REVISED

GENERAL INSTRUCTIONS
and
COURSE CURRICULUM

FOR

(PG Teaching Program in Microbiology)

M.Sc. MICROBIOLOGY

(Effective from November, 2021)

DEPARTMENT OF MICROBIOLOGY

HIMACHAL PRADESH UNIVERSITY

(NAAC Accredited "A" Grade University)

SUMMERHILL – SHIMLA – 171005 (HP) – India

www.hpuniv.ac.in/micro

Annexure-I

M.Sc. MICROBIOLOGY PROGRAMME

GENERAL INSTRUCTIONS/GUIDELINES FOR EXECUTION OF CURRICULUM

1. The M.Sc. Microbiology program will be of two years duration spread over four semesters.
2. **There will be sixteen (16) courses in *M.Sc. Microbiology* Programme**. In the 1st, 2nd and 3rd semesters, there will be five courses each, and in 4th semesters, there will be one course. However, in fourth semester there will also be research work. Course-MMB-402 will consist of Dissertation, Seminar, and viva-voce. Additionally, course MMB-403 will consist of internship in any Industry/Research institute/Medical institute for duration of 2-4 weeks any time during the course but evaluation will be done in 4th semester only.
3. The distribution of marks in each course for theory, practical and internal assessment will be as per details given in the *OUTLINE OF COURSES FOR M.Sc. MICROBIOLOGY*.
4. The split for internal assessment except Course MMB 401 and Elective course MMB-EL-301-308 will be: i)Two internal assessment tests of 10 marks each (20 Multiple choice questions, each question shall carry 0.5 mark in each test) in each course. Remaining 10 marks will include class seminar (5 marks) and class attendance (5 marks). The criteria to be followed shall be: i) up to 75% lectures including condonation of lectures as per ordinances:zeromark,ii)withoutcondemnationoflecturesupto75%:1mark;iii)76-80%lectures:2marks, iv)81-85% lectures: 3 marks; v) 86-90% lectures: 4 marks; vi) 91% and above lectures: 5 marks. However, for the Course-MMB 105 (Biostatistics, Computer and Bioinformatics), MMB 401 and Elective courses (MMB-EL-301-308), the internal assessment will be of 20 marks. A total of two Internal Assessment tests of 7.5 marks each (15 MCQs, each question will carry 0.5 marks in each Internal Assessment test) will be held in a semester and remaining 5 marks will be for the class attendance as per criterion mentioned above.
5. For internal assessment, the concerned teacher will examine the students in his/ her subject by giving multiple choice questions (MCQ of 0.5 mark each) covering the syllabus/ topics taught in the classes. The Chairman of the Department/ Coordinator of the programme will notify the date sheet for Internal Assessment test(s) at the beginning of semester/ academic calendar. In case a student is absent in the internal assessment test, the student will explain in writing the reason for absence to the Chairman of the Department/ Coordinator of the programme. Such case(s), if any will be discussed in the Departmental Council/ Staff Council and if it finds the reason given by the student valid, it will recommend to the Chairman/ Coordinator of the programme to allow the student to sit in such test separately.
6. The candidate who regularly attends teaching/ practical classes and maintains 75% attendance in each of the courses/ practicals shall be permitted to sit in the semester examinations.
7. Any candidate who intends to participate in intra-university or inter-university cultural/ sports/ extracurricular function(s) shall get her/ his name recommended by the Chairperson/ Coordinator Microbiology Programme for being considered for any such participation(s) and benefit(s) if any, thereof.
8. The project work will be in the specialized area of the Microbiology. The research/ dissertation work (Course MMB-402) will start from the 3rd semester. The students will submit the dissertation by the due date as fixed by the Examination Branch. The Departmental Council will evaluate the dissertation and will conduct seminar and viva-voce examination of the students. If the Coordinator of the programme feels, he may invite an External Expert for evaluation of the dissertations. The evaluation of the dissertation and seminar/ viva voce will be of 150 and 100 marks, respectively.
9. The admission to M.Sc. Microbiology programme of Himachal Pradesh University at campus as well as admission to M.Sc. Microbiology programme offered by institutions affiliated to Himachal Pradesh University will be through a Combined Entrance Examination conducted by Himachal Pradesh University Shimla or as decided by Himachal Pradesh University from time to time.
10. Eligibility for admission will be bachelor's degree under 10+2+3 pattern of Education in Sciences with any of the subjects *i.e.*, Microbiology, Biochemistry, Biotechnology, Genetics and Molecular Biology, Botany or Zoology or MBBS/ BVSc from any Institute/ University recognized by the Himachal Pradesh University, Shimla/ University Grant Commission, New Delhi with at least 50% marks or a Degree of a University recognized as equivalent by the Vice-Chancellor for the purpose.
11. The tuition fee and other monthly/ annual charges will be as per University rules.

OUTLINE OF COURSES FOR M.Sc. MICROBIOLOGY

***** The Departmental Council will evaluate the dissertation and will conduct seminar and viva-voce examination of the students.

Course No.	Title of Course	Marks			
		Theory	Practical	Internal assessment	Total
Semester I					
MMB-101	General Microbiology	80	40	30	150
MMB-102	Biochemistry	80	40	30	150
MMB-103	Cell and Molecular Biology	80	40	30	150
MMB-104	Microbial Physiology and Metabolism	80	40	30	150
MMB-105	Biostatistics, Computer & Bioinformatics	80	40	30	150
Total Marks in Semester I		**400**	**200**	**150**	**750**
Semester II					
MMB-201	Instrumental Methods of Analysis	80	40	30	150
MMB-202	Immunology and Immunotechnology	80	40	30	150
MMB-203	Mycology and Phycology	80	40	30	150
MMB-204	Medical Microbiology	80	40	30	150
MMB-205	Virology	80	40	30	150
Total Marks in Semester II		**400**	**200**	**150**	**750**
Semester III					
MMB-301	Environmental Microbiology	80	40	30	150
MMB-302	Industrial Microbiology	80	40	30	150
MMB-303	Food Microbiology	80	40	30	150
MMB- 304	Enzyme Technology	80	40	30	150
Elective (any-one)		80	-	20	100
MMB-EL-301	Recent Diagnostic Techniques in Microbiology				
MMB-EL-302	Microbial Genomics & Proteomics				
MMB-EL-303	Microbes in Sustainable Agriculture and Development				
MMB-EL-304	Parasitology				
MMB-EL-305	Management of Human Microbial Diseases				
MMB-EL-306	Microbial Diagnosis in Health Clinics				
MMB-EL-307	Microbial Quality Control in Food and Pharmaceutical Industries				
MMB-EL-308	IPR/ Bioethics and Biosafety				
Total Marks in Semester III		**400**	**160**	**140**	**700**
Semester IV					
MMB-401	Research Methodology	80	-	20	100
MMB-402	Dissertation	-	150	-	150
	Seminar and Viva-Voce	-	50	-	50
MMB-403	Internship in any Industry/Research Institute/Medical Institute for duration of 2-4 weeks any time during the Course, but the evaluation will be done in 4th Semester	-	100	-	100
Total Marks in Semester IV		**80**	**300**	**20**	**400**
Grand Total (Semester I-IV)		**1280**	**860**	**460**	**2600**

COURSE No.: MMB-101	GENERAL MICROBIOLOGY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **11**

Introduction to Microbiology: Scope and history of Microbiology: Abiogenesis, Spontaneous generation and germ theory of disease, Contributions of Antony Van Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Edward Jenner, Winogradsky, Beijerinck, Alexander Fleming and Waksman.

Characteristic features of bacteria, archaea, fungi, parasites, algae, and viruses. Beneficial applications of microbes: Human microflora, Prebiotics and Probiotics.

Unit II **12**

Bacterial Cell: Morphology and ultrastructure of bacteria, structure and properties of cell wall – Gram positive bacteria, Gram negative bacteria and archaebacteria, L-forms-cell wall synthesis, antigenic properties-capsule (Types, composition and function), cell membrane, ultrastructure and functions of flagella, cilia, pili, gas vesicles, chromosomes, carboxysomes-magnetosomes and phycobilisomes, cytoplasmic inclusions, ribosomes and nucleoid, Endospore structure, properties, germination, sporulation and morphogenesis, dormancy, bacterial reproduction.

Unit III **12**

Microbiological media and cultivation of microorganisms: Cultivation of bacteria, cell division, culture media used, growth curve, generation time, asynchronous, synchronous culture, measurement of growth. Microbial cultures: Concept of pure culture, Methods of pure culture isolation. Preservation and Maintenance of Microbial Cultures: Repeated subculturing, preservation at low temperature, sterile soil preservation, mineral oil preservation, deep-freezing and liquid nitrogen preservation, freeze-drying (lyophilization). Control of microorganism by physical and chemical agents.

Unit IV **10**

Classification of microorganisms: Introduction, Haeckel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese, Basis of microbial classification, Classification, and salient features of bacteria according to the Bergey's manual of determinative bacteriology, cyanobacteria, prochloron and cyanelles

Biosafety: Introduction, Risk assessment, Primary containment for biohazards, Biological safety cabinets, Biosafety levels of specific microorganisms, Biosafety guidelines: Government of India.

Suggested books [Latest edition]

1. Bergey's Manual of Systematic Bacteriology: P.H.A Sneath, N.S Mair, M.Elizabeth.
2. Stryer L. Biochemistry: W.H. Freeman Company, NewYork
3. General Microbiology. Macmillan Education Ltd.
4. Fundamental Principles of Bacteriology: Stainer R Y, Ingharam JL, Wheelis ML, Painter PR
5. Biology of Microorganisms. Prentice Hall Int. Inc.: A.J. Salle, Brock T.D, MadiganM.T,
6. Microbiology. Mc Graw Hill: Pelczar M.J, Chan E.C.S, Kreig N.R.
7. Topley and Wilson's principles of Bacteriology, Virology, and Immunity. Topley, W.W.C., Wilson, S.G.S. and Parker, M.T. Edward Arnold, London.
8. Fundamentals of Mycology. Burnett, J.H. St. Martin's Press, New York.
9. Algae and fungi. Alexopoulos, C.J. and Bold, H.C. MacMillan Press, London.
10. Algae. Graham, L.E. and Wilcox, L.W. Prentice Hall, New Jersey.
11. Textbook of algae. Sharma, O.P. Tata McGraw-Hill Education, New Delhi.
12. Introductory Phycology. Kumar, H.D. East-West Press, New Delhi.
13. A Textbook of Microbiology, S. Chand & Com., Ram Nagar, New Delhi.
14. Practical Microbiology, S. Chand & Com., Ram Nagar, New Delhi.
15. Vedic Microbiology- A Scientific Approach, Dubey R.C. Motilal Banarasidas International, Delhi.

List of practicals

1. Microscopy, Microscope and its operations, components, Microscope adjustments, Light sources, microscopic measurements, calibration: Types of microscope available, theory of various types of microbes under phase contrast, dark field and fluorescence.
2. Preparation of glassware, washing, sterilization techniques, wet heat, dry heat, filter types, laminar flow chamber types, CDC, safety levels.
3. Preparation of culture media, nutritional needs of microbes, dehydrated, selective, differential, autotrophic, heterotrophic. Culture techniques, adjustment of pH, buffers, pure culture techniques, preparation of slants, Sub-culturing.
4. Isolation and identification of bacteria and fungi.
5. Microbial growth measurements, cell count, turbidity measurements, percentage transmission, Optical density, serial dilution, standard plate count.
6. Morphological, nutritional and cultural characteristics of bacteria and identification of microbes: types of dyes, preparation, staining techniques, Gram, capsule, negative, flagella, spore and nuclear.
7. Drug susceptibility testing by various methods.

COURSE No.: MMB-102	BIOCHEMISTRY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **11**

Functional diversity of proteins, amino acids as building blocks of proteins, their structure, classification and chemical properties, determination of amino acid sequence of a protein, simple peptides, structure of peptide bond, organizational levels of protein structure. Properties of proteins: simple, conjugated, fibrous and globular proteins. General reactions of amino acids, catabolic aspects of amino acids. Assimilation of NH_3 (including urea cycle). Enzymes: Their chemical nature, coenzymes, cofactors and prosthetic groups, classification, units of enzyme activity, factors affecting enzyme activity.

Unit II **12**

Carbohydrates: their classification, structure, and properties. Glycolysis, TCA cycle, Pentose phosphate pathway, Gluconeogenesis, ETC and oxidative phosphorylation. Chemistry and biochemical roles of water and fat-soluble vitamins and their coenzymes. Deficiency diseases of vitamins.

Unit III **11**

Structure and properties of nucleic acid bases, nucleosides and nucleotides, biologically important nucleotides, Physical and chemical properties of RNA/DNA including DNA denaturation. Chemical and enzymatic hydrolysis of nucleic acids. Biosynthesis & degradation of purine and pyrimidine nucleotides. Biosynthesis of deoxyribonucleotides. Structure, properties, and classification of porphyrins. Porphyrin biosynthesis & degradation.

Unit IV **11**

Fatty acids as building blocks of most lipids, their structure, nomenclature and properties, classification of lipids, General structure and function of major lipid subclasses: Acylglycerols, phosphoglycerides, sphingolipids, glycosphingolipids, terpenes, steroids, Prostaglandins, catabolism of Fatty acids, β-, α-, ω- oxidation, oxidation of unsaturated fatty acids. Ketone Bodies: their formation and utilization. Biosynthesis of saturated and unsaturated fatty acids, triacylglycerol, and cholesterol.

Suggested books [Latest edition]

1. Principles of Biochemistry: AL Lehninger, DL Nelson and MM Cox.
2. Biochemistry: Lubert Stryer.
3. Biochemistry: Zubay.
4. Biochemistry: J Stenesh.
5. Outlines of Biochemistry: Conn and Stumpf
6. Practical Biochemistry: Plummer

List of practicals

1. Qualitative tests for proteins and amino acids.
2. Qualitative tests for carbohydrates.
3. Quantitative estimation of proteins by Lowry's and Bradford method.
4. Quantitative estimation of RNA by Orcinol method.
5. Quantitative estimation of DNA by Diphenylamine method.
6. Quantitative estimation of carbohydrates by Anthrone method.
7. Quantitative estimation of total cholesterol in serum.
8. Assay of Salivary amylase.
9. To study the U.V. absorption of nucleic acids.
10. To find the saponification number of fat.
11. Separation of amino acids and sugar by paper and thin layer chromatography (TLC).
12. Agarose gel electrophoresis of DNA, PAGE and SDS PAGE proteins.

COURSE No.: MMB-103	CELL AND MOLECULAR BIOLOGY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **12**

Membrane structure and function. Structural organization and function of cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, cytoskeleton. Structure and organization of DNA, genes, chromatin and chromosomes, super-helicity in DNA and its topological properties, DNA denaturation and renaturation, repetitive DNA, COT-curve, C-value paradox. Cell division and cell cycle (Mitosis and meiosis, their regulation, steps in cell cycle, regulation, and control of cell cycle).

Unit II **11**

DNA replication (enzymes involved, replication origin and replication fork, fidelity of replication, DNA damage and repair mechanisms, genetic recombination (homologous and site-specific), transformation, conjugation, and transduction. RNA synthesis and processing (transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure, and function of different types of RNA, RNA transport), Overview of Plasmid, Phagemid and Cosmid.

Unit III **11**

Basic features of the genetic code. Protein synthesis and processing (Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post- translational modification of proteins), Different types of mutation, Control of gene expression at transcription and translation level (regulating the expression of prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing). Operon concept, lac operon, tryptophan operon.

Unit IV **11**

Cell signaling Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways. General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins. Cancer genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis.

Suggested books [Latest edition]

1. Molecular Biology of Cell: Bruce Albert et. al. (Tylor and Francis Inc.)
2. Lewin Genes XIII: Jones and Barlett Publisher, Inc.
3. Molecular Cell Biology: Lodish et al. WH Freeman.
4. Karp's Cell and Molecular Biology: Gerald Karp, John Wiley Publications.
5. Molecular Biology of the Gene: James D. Watson, Pearson Education.

List of practicals

1. UV-absorbance of nucleic acids (hyper and hypo chromic effect) and quantification of nucleic acids and proteins.
2. To determine the melting temperature of DNA.
3. To study different stages of mitosis by onion root tip squash method.
4. To study different stages of meiosis using permanent slides.
5. To study multiple alleles in human (Blood Groups).
6. To study multiple alleles in plants(*Trifolium*).
7. To study cytoplasmic and nuclear inheritance on the basis of phenotypic characters.
8. Isolation of DNA from *E.coli.*
9. Extraction of DNA from plant
10. Extraction of DNA from human blood.
11. Induction of β-galactosidase strain of *E.coli*.
12. Effect of protein synthesis inhibitors on the activity of β-galactosidase.
13. cDNA synthesis and real time PCR (qPCR).
14. DNA sequencing (demonstration only).
15. NCBI BLAST search and Primer design.
16. Multiple Sequence Alignment and Phylogenetic analysis using MEGA.

COURSE No.: MMB-104	MICROBIAL PHYSIOLOGYAND METABOLISM
Maximum marks: 80	**Teaching hours: 45**
Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks	

Unit I **10**

Nutritional Categories of microorganisms based on carbon, energy and electron sources, Metabolite Transport: Diffusion, Passive and facilitated, Primary active and secondary active transport, Group translocation (phosphotransferase system), electro neutral transport, transport of Iron

Unit II **12**

Photosynthesis: General characteristics of photosynthetic bacteria, Brief account of photosynthetic and accessory pigments, Mechanism of oxygenic and anoxygenic photosynthesis, Dark Reaction: Fixation of Co_2, Calvin Cycle, C3-C4 pathway, Photosynthetic electron transport system, Photophosphorylation, Inorganic metabolism: Characteristic features of chemolithotrophs, Mechanism of sulphur, iron, hydrogen and nitrogen oxidations, Mechanism of energy generation in methylotrophs and methanogens. Nitrogen metabolism: Nitrogen fixation (Characteristics of nitrogen fixing bacteria, biochemistry of nitrogenase complex, nitrogenase types, functions of *nif* genes, symbiotic nitrogen fixation and regulation of nitrogenase)

Unit III **11**

Microbial growth, bacterial generation time, growth curve and growth kinetics, specific growth rate, batch and continuous culture, Monoauxic, Diauxic and synchronized growth curves. Factors affecting microbial growth, Methods of growth measurement : cell mass and metabolic activity, Communication mechanisms in prokaryotes: cell signaling, Intercellular and Intracellular signaling, cross kingdom talk and Quorum sensing

Unit IV **12**

Respiration (aerobic and anaerobic) and fermentation. Fermentation: Glucose, acetic acid, lactic acid, butyric acid, propionic acid, and mixed acid fermentation. Bacterial transport system: Donnan equilibrium, Thermodynamics of various transport systems, Osmosis, Plasmolysis, Osmotic pressure of electrolyte and non-electrolyte transport protein, PEP-PTS system in relation to catabolite repression, ABC transporter, Protein secretion pathways in bacteria, Osmotic stress and osmoregulation, Oxidative stress and its regulation, pH stress and acid tolerance response, Thermal stress and heat shock response

Suggested books (Latest edition)

1. Textbook of Microbiology by M. Burrows; General Microbiology by Stainier, Deudroff and Adelberg.
2. Microbiology by Pelczar MJ, Ried RD and Charu ECS.
3. Microbial Physiology by Moat; Brock's Biology of microorganisms by Madigan, MT et al
4. Photosynthesis by Dewlin and Barker; Laboratory Experiments in Microbiology by Gopal Reddy et al
5. General Microbiology by Stainier, Deudroff and Adelberg
6. Prokaryotic development. Brun, YV and Shimkets, LJ. ASM Press, Washington, D.C.
7. Advances in microbial physiology. Rose, A.H. Academic Press, New York.
8. Physiology and biochemistry of prokaryotes. David, W., Drummond, J.T. and Fuqua, C.
9. Microbial physiology and metabolism. Caldwell, D. R. Star Publishers, California.
10. Biology of the prokaryotes. Lengeler, J.W., Drews, G. and Schlegel, H.G. Blackwell Science, New York.
11. A Textbook of Microbiology, S. Chand & Com., Ram Nagar, New Delhi.

List of practicals

1. Preparation of microbiological media. Autotrophic media, minimal media, basic media, enriched media, enrichment media, differential media.
2. Isolation and cultivation of autotrophic microbes.
3. Microbial growth experiments - Viable count of growing cells.
4. Determination of microbial growth by turbidimetric methods.
5. Study of bacterial growth curve.
6. Methods studying microbial respiration.
7. Nitrogen metabolism- Nitrate reduction test.
8. Effect of temperature and pH on bacterial growth.
9. Culturing methods of microbes - slant and stab cultures, tube culture, flask cultures, shake flask cultures.
10. Isolation of free living nitrogen fixing bacteria.
11. Isolation of *Rhizobium* from root nodule.
12. Anaerobic culturing methods - anaerobic jar and its use, pyrogallol method, thioglycolate media culturing, anaerobic glove box and its application.

COURSE No.: MMB-105	BIOSTATICS, COMPUTER AND BIOINFORMATICS
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **12**

Population, samples and sampling procedures, variables, variations and frequency distributions, measures of central tendency and dispersion, element of probability, Gaussian or normal distribution, binomial distribution, Poisson distribution, t-distribution, F-distribution and Chi-square distribution, correlation, and linear regression. Normal curve test, t- test, F-test, ANOVA, analysis of covariance, Chi-square test, and confidence intervals. Types of data, Tools for data collection: Observation, interview schedule, questionnaire, Data Analysis: Coding, categorizing, classifying and analysis, use of computers in analysis, SPSS.

Unit II **16**

Computer basics. Concept of Operating systems: Windows and UNIX. Hardware, software, Computer Network concepts. Word processing using MS-Word, formatting the document, tables, mail merge and spell check. Spreadsheets basics with MS Excel, numerical and formula entries, basic mathematical and statistical functions, graphical representation of data. Introduction to internet use and search engines: www, HTML, URLs, browsers: Netscape (opera), Explorer, Search engines: Google. Introduction to data structures and database concepts.

Unit III **10**

PubMed, Sequence information sources (Structure and use on web): EMBL, GENBANK, Entrez, and UniGene. Protein information sources (Structure and use on web): PDB, SWISS-PROT and TrEMBL; Sequence and phylogeny analysis: Detection of open reading frames (ORF's), gene identification and prediction, method of gene family identification and outline of sequence assembly.

Unit IV **07**

Mutation matrices, pairwise alignments, introduction to BLAST (using it on web and interpreting results), multiple sequence alignment, phylogenetic analysis. Molecular modeling: introduction, dynamic simulation, conformational search, molecular modeling packages (Chem3D, HyperChem), protein modeling, structure prediction and molecular docking.

Suggested books [Latest edition]

1. Advanced Biology Statistics by A. Edmondson and D. Druce: Oxford University Press.
2. Biostatistics : A foundation for Analysis in Health Sciences by W. Danial : John Wiley and Sons Inc.
3. Statistical methods: S. P Gupta.
4. Mendiratta, P. Rastogi, Prentice Hall of India Private Ltd
5. Bioinformatics: A practical guide to the analysis of genes and proteins, Ed. Baxvains.
6. Molecular Evolution: A phylogenetic approach: ROM and Holmas EC, Blackwell Science
7. Bioinformatics: Sequences, structure and databanks: Des Higgins and Willie Taylor, Oxford University Press
8. Computer today: Suresh K Basandra, Galgotia Publications Pvt Ltd.
9. Computer fundamentals: PK Sinha, BPB Publications.

List of practicals

1. Word processing commands using MS-Word.
2. Mail Merge facility of MS-Word.
3. Graphical presentation using MS-Excel.
4. Creation of Data tables in MS Access and simple queries with SQL.
5. Online Bibliographic and patent search.
6. Offline Bibliographic search using Derwent Biotechnology Abstracts.
7. Sequence information resource
8. Understanding and using on web: EMBL, GenBank, Entrez, UniGene
9. Protein information resource
10. Understanding and using on web: PDB, SWISS-PROT, TrEMBL using BLAST and interpretation of results, multiple sequence alignment using Clustal-W.

COURSE No.: MMB 201	INSTRUMENTAL METHODS OF ANALYSIS
Maximum marks:80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **12**

Centrifugation: Concept of centrifugation, sedimentation coefficient, differential, rate zonal and isopycnic centrifugation, Analytical and preparative ultracentrifuges, k and k' factor, derating of rotor, special purpose rotors.

Chromatography: Paper, TLC, Gas chromatography, gel filtration, ion-exchange chromatography, reverse phase chromatography, hydrophobic interaction, affinity chromatography and HPLC, HPTLC, Liquid Chromatography-mass spectrometry (LC-MS)

Unit II **12**

Electrophoresis: Paper and gel electrophoresis, Ferguson plots, Immuno-electrophoresis, isoelectric focusing, two-dimensional electrophoresis, capillary electrophoresis, western blotting and pulse field gel electrophoresis, Denaturing gradient gel electrophoresis (DGGE).

Spectrophotometry: UV & Visible spectroscopy, Spectro-fluorimetry, atomic absorption and atomic emission spectroscopy. ORD and Circular dichroism, Florescent activated cell sorter (FACS).

IR spectroscopy and NMR Spectroscopy, Matrix assisted laser desorption ionization time of flight–mass spectrometry (MALDI-TOF MS).

Unit III **10**

Principle of microscopy, limit of resolution, Electron Microscopy: Transmission and Scanning Electron Microscopy, Concept of Tunneling Electron Microscopy and Atomic Force Microscopy.

PCR, rRT-PCR, DNA Sequencer, Protein sequencer.

Unit IV **11**

Radioisotope Techniques: Radio-tracers, types of radioisotopes, interaction of radiation with matter, adsorbed body dose, GM counter, Proportional and Scintillation counters, methods of quench correction, auto-radiography and radioimmunoassay.

Suggested books [Latest edition]

1. Principles and techniques of Practical biochemistry: Eds. K Wilson and J Walker
2. Fundamentals of Immunology: Paul Williams
3. Biophysical Chemistry: D Freifelder

List of practicals

1. Density gradient centrifugation for separation of bacterial and human (blood)cells.
2. To perform salting out and dialysis for partial purification of protein(s) in a given mixture.
3. To perform rapid dialysis using Sephadex G-15 gel permeation column.
4. To determine the void volume of gel permeation column.
5. To perform Native PAGE for a given protein mixture.
6. To perform SDS-PAGE for separation of proteins in a given sample.
7. To perform gel exclusion chromatography for the separation of serum proteins.
8. To perform DEAE anion exchange chromatography for the separation of human IgG.
9. To perform Protein-A affinity chromatography for the separation of human IgG.
10. To separate phospholipids/carbohydrates mixture by TLC.
11. Use of GLC for analysis of alcohols such as methanol and ethanol.
12. To perform micro titer ELISA using human serum
13. To perform DOT-ELISA using human serum.

COURSE No. : MMB-202	IMMUNOLOGY AND IMMUNOTECHNOLOGY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **11**

Types of immunity: innate, acquired, active and passive, primary and secondary lymphoid organs, antigen-antibody Interactions (physical aspects), elements of immune system: T-cells, B-cells, cell mediated subset of T-cells, helper and suppressor cells, markers, third population of lymphocytes, antigen presenting cells, cell mediated and humoral immunity, antibody dependent cell mediated cytotoxicity, natural killer cells, Gnotobiotic animals: nude mouse, knock-out mouse. Germ-free animals

Unit II **12**

Cellular and molecular aspects: nature of antigens, basic structure of antibodies, their function and diversity, antibody classes and biological activity, T-cell receptors, complement system, major histo-compatibility complex (MHC), MHC molecules, exogenous and endogenous antigen presentation, lymphokines, regulation of immune response, immunological tolerance

Unit III **11**

Agglutination, Precipitation, Single and double immunodiffusion, immunoelectrophoresis, ELISA and its various types, Radioimmunoassay (RIA),Western blotting, Flow cytometry, Recent immunological diagnostic techniques, Fusion of myeloma cells with lymphocytes, concept of trioma, hybrid-hybridoma and thymoma, applications of monoclonal antibodies

Unit IV **11**

Synthetic vaccines, autoimmunity, hyper-sensitivity, tumor immunity, concept of idiotypes and anti-idiotypes. Immunization, Different types of vaccines (live attenuated, inactivated toxoid based, subunit based, DNA and RNA based, Polysaccharide based-synthetic and genetically engineered vaccines). National Immunization Schedule for infants, children, and pregnant women in India.

Suggested books [Latest edition]

1. Immunology: Janis Kuby
2. Essentials of Immunology: Ivan Roitt
3. Cellular and Molecular Immunology: Abul K Abbas, Andrew H Lichtman and S Jordan.
4. Immunology: An Introduction: Ian R Tizard
5. A Handbook of Practical Immunology: GP Talwar

List of practicals

1. To study the techniques of immunization and generation of antibodies.
2. To perform differential leukocyte count of human blood.
3. Isolation of IgG from human serum by affinity chromatography using protein column.
4. To perform precipitation tests (a) ring test (b) slide test in solution given an antigen and antibody.
5. To perform precipitation reactions in gel by Ouchterlony Technique given an antigen and antibody (double immunodiffusion).
6. To perform single radial immunodiffusion (Mancini's Technique) using an antigen and antibody.
7. To perform immunoelectrophoresis given an antigen and antibody.
8. To perform rocket immunoelectrophoresis on given antigen and antibody.
9. To perform ELISA.
10. To perform rapid Agglutination Test for detection of RA factor in serum.

COURSE No. : MMB-203	MYCOLOGY AND PHYCOLOGY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **10**

Introduction to fungi: Classification and characteristics of fungi, fungal life cycles, mechanisms of fungal pathogenesis, Laboratory and clinical mycology, antifungal therapy, Prognosis and Treatment, Isolation and culturing of pathogenic fungi, Types of Mushroom Poisoning and other Mycotoxins

Unit II **13**

Superficial mycoses: Pityriasis Versicolor; Tinea Nigra; Piedra, Cutaneous mycoses - various forms of Tinea and their causes, symptoms, and treatment: *Microsporum* spp., *Trichophyton* spp., and *Epidermophyton floccosum*, Subcutaneous mycoses: Chromoblastomycosis, Phaeohyphomycosis, Sporotrichosis, Lobomycosis, Rhinosporidiosis, Systemic mycoses caused by true pathogenic fungi: Blastomycosis, Paracoccidioidomycosis, Histoplasmosis, Coccidioidomycosis, Opportunistic Infections resulting from a weakened immune system due to a variety of intrinsic and extrinsic causes: Candidiasis, Pseudallescheriasis, Aspergillosis, Zygomycosis, Geotrichosis, Entomophthoromycosis, Cryptococcosis and miscellaneous rare mycoses (including pneumonia caused by *Pneumocystis carinii*)

Unit III **12**

Principles, criteria (pigments, flagellation, food reserve and eye spots) and systems of classification of algae. Cyanophyta: cell structure, heterocyst and akinete development, chromatic adaptation, thallus organization and reproduction. A brief account of thallus organization and reproduction in Chlorophyta, Phaeophyta and Rhodophyta, alternation of generation in Phaeophyta and post-fertilization development and site of meiosis in Rhodophyta. A brief account of Xanthophyta, Chrysophyta, Bacillariophyta, Pyrrophyta, Euglenophyta, Eustigmatophyta, Prasinophyta and Prochlorophyta

Unit IV **10**

Distribution of algae, algal nutrition, algal thallus, algal reproduction, green algae, diatoms, euglenoids, brown Rhodophyta, Pyrrophyta, Algal ecology and algal biotechnology. Algae in diverse habitats, algal blooms and Phycoviruses. Algae as food, biofertilizers and source of phycocolloids. Commercial potential of *Spirulina*, *Dunaliella* and *Porphyra*, Production of hydrogen by algae.

Suggested books [Latest edition]

1. Mehrotra RS and KR Aneja: An introduction to Mycology. New Age International publishers.
2. Introduction to Mycology: CJ Alexopoulos and CW Mims, Wiley Eastern Ltd, New Delhi.
3. Fundamentals of Mycology: JH Burnett, Publisher: Edward.
4. The Fungi: M. Charlile and SC Watkinson, Publisher: Academic Press.
5. Fundamentals of the fungi: E Moore – Landeekeer, Publisher: PrenticeHall.

List of practicals

1. Isolation of fungi by baiting method.
2. Microscopic observation of different asexual fungal spores.
3. Microscopic observation of fungal fruiting bodies.
4. Identification of Dermatophytes.
5. Culturing and morphological study of some common molds: *Rhizopus, Mucor, Penicillium, Alternaria, Trichiderma*
6. Identification of plat diseases: Apple scab, Citrus canker, Late blight of potato, Rust of wheat, Red rot of sugarcane, Green ear disease of Bajra, Leaf curl disease of peach.
7. Culture and identification of *Candida, Cryptococcus, Rhodotorula, Trichosporon, Geotrichum*
8. Morphological identification of mushrooms.
9. Study of mycorrhiza.
10. Study of the vegetative and reproductive feature of algae: *Oscillatoria, Spirogyra, Chlamydomonas, Spirullina, Nostoc*
11. Isolation of algae from soil and water.
12. Cultivation of *Spirullina*.
13. Study of the symbiotic association of algae.

COURSE No. : MMB-204	MEDICAL MICROBIOLOGY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **12**

Classification of medically important microorganisms, establishment, spreading, tissue damage and anti-phagocytic factors, mechanism of bacterial adhesion, colonization, and invasion of mucous membranes of respiratory, enteric, and urogenital tracts

Diagnosis of microbial diseases: Collection, transport, and preliminary processing of clinical pathogens/samples. Clinical, microbiological, immunological, and molecular diagnosis of microbial diseases. Modern methods of microbial diagnosis

Unit II **10**

Antibiotics and mode of action of antimicrobial agents, antibiotic resistance mechanisms. nosocomial infections, common types of hospital infections, their diagnosis and control.

Bacterial endotoxin test, Minimum Inhibitory concentration (MIC), Different types of drug toxicity testing, Sexual transmitted disease (STD) and Urinary Tract Infections (UTI)

Unit III **10**

Gram positive pathogens: *Staphylococcus, Streptococcus, Pneumococcus, Corynebacterium, Bacillus, Clostridium, Mycoplasma, Actinomycetes*. Gram negative pathogens: *Neisseria, E.coli, Klebsiella, Proteus, Salmonella, Shigella, Vibrio, Yersinia, Haemophilus, Bordetella, Brucella, Mycobacteria, Spirochaetes, Rickettsiae, Chlamydiae, Helicobacter, Campylobacter, Legionella, Leptospira, Borrelia, Pasteurella,* and *Coxiella.*

Unit IV 13

Brief account of protozoa (*Entamoeba, Giardia, Leishmani*a, *Trypanosoma* and *Plasmodium*) and helminth parasites (*Schistosoma, Taenia, Ascaris, Hookworms* and *Wuchereria*) of man and their diseases, Immunity to amoebiasis, trypanosomiasis, leishmaniasis, malaria, filariasis, hookworm and ascariasis

Suggested books [Latest edition]

1. Text of Microbiology: R. Ananthanarayanan and C.K.J. Paniker, Orient Longman.
2. Mackie and McCartney: Medical Microbiology Vol 1: Microbial infection, Vol 2: Practical medical microbiology. Churchill Livingstone.

List of practicals

1. Fixation of smears for microscopy by different staining techniques
    a. Simple (Loeffer's polychrome methylene blue and Negative staining)
    b. Gram's staining
    c. Ziehl-Neelsen method for AFB
    d. Fluorochrome staining
    e. Leishman's staining
    f. Giemsa's staining
    g. Special staining methods to demonstrate granules, capsules and spores
2. Culture and Biochemical Identification of *Staphylococcus*, *Streptococcus*, *Escherichia coli*, *Vibrio*, *Pseudomonas*, *Bacillus*, *Klebsiella*.
3. Isolation of pure cultures of normal flora of skin and their identification.
4. Establishment of haemolytic activity of isolated bacteria.
5. Testing of antimicrobial activity of skin on bacteria.
6. Determination of dental caries susceptibility
7. Drug susceptibility testing by various methods

COURSE No. : MMB-205	VIROLOGY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **12**

General Virology: Brief outline on discovery of viruses, nomenclature and classification of viruses; distinctive properties of viruses; morphology and ultrastructure; capsids and their arrangements; types of envelopes and their composition-viral genome, their types and structures; virus related agents (viroid). Prion : Definition, history, biology, and diseases.

Unit II **10**

Bacterial Viruses: Bacteriophage structural organization; life cycle; one step growth curve; transcription; DNA replication; eclipse phase; production; burst size; lysogenic cycle; bacteriophage typing; application in bacterial genetics; brief details on M13, Mu, T3, T4 and Lambda P1.

Unit III **12**

General Methods of Diagnosis and Serology: Cultivation of viruses in embryonated eggs, experimental animals, and cell cultures; primary and secondary cell cultures; suspension cell cultures and monolayer cell cultures, Virus isolation, purification and virus titration, Quantification of cytopathic effect(s).

Unit IV **11**

Animal Viruses: Infectivity assay (plaque method, end point method), virus titration by Reed and Muench method Classification and nomenclature of animal human viruses; epidemiology, lifecycle, pathogenicity, diagnosis, prevention and treatment of RNA viruses: Picorna, Orthomyxo, Paramyxo, Flavi, Ebola, Toga, corona and other arthropod viruses, Rhabdo, Rota, HIV and other Oncogenic viruses; DNA viruses; Pox, Herpes, Adeno, SV40 and Hepatitis viruses. Newly emerging viruses, Interferons and antiviral drugs.

Suggested books {latest edition]

1. Medical virology: Morag C and Timbury MC, Churchill Livingstone, London.
2. Introduction to Modern Virology: Dimmock NJ, Primrose SB, Blackwell Scientific Publications, Oxford.
3. Virology: Conrat HF, Kimbell PC and Levy JA: Edition Prentice Hall, Englewood Cliff, New Jersey.
4. Functional of plant virology: Mathews, RE, Academic Press, San Diego.
5. Diagnostic procedures for Viral and Rickettsial diseases: Lennetter, EH, American Public Health Association, NY.

List of practicals

1. Preparation of tissue culture media and concept of sterilization in animal cell culture.
2. Sub-culturing and maintenance of continuous cell lines [any one such as myeloma, Hep-2, Vero and HeLa cells].
3. Propagation of animal viruses using cell lines.
4. Sample collection for virus isolation.
5. Detection of Hepatitis/ HIV using ELISA method.
6. Propagation of animal viruses using egg inoculation techniques.
7. Tissue culture and serological methods for identification of viruses.
8. Staining of smear and tissue sections for viruses and their effects.
9. Detection of plant viruses with indicator hosts.
10. Physical characterization of plant viruses.
11. Infectivity assay of plant viruses.
12. Cultivation and preservation of phages from sewage/soil sample.
13. Quantitation of phages.
14. Demonstration of cytopathological changes (slides /pictures).
15. Detection of viral antibodies in given sample using agglutination assay.
16. Determination of specificity of anti-viral response by agglutination-inhibition assay.
17. Growth of animal cells in culture medium.

COURSE No. : MMB-301	ENVIRONMENTAL MICROBIOLOGY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **12**

Aerobiology: Brief account of air borne transmission of microbes – viruses – bacteria and fungi, their diseases and preventive measures. Assessment of air quality. **Aquatic microbiology:** Water ecosystems – fresh water and marine habitats. Potability of water – microbial assessment of water quality, brief account of major water borne diseases and their control measures. **Soil** Microbiology: Classification of soils – physical and chemical characteristics, microflora of soil, a brief account of microbial interactions symbiosis – mutualism – commensalisms – competition – amensalism – synergism – parasitism – predation; significance effect of agricultural practices on soil organisms. Biogeochemical cycles (C, N, P & S)

Unit II **11**

Solid Waste treatment: Wastes–types, characterization, solid waste treatment, saccharification, gasification, composting, utilization of solid wastes, foods (SCP, mushroom, yeast); fuel (ethanol, methane) and Biofertilizers, compost, vermicompost.
Bio Medical Waste: Segregation, Management and Handling

Unit III **11**

Waste water: Waste water quality parameters, Objectives of waste water treatment, Aerobic treatment of waste water (Trickling Filters, Rotating Biological Contactors, Fluidized bed reactors, Activated Sludge and Oxidation Ponds), Anaerobic treatment of waste water (Anaerobic Contact Digesters, Packed Bed Reactors, Anaerobic Baffled Digester sand Up-flow Anaerobic Sludge Blanket Reactors), Advanced waste water treatment for removal of suspended solids, nutrients (N &P), oil and grease and dissolved inorganic substances.

Unit IV **11**

Bioremediation and biorestoration of contaminated lands. Bioaccumulation and biosorption of metals and biodegradation of herbicides and pesticides, chlorinated hydrocarbons and xenobiotic compounds. biodeterioration of paper leather, wood, and textiles. Microbial Leaching and biomining, Microbes in petroleum extraction, Microbial desulfurization of coal,
Biofertilizer: Mass cultivation of microbial inoculants; green manuring; algalization; *Azolla*. Microbial products and plant health: Plant growth promoting rhizobacteria (PGPR); significance of mycorrhizae.
Microbial herbicides; biological control

Suggested books [Latest edition]

1. Microbial ecology: Alexander M; John Wiley and Sons, Inc., NewYork.
2. Pollution - Ecology and biotreatment: Longman Scientific Technical.
3. Advances in microbial ecology: S McEldowney, DJ Hardman, S Waite S and KC Marshall.

List of Practicals

1. Estimation of total solids in sewage samples.
2. Estimation of volatile matter and fixed residues in sewage samples.
3. Rapid detection of bacteriological quality of water with special reference to fecal coliform.
4. Determination of dissolved oxygen in waste-water samples.
5. Determination of BOD of waste-water samples.
6. Determination of COD of waste-water samples.
7. Determination of rate of decomposition of organic matter.
8. Determination of moisture content of soil sample.
9. Determination of microbial biodiversity in soil.
10. Determination of hardness of given water sample.
11. Transformation of waste into valuable products.

COURSE No. : MMB-302	INDUSTRIAL MICROBIOLOGY
Maximum marks: 80	Teaching hours: 45

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **12**

Overview of industrial microbiology, Biotechnological innovations in the chemical industry, Industrial strains-Strategies for isolation, screening & selection, maintenance & preservation of industrially important microorganisms, approaches for the genetic improvement of industrial organisms, microbial growth kinetics, measurement of growth (cell number, direct and indirect methods), efficiency of growth and product formation, effect of environmental factors on growth, maintenance energy requirement and maximum biomass, growth yield, metabolite overproduction and growth efficiency. Brief account of Solid state fermentation and Liquid submerged fermentation. Experimental designs for improvement of fermentations

Unit II **11**

Media formulation. Sterilization: kinetics of thermal death of microorganisms, batch and continuous sterilization. Basic design and operation of fermenter, stirred tank, airlift fermenter, batch, fed batch, continuous and immobilized cell reactors. Aeration and agitation, power requirement, oxygen transfer kinetics, concepts of fluids-types and properties.

Unit III **10**

Metabolic pathways and metabolic control mechanism, biocatalyst in organic chemical synthesis, industrial production of citric acid, enzymes, ethanol, biofuels, acetic acid, fermented food/beverages, Biopolymers. Bio-process technology for the production of recombinant vaccines, therapeutic proteins, antibiotics, and diagnostics.

Unit IV **12**

Large-scale production of protein/enzyme using recombinant microorganisms. Scale-up, economics of industrial processes-Total product cost, capital investment and profitability, Monitoring, and control of environmental parameters in fermentation process, biosensors, downstream processing. Concepts and overview of Quality control and Quality assurance in Industrial Microbiology. Regulatory and IPR issues, Intellectual Property Rights, Licensing and Patenting of bio-product, GLP and GMP guidelines in fermentation processes.

Suggested books [Latest edition]

1. Biotechnological innovations in chemical synthesis: BIOTOL. Publisher.
2. Industrial microbiology: G Reed, CBS Publishers.
3. Biology of industrial microorganisms: A L Demain.
4. Principles of fermentation technology: Stanbury, Whitaker and Hall.
5. Fermentation: A practical approach. IRL.
6. Advanced biotechnology, S. Chand & Com., Ram Nagar, New Delhi.
7. A Textbook of Biotechnology, S. Chand & Com., Ram Nagar, New Delhi

List of practicals

1. Design and operation of a laboratory fermenter.
2. Determination of viability of cells in a yeast culture by Methylene Blue staining, plate count and Haemocytometer methods
3. Preparation of microbial growth curve in a batch culture.
4. Concentration of protein by ultra-filtration.
5. Determination of K_La by sulphite oxidation method.
6. Determination of thermal death rate constant and decimal reduction time for *E.coli*.
7. Disruption of microbial cells (Baker's yeast) for the release of the intracellular protein.
8. Production of Ethanol by simple/complex carbohydrate sources (media) using *Saccharomyces cerevisiae*.
9. Determination of quality of milk sample by methylene blue reduction test
10. Production of wine from Apple / Grape juices by *Saccharomyces cerevisiae*.

COURSE No. : MMB-303	FOOD MICROBIOLOGY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **10**

Introduction and history of food microbiology, General characteristics, classification and importance of microorganisms important in food microbiology, Principles of food preservation. Asepsis–Removal of microorganisms, (anaerobic conditions, high temperatures, low temperatures, drying, canning, food irradiation). Factors influencing microbial growth in food – Extrinsic and intrinsic factors; Chemical preservatives.

Unit II **12**

Contamination and spoilage: Cereals, sugar products, vegetables, fruits, meat and meat products, Milk and Milk products, Fish and sea foods, poultry food, spoilage of canned foods. Detection of spoilage and characterization. Food-borne infections and intoxications: Bacterial and nonbacterial toxins with examples of infective and toxic types – *Brucella*, *Bacillus*, *Clostridium*, *Escherichia*, *Salmonella*, *Shigella*, *Staphylococcus*, *Vibrio*, *Yersinia*, Nematodes, protozoa, algae, fungi and viruses.

Unit III **13**

Food fermentations: Industrial production method for microbial starters, bread, cheese, vinegar, fermented vegetables, fermented dairy products; fermented foods, microbial cells as food (single cell proteins, mushrooms), fermented beverages: beer and wine. Amino acid production: glutamic acid and lysine. Production of probiotics and prebiotics, nutraceuticals, low calorie sweetener, food coloring and naturally occurring flavor modifiers.

Unit IV **10**

Food quality standards, Monitoring and control, Food Adulteration, R&D innovations in food microbiology, genetically modified foods, Need and requirements of food packaging; Containers for packaging, Dispensing devices, Food Regulations/Safety & Quality Standards & Food Laws

Suggested books [Latest edition]

1. Food microbiology- Royal society of chemistry: MR Adams and MO Moss.
2. Principles of fermentation technology: PF Stanbury, A Whitaker and SJ Hall, Pergamon Press.
3. Basic Food Microbiology: GJ Banwart, CBS Publishers.

List of Practicals

1. Microbiological examination of foods
2. Detection of number of bacteria in milk by standard plate count (SPC)
3. Determination of quality of milk sample by methylene blue reduction test
4. Microbiological assay of toxins
5. Detection of nicotinic acid by bioassay
6. Role of yeast in bread making
7. Production of wine from Apple/Grape juices by *Saccharomyces cerevisiae*
8. Biotransformation of sucrose into high fructose syrup by immobilized cell of *Saccharomyces cerevisiae*

COURSE No. : MMB- 304	ENZYME TECHNOLOGY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **11**

Introduction to enzyme and enzyme technology: History and scope of enzymes and enzyme technology, nomenclature of enzymes, enzyme activity units.

Enzyme Kinetics: Activation Energy & Transition State concept. Mechanism of enzyme catalysis, simple kinetics of enzyme action, factors affecting enzyme activity, reversible reaction, enzyme inhibition, determination of Vmax and Km values.

Sources and preparation of enzymes: Sources of enzymes, screening strategies for novel enzymes, media for enzyme production, methods of purification and concentration of intracellular and extracellular enzymes, factors affecting enzyme stability, preparation of enzymes for sale, customer service, safety and regulatory aspects of enzyme use, enzyme business, major manufacturers of enzymes in India and World

Unit II **10**

Large Scale use of enzymes in solution: Use of enzymes in detergents, food industry, fruit juice, wine, brewing and distilling industries, textile industries, waste treatment, diagnostics, pharmaceutical and chemical industries, application of enzymes in medicine

Preparation and kinetics of immobilized enzymes: Methods of immobilization of enzymes, Physical adsorption, covalent binding, entrapment and micro encapsulation, kinetics of immobilized enzymes, effect of solute partition and diffusion on the kinetics of immobilized enzymes, use of immobilized enzymes.

Unit III **11**

Immobilized enzymes and their use, Enzyme reactors, stirred tank reactors, plug flow reactors, continuous flow stirred tank fluidized bed reactor, Membrane/hollow fiber reactors, selection of reactors, productivity and performance of various types of reactors, immobilized enzyme processes - production of high fructose corn syrups, production of antibiotics, production of acrylamide and use of immobilized invertase, lactase, raffinase.

Biosensors: Use of enzymes in analysis, biosensors- calorimetric, potentiometric, amperometric, optical, piezoelectric biosensors and immuno-sensors.

Unit IV **11**

Advanced topics in enzyme technology: Enzyme reactions in biphasic liquid systems; proteases, glycosidases and lipases in synthetic reactions, interesterification of lipids, artificial enzymes, un-natural substrates, enzyme engineering, extremophilic enzymes, hybrid enzymes, high throughput screening and assay techniques

Suggested books [Latest edition]

1. Enzyme Technology: MF Chaplin and DC Bucks
2. Industrial Enzymology: Godfrey and West
3. Enzyme: Copeland
4. Enzymes in Industry: W Gerhartz

List of Practicals

1. Assay of some common enzymes (amylase, protease, pectinase, lipase etc.)
2. Microbial production of an enzyme.
3. Purification of enzyme, determination of V_{max} and Km values.
4. Effect of temperature, pH, ionic strength, inhibitors and metal ions.
5. Immobilization of enzymes/ cells by adsorption, covalent linkage, entrapment methods.
6. Enzyme reactions in biphasic aqueous - organic solvent.
7. Applications of enzymes in detergents, chemical production, juice clarification and bioprocessing.

ELECTIVE PAPER(S)

COURSE No. : MMB-EL-301	RECENT DIAGNOSTIC TECHNIQUES IN MICROBIOLOGY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **10**

Comparison of enzymes available for enzyme immunoassays, Conjugation of enzymes, Solid phases used in enzyme immunoassays, Homogeneous and heterogeneous enzyme immunoassays, Enzyme immunoassays after immunoblotting, Enzyme immune histochemical techniques, Use of polyclonal or monoclonal antibodies in enzymes immune assays

Unit II **15**

Molecular diagnosis by PCR and RT-PCR, true-NET, RFLP, Nuclear hybridization methods, Single nucleotide polymorphism and plasmid finger printing in clinical microbiology, Types of laboratory tests used in chemotherapy: Micro-dilution and macro-dilution broth procedures, Diffusion test procedures, Tests for bactericidal activity and automated procedures for antimicrobial susceptibility tests

Unit-III **10**

Manual-biochemical system, Mechanized automated systems, Immunological methods, Substrate profile systems. Serological techniques & Immuno-mapping, Agglutination, Counter Current Immuno-electrophoresis, Dot Blot Assay, Western Blot, Radioimmunoassay, Chromatographic techniques: Size exclusion chromatography, ion exchange chromatography, affinity chromatography, GLC, HPLC

Unit-IV **10**

Flowcytometry and cell sorting, Immunofluorescence, Electron Microscopy (Types of Electron Microscopy, concepts and operations with applications),Transgenic animals: Development and applications

Suggested books [Latest edition]

1. Antimicrobial chemotherapy, January 5th, 2012 Finch, Davey, Welcox, Irving (6thEdition).
2. Rose, N. R. (2001). Manual of Clinical Laboratory Immunology. American Society for Microbiology Press. Washington, D.C. 6th edition.
3. Murray, P.R; Baron, E.J; Jorgensen, J.H; Landry. M.L and P. faller, M.A. (2007).Manual of Clinical Microbiology. American Society for Microbiology, Washington D.C.9th edition.
4. Detrick, B; Hamilton, R.G and Folds, J.D. (2006)Manual of Molecular and Clinical Laboratory Immunology. American Society for Microbiology press. 7th edition.

COURSE No. : MMB-EL- 302	MICROBIAL GENOMICS & PROTEOMICS
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit 1 **10**

Whole genome analysis, preparation of ordered cosmid libraries, bacterial artificial chromosome libraries, shotgun libraries and sequencing, conventional sequencing (Sanger, Maxam and Gilbert methods), automated sequencing.

Unit II **11**

Sequence analysis: computational methods, homology algorithms (BLAST) for proteins and nucleic acids, open reading frames, annotations of genes, conserved protein motifs related structure/function (PROSITE, PFAM, ProfileScan), DNA analysis for repeats (direct and inverted), palindromes, folding programmes. Use of Internet, public domain databases for nucleic acid and protein sequences (EMBL, GenBank), database for protein structures (PDB).

Unit III **12**

DNA microarray, printing or oligonucleotides and PCR products on glass slides, nitrocellulose paper. Whole genome analysis for global patterns of gene expression using fluorescent labeled cDNA or end labeled RNA probes. Analysis of single nucleotide polymorphisms using DNA chips.

Unit IV **12**

Proteome analysis: Two-dimensional separation of total cellular proteins, isolation and sequence analysis of individual protein spots by mass spectroscopy. Protein microarray. Advantages and disadvantages of DNA and protein microarrays.

Suggested books [Latest edition]

1. The internet and the new biology - Tools for genomic and molecular research: LH Peruski Jr and AH Peruski.
2. DNA microarrays - A practical approach: Edited by Mark Schena.

COURSE No. : MMB-EL- 303	Microbes in Sustainable Agriculture and Development
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **15**

Soil Microbiology: Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity, and distribution of microorganisms in soil

Mineralization of cellulose, hemicelluloses, lignocelluloses, lignin and humus, phosphate, nitrate, silica, potassium

Unit II **14**

Microbial Activity in Soil , Green House Gases and Soil Borne Plant Pathogens

Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control.

Microbial Control of Soil Borne Plant Pathogens: Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant pathogens, Insects, Weeds

Unit III **15**

Biofertilization, Phytostimulation, Bioinsecticides: Plant growth promoting bacteria, biofertilizers – symbiotic (Bradyrhizobium, Rhizobium, Frankia), Non Symbiotic (Azospirillum, Azotobacter, Mycorrhizae, MHBs, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs

Unit IV **16**

Secondary Agriculture Biotechnology and GM crops: Biotech feed, Silage, bio-manure, biogas, biofuels – advantages and processing parameters. GM crops: Advantages, social and environmental aspects, Bt crops, golden rice, transgenic animals.

Suggested Readings

1. Agrios GN. (2006). Plant Pathology. 5th edition. Academic press, San Diego,
2. Singh RS. (1998). Plant Diseases Management. 7th edition. Oxford & IBH, New Delhi.
3. Glick BR, Pasternak JJ, and Patten CL (2010) Molecular Biotechnology 4th edition, ASM Press,
4. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
5. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
7. Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
8. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
9. Altman A (1998). Agriculture Biotechnology, Ist edition, Marcel decker Inc.
10. Mahendra K. Rai (2005). Hand-Book of Microbial Biofertilizers, The Haworth Press, Inc. New York.
11. Reddy, S.M. et. al. (2002). Bioinoculants for Sustainable Agriculture and Forestry, Scientific Publishers.
12. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG

COURSE No. : MMB-EL- 304	PARASITOLOGY
Maximum marks: 80	**Teaching hours: 45**
Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks	

Unit I **10**

Protozoology: Brief history of protozoology, ecology and host parasite relationship (parasitism and symbiosis): Basis of host cell parasite interactions with special reference to autoimmune response and pathogenesis of protozoan diseases in general, zoonotic potentiality of protozoa.

Unit II **20**

Amoeba: Non-pathogenic and pathogen amoeba. Morphology and life cycle of amoeba pathology. Symptomatology, Laboratory Diagnosis of

i. Giardia (*Giardia lamblia*)
ii. Flagellates of genital tract Trichomonas (*T. tenax, T.hominis, T.vaginalis*)
iii. Malaria parasite (*Plasmodium vivax, P.malariae, P.ovale*) General life cycle of Malarial parasite in man and Anopheles mosquito, sequel of malaria, *Toxoplasma gondii*, life cycle, Symptomatology, Transmission and Lab diagnosis of Toxoplasmosis.

Unit III **15**

Helminthology: General introduction of helminths and classification , medically important helminths. Immunity in *Taenia saginata, T. solium. Echinococcus granulosus, Trematodes, Schistosome (S. haematobium, S. mansoni, S. Japonicum) Nematodes. Ascaris lumbricoides, Ancylostoma duodenale, Strongyloides stercoralis, Enterobius, Wuchereria bancrofti, Brugiamalayi, Dracunculus medinensis.*

Unit IV **15**

Medical entomology: Role of arthropods in the spread and causation of parasite diseases. Classification and general characteristics of important insect vectors. Mode of transmission of various diseases.

Suggested Readings

1. Parasitology(K.D Chatterjee)
2. Medical Parasitology (Gillespie and Hawkey)
3. Modern Parasitology (F.E.G Cox)
4. Essential of Parasitology(Schimidt).

COURSE No. : MMB-EL- 305	MANAGEMENT OF HUMAN MICROBIAL DISEASES
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **15**

Human Diseases: Infectious and non-infectious diseases, microbial and non-microbial diseases, Deficiency diseases, occupational diseases, Incubation period, mortality rate, nosocomial infections.

Unit II **15**

Microbial diseases: Respiratory microbial diseases, gastrointestinal microbial diseases, Nervous system diseases, skin diseases, eye diseases, urinary tract diseases, sexually transmitted diseases: Types, route of infection, clinical systems and general prevention methods, study of recent outbreaks of human diseases (SARS/ Swine flu/Ebola) – causes, spread and control, Mosquito borne disease – Types and prevention.

Unit III **14**

Therapeutics of Microbial diseases: Treatment using antibiotics: beta lactam antibiotics (penicillin, cephalosporins), quinolones, polypeptides and aminoglycosides. Judicious use of antibiotics, importance of completing antibiotic regimen, Concept of DOTS, emergence of antibiotic resistance, current issues of MDR/XDR microbial strains. Treatment using antiviral agents: Amantadine, Acyclovir, Azidothymidine. Concept of HAART.

Unit IV **16**

Prevention of Microbial Diseases: General preventive measures, Importance of personal hygiene, environmental sanitation and methods to prevent the spread of infectious agents transmitted by direct contact, food, water and insect vectors. Vaccines: Importance, types, vaccines available against microbial diseases, vaccination schedule (compulsory and preventive) in the Indian context.

Suggested Readings

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
4. Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education
5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edit

COURSE No. : MMB-EL- 306	MICROBIAL DIAGNOSIS IN HEALTH CLINICS
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **18**

Importance of Diagnosis of Diseases and Collection of Clinical Samples Bacterial, Viral, Fungal and Protozoan, Diseases of various human body systems, Disease associated clinical samples for diagnosis. Collection of Clinical Samples: How to collect clinical samples (oral cavity, throat, skin, Blood, CSF, urine and faeces) and precautions required. Method of transport of clinical samples to laboratory and storage.

Unit II **18**

Direct Microscopic Examination and Culture: Examination of sample by staining - Gram stain, Ziehl-Neelson staining for tuberculosis, Giemsa-stained thin blood film for malaria. Preparation and use of culture media - Blood agar, Chocolate agar, Lowenstein-Jensen medium, MacConkey agar, Distinct colony properties of various bacterial pathogens.

Unit III **14**

Serology, Molecular Methods and Kits for Rapid Detection of Pathogens: Serological Methods - Agglutination, ELISA, immunofluorescence, Nucleic acid based methods - PCR, Nucleic acid probes. Kits for Rapid Detection of Pathogens: Typhoid, Dengue and HIV, Swine flu.

Unit IV **10**

Testing for Antibiotic Sensitivity in Bacteria Importance: Determination of resistance/sensitivity of bacteria using disc diffusion method, Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method

Suggested Readings

1. Ananthanarayan R and Paniker CKJ (2009)Textbook of Microbiology, 8th edition, Universities Press Private Ltd.
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Randhawa, VS, Mehta G and Sharma KB (2009) Practicals and Viva in Medical Microbiology 2nd edition, Elsevier India Pvt Ltd
4. Tille P (2013) Bailey's and Scott's Diagnostic Microbiology, 13th edition, Mosby
5. Collee JG, Fraser, AG, Marmion, BP, Simmons A (2007) Mackie and Mccartney Practical Medical Microbiology, 14th edition, Elsevier.

COURSE No. : MMB-EL- 307	MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **12**

Microbiological Laboratory and Safe Practices: Good laboratory practices - Good laboratory practices, Good microbiological practices; Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration

Unit II **18**

Determining Microbes in Food / Pharmaceutical Samples Culture and microscopic methods - Standard plate count, Most-probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products; Molecular methods - Nucleic acid probes, PCR based detection, biosensors.

Unit III **18**

Pathogenic Microorganisms of Importance in Food & Water Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Mannitol salt agar, EMB agar, McConkey Agar, Sabouraud Agar. Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres (COB, 10 min Resazurin assay)

Unit IV **12**

HACCP for Food Safety and Microbial Standards: Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations. Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water

Suggested Readings

1. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press
2. Garg N, Garg KL and Mukerji KG (2010) Laboratory Manual of Food Microbiology I K International Publishing House Pvt. Ltd.
3. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer
4. Baird RM, Hodges NA and Denyer SP (2005) Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.

COURSE No. : MMB-308	IPR/ BIOETHICS AND BIOSAFETY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **11**

Introduction to Intellectual Property Rights (IPR): Types of IP: Patents, Trademarks, Copyright and Related Rights, Industrial Design, Traditional Knowledge Geographical Indications, Protection of New GMOs, International framework for the protection of IP, Invention in context of "prior art".

Unit II **12**

Patent, Filing and Infringement: Types of patents, databases, Indian Patent Act 1970, Recent Amendments, Patent application- types (Provisional and complete specifications), forms and guidelines, fee structure, time frames, Precautions before patenting-disclosure/non-disclosure, World Intellectual Property Organization (WIPO) Treaties, Budapest Treaty, Patent Cooperation Treaty (PCT) and Implications, Role of a Country Patent Office, for filing a PCT application.

Unit III

Bioethics and Biosafety: Introduction, Historical background, Introduction to Biological Safety Cabinets, Primary Containment for Biohazards, Recommended Biosafety level for Infectious agents and Infected Animals, Biosafety Levels of Specific Microorganisms, Biosafety guidelines – Government of India. Definition of genetically modified organisms(GMOs), Roles of Institutional Biosafety Committee, Review Committee on Genetic Modification (RCGM) India, Genetic Engineering Appraisal Committee(GEAC) India etc. for GMO applications in food and agriculture, Environmental release of GMOs, Risk Analysis, Risk Assessment, Risk management and communication, Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

Unit IV **11**

Quality Assurance and Validation in Industries: The concept of ISO Certification, Preparation of Standard Operating procedure (SOP),Validation protocols for methods in - Quality Control, Process validation-The above should be discussed within World Health Organization (WHO) Norms, Exercises on preparation of SOPs, Operation and validation for analytical methods.

Suggested books [Latest edition]

1. P. Narayan: Patent Law.
2. S. L Rao: Economic reforms and Indian markets

COURSE No. : MMB- 401	RESEARCH METHODOLOGY
Maximum marks: 80	**Teaching hours: 45**

Note: **The Examiner will set a total of nine (9) questions** covering all topics/ units of the prescribed course by setting at least two questions from each unit. Out of the nine questions, one question containing eight (8) short-answer type questions that will cover entire course will be compulsory. The candidate will attempt a total of five questions (one from each unit) including the compulsory question. All questions will carry equal marks

Unit I **12**

Research and Types of research: Meaning of Research- Objectives of Research. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Research Process. Criteria of good Research. Literature review – Primary and secondary sources, Critical literature review – Identifying gap areas from literature review.

Unit II **10**

Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection – Modeling, Mathematical Models for research, Sampling Methods- Data processing and Analysis strategies.

Unit III **10**

Designing research work. Scientific writing - characteristics. Logical format for writing thesis and papers. Essential features of abstract, introduction, review of literature, materials and methods and discussion. Effective illustration - tables and figures. Reference styles - Harvard and Vancouver systems.

Unit IV **13**

Guidelines for preparing an article - ISSN, ISBN, impact factor, citation index, downloading index, h-index, i-index, Google scholar, Scopus, Thomson &Reuters, Web of Science and Science Citation Index (SCI) of Web of Science (WOS). Plagiarism and its software.

Reference Books

1.Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, EssEss Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
5.Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.

COURSE No. : MMB-402	DISSERTATION
Maximum Marks : 250 (150 + 100)	**Full Semester**

Note: Each candidate will carry out the project work assigned to him/her. The candidate will submit three bound copies of the Report of Research Project work performed by him/her duly certified by the guide/supervisor. The project report should cover the summary, introduction, materials and methods, results and discussion and references. The references will be arranged alphabetically under the format given below:

Referred Journal

Bhalla TC, Sharma NN and Sharma M (2006). Expression of alkaline protease in *Rhodococcus* sp. J Appl Biotechnol 32: 225-230.

Books

Demartino GN (1996). Purification of proteolytic enzyme. In: Proteolytic enzyme: a practical approach. Berjnon RJ and Bond JS (Ed. Or Eds.), IRL Press, New York, pp 120- 180.

Thesis

Verma ML (2006). Production, purification, and characterization of thermotolerant *P. aeruginosa* lipase. Ph.D. Thesis, Himachal Pradesh University, Shimla, India.

Website

www.elsevier.com

***** The Departmental Council will evaluate the dissertation and will conduct seminar and viva-voce examination of the student(s). The dissertation and viva-voce will carry 250 marks.