in foods.

UNIT- III : Food Preservation & Advanced Food Microbiology (08)

Radiations- UV, Gamma & Microwave.

-Temperature

-Chemical and naturally occurring antimicrobials.

-Biosensors in food

-Microbial enzymes in food & dairy industry (Proteases, Lipases, Amylases, Pectinase)

-Probiotics and their applications, genetically modified foods

-Mushroom and spirulina

-Utilization of Byproduct .1) Dairy Industry - Whey 2) Sugar Industry - Molasses.

UNIT –IV: Pathogenic Interactions with Plants. (08)

-Plant defence mechanism

-Microbial pathogencity mechanism in virus, bacteria, fungal pathogens

-Genetic basis of plants – pathogen interactions.

-Region- specific plant diseases (Etiology, Symptoms and control) Red rot of sugarcane, Sigatoka diseases of banana, Tikka diseases of ground nut , Black smut of Jawar,Yellow vein mosaic of papaya.

-Strategies for plant diseases management and epidemiology

-Biological control of post harvest diseases- Traditional and Advanced

-Control of plant pathogens by genetic engineering.

UNIT-V Newer approaches in Agricultural Microbiology (08)

-Chitinase & other metabolites, BT, Pseudomonas, Trichoderma

- Integrated plant nutrition through bio fertilizer: PSM, S-SOLUBILISER, N2 fixer

-Phytoremediation- Rhizodegradation

-Rhizosphere engineering

PRACTICAL LAB-II MB-103: FOOD, DAIRY & AGRICULTURE MICROBIOLOGY (Two Credits)

1. Production and estimation of lactic acid by *Lactobacillus Sp*.
2. Extraction and estimation of Diacetyl.
3. Grape wine fermentation.
4. Isolation of food poisoning bacteria from contaminated food products.
5. Extraction and detection of Afla toxin from infected foods.
6. Preservation of Potato / Onion by UV radiation.
7. Production of fermented milk by *Lactobacillus acidophilus*
8. Rapid analytical technique in food quality.
9. Isolation of microorganism from Rhizosphere/ phylloplane
10. Isolation of VAM spore from soil
11. Nodulation of Legume by Rhizobium using Leonard Jar/ Pot assay
12. Isolation and Characterization of Casein from milk

REFERENCES.

1. *Food Microbiology (2nd Edition)* by M. R. Adams & M. O. Moss, (2008) RSC Publishing.
2. *Basic Food Microbiology* by George J. Banwart (1979) Avi Publishing.
3. Food Microbiology : Fundamentals and Frontiers by Dolle
4. *Biotechnology: Food Fermentation Microbiology, Biochemistry and Technology*. Volume 2 by Joshi.
5. *Fundamentals of Dairy Microbiology* by J. B. Prajapati (1995), Akta Prakashan.
6. *Essentials of Food Microbiology* Edited by John Garbult, Arnold International Students Edition.
7. *Microbiology of Fermented Foods.* Volume I & II by Brain J. Wood. Elsevier Applied Science Publication.
8. *Microbiology of Foods* by John C. Aryes, Orwin Mundt, William E. Sandinee , W.H. Freemen and Co.
9. *Dairy Microbiology* Volume I & II by R. K. Robinson (2005), Academic Press London.
10. *Modern food Microbiology* by James M Jay, Martin J Loessner & David A Golden (2005), Springer.
11. *Food Microbiology: Fundamentals and Frontiers*. 2nd Edition by Michael P. Doyle, Larry R. Beuchat and Thomas I. Montville. (Eds.) ASM Publication.
12. *Bacterial Pathogenesis. A Molecular Approach. 2nd Edition* by 2001 by Abigail A. Salyers and Dixie D.Whitt. ASM Publications.
13. *Advances in Applied Microbiology* by D. Pearlman, Acedemic Press.
14. *Modern concepts of Microbiology*, 2nd edition by Kumar, HD and Kumar, S (2004)., Vikas Publishing House Pvt. Ltd., New Delhi (ISBN: 81-259-1000-X).
15. *Manual of Environmental Microbiology*, 2nd edition by Hurst, CJ, Crawford, RL, Knudsen, GR, McInerey, MJ and Stetzenbach, LD (2002) ASM Press, Washington DC (ISBN: 1-55581-199-X).
16. *General Concepts in Integrated Pest and Disease Management* by Ciancio, A and Mukerji, KG (2007), Springer, The Netherlands (ISBN: 978-1-4020-6060-1).
17. *Biochemistry and Molecular Biology of Plants* by Buchnan, BB, Gruissem, W and Jones, RL (2000), IK International Pvt. Ltd., New Delhi (ISBN:81-88237-11-6).
18. *Plant-Microbe Interactions and Biological Control* by Boland, GJ and Kuykendall, LD (1998), Marcel Dekker Inc., NY, USA (ISBN: 0-8247-0043-0).
19. *Biological Control of Plant Diseases* by Chincholkar, SB and Mukerjii, KG (2007), Haworth Press Inc., London (ISBN: 1-56022-328-6).

MB-104: BIOINSTRUMENTATION (Four Credits)

(ELECTIVE)

UNIT –I: **(10)**

Laboratory Instruments: Theory, Principle, Working and applications of: pH meter, Laminar-air flow, Centrifuge machine types and Centrifugation: Differential, Rate Zonal, Isopycnic, Density gradient, Rotor types and Ultra centrifugation. Phase Contrast Microscope; Fluorescent Microscope; Scanning and Transmission Electron Microscopy. Cytophotometery and flow cytometery.

UNIT-II: **(08)**

Chromatography Techniques: Theory, Principle and Applications of Paper Chromatography, TLC, HPTLC, Gel Filtration Chromatography, Ion Exchange Chromatography, Affinity Chromatography, Gas Chromatography, and HPLC.

UNIT–III: **(08)**

Electrophoretic Techniques: Theory, Principle and Applications of Paper Electrophoresis, Poly Acrylamide Gel Electrophoresis (PAGE), Agarose Gel Electrophoresis. Principle and Applications of: Iso-electric Focusing, Immuno Electrophoresis, Enzyme-Linked Immunosorbant Assay (ELISA), Southern, Northern and Western Blotting.

UNIT–IV: **(08)**

Radio-isotopic Techniques : Introduction to Radioisotopes and their Biological Applications, Radioactive Decay–Types and Measurement, Principles and Applications of GM (Geiger Muller) Counter, Solid and Liquid Scintillation Counter, Autoradiography, Radioimmunoassay (RIA), Radiation Dosimeters.

UNIT-V: **(11)**

Molecular Biophysics : Theoretical and experimental methods for determination of size of proteins, Physical nature of non-covalent interactions, Conformational properties of proteins, Ramachandran plot, secondary, super-secondary, tertiary and quaternary structures of proteins, Classification of three dimensional structures of proteins (motifs and fold domains) Protein structure/properties determination.

i. UV Absorption spectra of Macromolecules, X-ray crystallography: Isolation and purification of proteins, crystallization of proteins, instrumentation, acquisition of the diffraction pattern, basic principles of x-ray diffraction, Phase determination

ii. NMR spectroscopy: Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin-spin coupling, Nuclear Overhauser Effect, NMR Applications in Biology

iii. Mass spectroscopy: Principles of operation and types of spectrometers, ionization, Ion transport and ion detection, Ion fragmentation, Combination with chromatographic methods, Biological applications, MALDI-TOF

iv Lim's stereochemical method, Chou-Fasman method, Garnier-Osguthorpe-Robson (GOR) method, Neural networks, Homology based methods. (Concept and introduction)

PRACTICAL LAB-II MB-104: BIOINSTRUMENTATION (Two Credits)

1. Studies on pH titration curves of amino acids/acetic acid and determination of pKa values and Handerson-Hasselbach equation.
2. Separation of bacterial lipids/amino acids/sugars/organic acids by TLC and Paper Chromatography.
3. Study of UV absorption spectra of macromolecules (protein, nucleic acid, bacterial pigments).
4. Quantitative estimation of hydrocarbons/pesticides/organic Solvents/methane by Gas chromatography.
5. Staining of PHB/Nuclear material using Phase contrast microscope.
6. Paper Electrophoresis of proteins.
7. Separation of Proteins/Nucleic acids by Gel electrophoresis.
8. Density gradient centrifugation.
9. Study of macromolecular structures using ball stick models/ computer simulation.

REERENCES:

1. *Biochemistry.* 6th Edition by Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Freeman,New York.
2. *Biophysics: An Introduction* by Cotterill, R. M. J. (2002). John Wiley & Sons, England.
3. *Principles of protein X-ray crystallography* by Drenth, J. (2007). 3rd Ed. Springer,Germany.
4. *Biochemistry.* 3rd edition by Garrett, R. H. and Grisham, C. M. (2004). Brooks/Cole, Publishing Company, California.
5. *Understanding NMR Spectroscopy* by Keeler, J. (2002). John Wiley & Sons, England.
6. *Bioinformatics: sequence and genome analysis* by Mount, D. W. (2001). Cold SpringHarbor Laboratory Press, New York.
7. *Methods in Modern Biophysics.* Second Edition by Nölting, B. (2006). Springer, Germany.
8. *Biophysics* by Pattabhi, V. and Gautham, N. (2002). Kluwer Academic Publishers, NewYork and Narosa Publishing House, Delhi.
9. *Principles and Techniques of Biochemistry and Molecular Biology* by Wilson Keith and Walker John (2005), 6th Ed. Cambridge University Press, New York.
10. *Proteins NMR Spectroscopy: Principles and Practice* by Cavanagh John *et.al.* (1995), Academic Press
11. *Molecular Biophysics: Structures in Motion* by Daune M. and W. J. Duffin (1999), Oxford University Press.
12. *Methods in Modern Biophysics by* Nalting B. and B. Nalting (2003) Springer Verlag
13. *Computational Analysis of Biochemical Systems by* Voit E. O. (2000) Cambridge University Press.
14. *Physical Biochemistry: Applications to Biochemistry and Molecular Biology* by Freilder, D. Freeman, San. Francisco, 1976
15. *Biochemical Techniques: Theory and Practice* by Robyt, John F.; White, Bernard J. Waveland Press, Inc., U.S.A. Published: 1990.
16. *Principles of Instrumental Analysis* by Douglas A. Skoog, F. James Holler, Timothy A. Nieman: (Saunders Golden Sunburst Series) published by Wadsworth Pub Co. 2007
17. *Biophysical chemistry. Principles and techniques* by Upadhyay A, Upadhyay K, Nath N:. Himalaya Publishing House, Mumbai.1997.
18. *Introduction to Radiological Physics and Radiation Dosimetry* by Attix, F.H., , Wiley, New York (1986).
19. *An Introduction to Centrifugation,* by TC. Ford and J.M. Graham (1991). 118 pages. BIOS Scientific Publishers, Ltd. ISBN 1 872748 40 6
20. *Biological Centrifugation* by D. Rickwood, J.M. Graham (2001), Springer Verlag; ISBN: 0387915761
21. *Paper Electrophoresis as a Quantitative Method for serum proteins* by W. P. Jencks, Mera r. Jetton and E. L. Durrum. Biochemistry (Journal) 1955 Vol:60pp 205-215
22. *Electrophoresis of proteins on filter paper* by Henry G. Kunkel and Arne Tiselius. The Journ. of Gen. Physiol. (1951) pp 89-118.
23. *Brocks Biology of Microorganisms* (Eleventh Edition) by Michael T. Madigan, John M. Martinko (2006), Pearson Prentice Hall.

MB - 105: Seminar

(Based on theory paper MB-101-104 & LAB: I & II)

Paper: MB: 105
CREDIT: I
W.E.F.: June 2014

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

CBCS Syllabus for M.Sc. (MICROBIOLOGY)

(Effective progressively from 2014)

SECOND SEMESTER

MB 201: MICROBIAL METABOLISM (Four Credits)

Unit I: Thermodynamics and Bioenergy transduction (08)

Basic aspects of bioenergetics: - Entropy, Enthalpy Modes of ATP generation, Hypothesis of phosphorylation. Chemiosmotic energy transduction, Chemiosmotic theory fundamentals. Basic morphology of Energy transduction membrane (Mitochondria & sub mitochondrial particles, Respiratory bacteria & derived preparation, Chloroplast & thylakoids, Photosynthetic bacteria and chromatophore), Reconstituted System: - pathway of energy transduction.

Unit II: Carbohydrate Metabolism (10)

Major Carbohydrate catabolic pathway & their regulation: (EMP, HMP, ED, PKP, TCA, Methyl glycoxal bypass, Anaplerotic Sequences, Glycerol metabolism, Catabolism of different carbohydrate).

Fermentations: Ethanol, Lactate, Butyrate & Butanol-acetone, Mixed Acid, 2, 3-butandiol, propionate, succinate, acetate, methane and sulphate.

Unit III: Nitrogen circulation on earth & bacteria (11)

Biosynthesis of Amino acid: Oxaloacetate and Pyruvate families, Phosphoglycerate family, α-Oxoglutarate family, Aromatic amino acids and L-histidine synthesis.

Nucleic acid metabolism: Biosynthesis of purine and pyrimidine nucleiotide

Bacterial Nitrification

a) Oxidation of ammonia, hydroxylamine, ETS coupled to

Oxidation of ammonia, dehalogenation of chloroethylene by bacteria

b) Oxidation of Nitrite:

i) Nitrite oxidoreductase

ii) Cytochrome 550(S) & Cytochrome 550 (M)

iii) Cytochrome c oxidase

iv) Reconstitution of nitrite oxidation system

v) Application of nitrifying bacteria.

c) Interaction between ammonia oxidizing & nitrite oxidizing bacteria.

d) Reduction of Nitrite & Nitrogen gas

Biological nitrogen Fixation (*Rhizobia, Azatobactor, Cyanobacteria*)

Unit IV: Lipid Metabolism and Aliphatic, aromatic hydrocarbon catabolism (7)

Microbial degradation of aliphatic hydrocarbon (Monoterminal, Biterminal oxidation).Microbial degradation of aromatic hydrocarbon via catachol, protocatachuate. Metaclevage of catachol, protocatachuate. Homogentisate pathway.

Unit V: Endogenous Metabolism & Microbial growth on C1 compounds. **(10)**

Concept of endogenous metabolism, Type, functions of reserve food material. Microbial synthesis, degradation & regulation of glycogen, poly phosphate, poly β hydroxybutyrate (PHB) production and its futuristic application.

Microbial growth on C1 compound (Cyanide, methanol, methane, methane, methylated amines and carbon monoxide).

PRACTICAL LAB-III MB-201: MICROBIAL METABOLISM (Two Credits)

1) Isolation and identification of Reserve food material (Glycogen / Polyphosphate/ PHB) of *B.megaterium* and *Azotobacter sp.*

2) Demonstration of endogenous metabolism in *B. megaterium* or *E.coli* and their survival under saturation condition.

3) Quantitative estimation of amino acid by Rosen's method.

4) Quantitative estimation of sugar by Sumners method.

5) Quantitative estimation of protein by Folin Lowry /Biuret method.

6) Preparation and analysis of polar lipids from *S. aureus* and *E.coli*.

7) Isolation of autotrophs.

8) Isolation of hydrocarbon degraders.

REFERENCES:

1) *Bacterial metabolism* by Gerhard Gottschalk (second edition), (1986) Springer Verlag New York Inc.
2) *Bacterial metabolism* by H. W. Doelle (Second edition), (2005), Academic press, Inc.
3) *Biochemistry* by A. L. Lehninger,
4) *Biochemistry, Seventh Edition* by Jeremy M. Berg, John L. Tymoczko and Lubert Stryer (Dec 24, 2010), W.H. Freeman & Company.
5) *Chemolithoautotrophic bacteria*: Biochemistry and environmental biology by Tateo Yamanaka, (Jan. 2008). Springer.
6) *Lehninger: Principles of Biochemistry* by Albert L. Lehninger, Michael Cox and David L. Nelson (4 May 2004), W. H. Freeman.
7) *Microbial Biochemistry (Second Edition)* by G.N. Cohen, (2011) Springer Dordrecht Heidelberg London New York.
8) *Principles of Biochemistry (Lehninger Principles of Biochemistry)* by Albert L. Lehninger, Michael M. Cox and David L. Nelson (February 2008), W. H. Freeman.

MB 202: MOLECULAR BIOLOGY AND MICROBIAL GENETICS (Four Credits)

Unit I: DNA Replication and Repair (10)

Unit of replication, enzymes involved in replication origin and replication fork, fidelity of replication, extrachromosomal replicon, DNA damage and repair; types of damage (deamination, oxidative damage, alkylation, pyrimidine dimmers) repair path-methyl directed mismatch repair, very short patch repair, nucleotide excision repair, excision repair, recombination repair, SOS system.

Unit II : Transcription and Processing (08)

Transcription factors and machinery, formation of initiation complex, transcription activators and repressors RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation, structure and function of different types of RNA, RNA transport.

Unit III: Translation and Processing (10)

Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, translational proof-reading, translational inhibitors, post-translational modification of proteins.

Unit IV: Regulation of Gene Expression (08)

Regulation of phage, viruses, eukaryotic and prokaryotic gene expression, operon concept, co-ordinated control of structural gene, stringent response, positive regulation (Arabinose operon), negative regulation (Lac operon), trp operon, regulation by attenuation.

Unit V: Genetic Exchange: Mapping and Recombination (10)

Molecular mechanism of genetic transfer and mapping genes in – transformation, conjugation, transduction and sexduction. F plasmid, structure and function, origin of Hfr and F' strain; transducing phages, P1, T4, μ, λ. Bacterial transposones, homologous and non-

homologous recombination including transposion and side specific recombination. Molecular genetic approaches in bacteria with no natural system.

PRACTICAL LAB-III MB-202: MOLECULAR BIOLOGY AND MICROBIAL GENETICS (Two Credits)

1) Purification of chromosomal/plasmid DNA and study of DNA profile.
   - ☐ Confirmation of nucleic acid by spectral study.
   - ☐ Quantitative estimation by diphenylamine test.
   - ☐ DNA denaturation and determination of Tm and G + C contents.
   - ☐ Agarose gel electrophoresis of DNA.

2) Effect of UV radiations to study the survival pattern of *E.coli* /yeast. Repair mechanisms in *E.coli* / yeast (Dark and Photo reactivation).

3) Isolation of antibiotics resistant mutants by chemical mutagenesis.

4) Ampicillin selection method for isolation of autotrophic mutants.

5) Extraction and purification of RNA from *S.cerevisiae*.

6) Studies on gene expression in *E.coli* with reference to Lac operon.

7) Study of conjugation in *E.coli*.

8) Restriction digestion and Agarose gel electrophoresis of DNA.

9) Generalized transduction in *E.coli* using p1 phage.

REFERENCES:

1. Gene VIII by Benjamin Lewin (2007), Oxford University Press.
2. Microbial genetics by David Freifelder (1987) Jones and Bartlett.
3. Microbial Genetics by Stanley R. Maloy, John E. Cronan, David Freifelder (1994) Jones and Bartlett Publishers.
4. Modern Microbial Genetics, 2nd Edition. Uldis N. Streips, Ronald E. Yasbin (2002), Wiley.
5. Molecular biology of the gene, 4th Edition, Vol. I, by James D. Watson, Nancy H. Hopkins, Jeffrey W. Roberts, Joan Argetsinger Steitz and Alan M. Weiner (2005) The Benjamin/Cummings Publ. Co.
6. Molecular Genetics of Bacteria by Jeremy W. Dale, Simon F. Park (2013), John Viley & Sons, Ltd.
7. Organization of Prokaryotic Genome by Robert Charlebois (1999).
8. Recombinant DNA by James D. Watson (1992), W. H. Freeman.

MB 203: BIOPROCESS ENGINEERING (Four Credits)

Unit-I: Introduction to Industrial Bioprocess Engineering (10)

Definition of bioprocess engineering, bioprocess engineer, biotechnology and bioprocess engineering, approach of biologist and engineers towards research, regulatory constraints of bioprocess.

Batch growth (growth pattern and kinetics in batch culture, environmental factors affecting growth kinetics), Monod's equation, continuous culture, chemostat and turbitostat (construction and working), mixed culture in nature, industrial utilization of mixed culture.

Unit-II : Bioreactors (08)

Design of basic bioreactor, bioreactor configuration, design features, individual parts, baffles, impellers, foam separators, spargers, culture vessel, cooling and heating devices, probes for on-line monitoring computer control of fermentation process, measurement and control of process.

Ideal batch reactor, ideal continuous flow stirred tank reactor, packed bed reactor bubble column reactor, fluidized bed bioreactor, Trickle bed reactor (Their basic construction, working, and distribution of gases).

Unit II: Mass Transfer and Sterilization (10)

Transport phenomena in bioprocess system: Gas liquid mass transfer in cellular systems, basic mass transfer concept, Rate of metabolic oxygen utilization, Determination on oxygen transfer rates, determination of Kla, Heat transfer, aeration / agitation and its importance.

Sterilization of bioreactors, nutrients, air supply, product and effluents, process variable and control, scale – up of bioreactor.

Unit-IV: Upstream processes (08)

Inoculum development, formulation of production media, sterilization of media, maintenance of stock culture, scale up of the process from shake flask to industrial level.

Growth of culture in fermentor , choosing cultivation methods , Modifying batch and continuous reactors, immobilization cell systems, active and passive immobilization , solid state fermentation process.

Unit-V: Down Stream Process (10)

Downstream processes: Introduction, Recovery of particulates filtration ,centrifugation, sedimentation, emerging technologies for cell recovery, product isolation, extraction, solvent extraction, aqueous two phase system, sorption, precipitation, reverse osmosis, ultra filtration.

Product recovery traits: Commercial enzymes, Intracellular foreign proteins from recombinant *E. coli*, polysaccharide and biogum recovery, antibiotic, organic acids, ethanol, single cell protein.

PRACTICAL LAB-IV MB-203: BIOPROCESS ENGINEERING (Two Credits)

1. Isolation of Industrially important microorganisms for microbial processes.
2. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer.
3. Cultivation and determination of growth curve of bacteria *E. coli* in batch reactor/flask.
4. Continuous cultivation of bacteria in laboratory (Chemostat)
5. Study of mixed culture and its comparison with the pure culture (growth pattern).
6. Designing of batch bioreactor.
7. Determination of Oxygen Absorption rate as a function of flack size.
8. Determination of Oxygen Absorption rate as a function of RPM on shaker.
9. Determination of KLa.
10. Fermentative production and recovery of amino acid (Glutamic acid).
11. Fermentative production and recovery of alkaline protease.
12. Estimation of amino acids.
13. Estimation of Alkaline protease.

REFERENCES:

1. *Biotechnology : A text Book of Industrial Microbiology* by Cruger and Cruger, (1997)
2. *Biochemical Engineering Fundamentals* by James E .Bailey and David F Ollis (2003) McGraw Hill Publication.
3. *Microbial Technology, Vol I and II* by Peppler and Perlmen (2007), Academic Press.
4. *Bioprocess engineering basic concepts, 2nd edition* by Shuler and Fikret Kargi (2006) Prentice Hall publication.
5. *Principles of fermentation Technology* by Peter F. Stanbury, Allan Whitaker, Stephen J. Hall (1995), Butterworth-Heinemann.

MB 204: ENZYME TECHNOLOGY (Four Credits)

(ELECTIVE)

Unit I: Extraction and Purification of Microbial Enzyme. (10)

Importance of enzyme purification, different sources of enzyme. Extracellular and Intracellular enzyme. Physical and chemical methods used for cell disintegration ,enzyme fractionation by precipitation (using temperature, salt ,solvent, pH etc.), liquid-liquid extraction, ionic exchange , gel electrophoresis , affinity chromatography and other special purification methods. Enzyme crystallization technique. Criteria of purity of enzyme. Pitfalls in working with pure enzyme.

Unit –II- Enzyme Kinetics and Enzyme Inhibition. (10)

Enzyme kinetics- Steady state kinetics, Brigs Haldane equation, Michaelis Menten equation, Irreversible, Reversible, competitive, Noncompetitive and Uncompetitive Inhibition with suitable examples and their kinetics studies. Allosteric regulation, types of allosteric regulation and their significance in metabolic regulation and their kinetics study (Hills equation).

Unit-III: Immobilization of Microbial enzymes. (08)

Methods viz. adsorption, covalent bonding, entrapment and membrane confinement, Analytical, therapeutic and industrial application. Properties of Immobilization enzyme.

Unit-IV: Enzyme as a biocatalyst and Enzyme Engineering (10)

Structure of active sites, Role of Ionizable group in catalysts, study on vitamins and co-enzymes:- Structure and functions with suitable examples. Metallo enzymes and metal ions as co-factors and enzyme activators. Chemical modification and site directed mutagenesis to study structure –function relationship of industrially important enzyme.

Unit-V: Application of Microbial enzymes. (08)

Microbial enzymes in textiles, leather, wood industries and detergent. Enzymes in clinical diagnosis. Enzyme sensors for clinical processes and environment analysis. Enzymes as therapeutic agents. Extremozymes, Solventogenic enzymes.

PRACTICAL LAB-IV MB-204: ENZYME TECHNOLOGY (Two Credits)

1. Microbial production, Extraction, Purification and confirmation of alpha amylase / Lipase.
2. Determination of efficiency of enzyme purification by measuring specific activity at various stages viz. Salt precipitation, dialysis, electrophoresis etc.
3. Studies on enzyme activation and inhibition of extracted alpha amylase / Lipase. Effect of heavy metal ions, Chelating agents activators and inhibitors.
4. Immobilization of cells and enzyme using sodium alginate and egg albumin and measurement of enzyme activity (amylase / Lipase).
5. Studies on impact of immobilization of enzyme activity in terms of temperature tolerance and Vmax and Km using various forms of alpha amylase/ Lipase.
6. Determination of molecular weight of enzyme using PAGE technique.
7. Preparation of biosensors of urease and determination of its activity.

References:

1. *Advances in Enzymology* by Alton Meister (1996), Interscience Publishers.
2. *Allosteric enzymes – kinetic Behaviour* by B.I Kurganov (1982) John Wiley and sond Inc., New York.
3. *Biology enzymes in biotechnology* by H.J.Rehm and G. Reed Verlag (1983) VCH Publishers. New York.
4. *Enzymes as Drugs* by John S. Hoilenberg and Joseph Roberts (2001). John Wiley and Sons New York.
5. *Enzymes* by Dixon, M., and E. C. Webb, 3rd edition, (1980), Academic Press. New York.
6. *Enzymology by palmer*
7. *Hand Book of Enzyme Biotechnology* by Wiseman (1985), Ellis Horwood.
8. *Methods in Enzymology* by W. A. Wood (1980) Academic Press New York.
9. *Methods in Enzymology. Volume 22- Enzyme purification and related techniques* by William B. Jakoby. Academic press, New York.
10. *Methods of Enzymatic Analysis* by Hans Ulrich. Bergmeyer (1974) Verlag Chemie.
11. *Topics in enzymes and fermentation biotechnology* by L.N.Weiseman, John wiley and Sons.

MB - 205: Seminar

(Based on theory paper MB-201-204 & LAB: III & IV)

Paper: MB: 205
CREDIT: I
W.E.F.: June 2014

Swami Ramanand Teerth Marathwada University, Nanded.

Model Question Paper Pattern (Theory) with effective from 2014
Class: **M. Sc. First Year** (Semester I & II) CBCS Pattern
Subject: MICROBIOLOGY
Papers: **MB-101 to 104** and **MB-201 to 204**

Time: Three Hrs **Max. Marks: 75 (ESE)**

NB: All questions are compulsory.

Q. 1: Essay Type Question (On Unit I)	15 Marks
OR	
a) Short Question	8 Marks
b) Short Question	7 Marks
Q. 2: Essay Type Question (On Unit II)	15 Marks
OR	
a) Short Question	8 Marks
b) Short Question	7 Marks
Q. 3: Essay Type Question (On Unit III)	15 Marks
OR	
a) Short Question	8 Marks
b) Short Question	7 Marks
Q. 4: Essay Type Question (On Unit IV)	15 Marks
OR	
a) Short Question	8 Marks
b) Short Question	7 Marks
Q. 5: Essay Type Question (On Unit V)	15 Marks
OR	
a) Short Question	8 Marks
b) Short Question	7 Marks

Swami Ramanand Teerth Marathwada University, Nanded.

Model Question Paper Pattern (Practical) with effective from 2014
Class: **M. Sc. First Year** (Semester **I** & **II**) CBCS Pattern
Subject: MICROBIOLOGY
Practical Paper LAB-I (Based on theory Papers: MB-101 to 102) (Morning) &
LAB-II (Based on theory papers: MB-103 to 104) (Evening)
For two Consecutive days for each batch

Time: Four Hrs (Morning: 09amTo 1pm &Evening: 2 pm To 6 pm) **Max. Marks: 75 (ESE)**

Q. 1: Long Experiment (MB-101/MB-103)	15
Q. 2: Long Experiment (MB-102/MB-104)	15
Q. 3: Short Experiment (MB-101/MB-103)	10
Q. 4: Short Experiment (MB-102/MB-104)	10
Q. 5: Record Book	10
Q. 6: Viva Voce	15

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Swami Ramanand Teerth Marathwada University, Nanded.

Model Question Paper Pattern (Practical) with effective from 2014
Class: **M. Sc. First Year** (Semester **I** & **II**) CBCS Pattern
Subject: MICROBIOLOGY
Practical Paper: LAB-III (Based on theory Papers: MB-201 to 202) (Morning) &
LAB- IV (Based on theory papers: MB-203 to 204) (Evening)
For two Consecutive days for each batch

Time: Four Hrs (Morning: 09amTo 1pm &Evening: 2 pm To 6 pm) **Max. Marks: 75 (ESE)**

Q. 1: Long Experiment (MB-201/MB-203)	15
Q. 2: Long Experiment (MB-202/MB-204)	15
Q. 3: Short Experiment (MB-201/MB-203)	10
Q. 4: Short Experiment (MB-202/MB-204)	10
Q. 5: Record Book	10
Q. 6: Viva Voce	15