THE UNIVERSITY OF BURDWAN

Syllabus for M.Sc. Course in Microbiology

First Semester

Theory Papers

Paper 101 - 50 marks (45 + 5*)

Paper 102 - 50 marks (45 + 5*)

Paper 103 - 50 marks (45 + 5*)

Paper 104 - 50 marks (45 + 5*)

Practical Papers

Paper 105 - 50 marks (45 + 5*)

Paper 106 - 50 marks (45 + 5*)

Total marks – 300

Second Semester

Theory Papers

Paper 201 - 50 marks (45 + 5*)

Paper 202 - 50 marks (45 + 5*)

Paper 203 - 50 marks (45 + 5*)

Paper 204 - 50 marks (45 + 5*)

Practical Papers

Paper 205 - 50 marks (45 + 5*)

Paper 206 - 50 marks (45 + 5*)

Total marks – 300

Third Semester

Theory Papers

Paper 301 - 50 marks (45 + 5*)

Paper 302 - 50 marks (45 + 5*)

Paper 303 - 50 marks (45 + 5*)

Paper 304 - 50 marks (45 + 5*)

Practical Papers

Paper 305 - 50 marks (45 + 5*)

Paper 306 - 50 marks (45 + 5*)

Total marks – 300

Fourth Semester

Theory Papers

Paper 401 - 50 marks (45 + 5*)

Paper 402 - 50 marks (45 + 5*)

Paper 403 - 50 marks (45 + 5*)

Practical Papers

Paper 404 - 50 marks (45 + 5*)

Paper 405 - 50 marks (35 marks practical + 15 marks industrial tour report)

Paper 406 - Project Work 50 marks

Total marks – 300

*** indicates 10% marks of each Theory paper will be given on the basis of internal assessment**

Total marks for Semester I, II, III, IV - 1200

Syllabus for Semester-I

Total : 300 marks

Theory		**Total**
Paper 101 :	: Bacteriology 50 marks (45 + 5*)	50
Paper 102	: Acellular and eukaryotic microorganisms 50 marks (45 + 5*)	50
Paper 103	: Biomolecules, biochemistry and enzymology 50 marks (45 + 5*)	50
Paper 104:	Microbial Metabolism … 50 marks (45 + 5*)	50

Practical		
Paper 105:	General Microbiology	50 marks
Paper 106	Biochemistry & Bacterial Metabolism	50 marks

*** =Internal assessment**

Syllabus for Semester-II

Total : 300 marks

Theory		**Total**
Paper 201:	Molecular Biology 50 marks (45 + 5*)	50
Paper 202:	Microbial Genetics 50 marks (45 + 5*)	50
Paper 203:	Biostatistics and Computer Application 50 marks (45 + 5*)	50
Paper 204:	Physico-chemical principles & techniques 50 marks (45 + 5*)	50

Practical		
Paper 205:	Microbial Genetics	50 marks
Paper 206:	Molecular Biology	50 marks

*** =Internal assessment**

Syllabus for Semester-III

Total: 300 marks

Theory		**Total**
Paper-301:	Fermentation Technology 50 marks (45 + 5*)	50
Paper 302:	Food & Industrial Microbiology 50 marks (45 + 5*)	50
Paper-303:	Immunology 50 marks (45 + 5*)	50
Paper-304:	Medical Microbiology 50 marks (45 + 5*)	50

Practical

Paper-305: Microbial Biotechnology	50 marks
Paper-306 : Medical Microbiology & Immunology	50 marks

***=Internal Assessment**

Syllabus for Semester-IV

Total: 300 marks

Theory		**Total**
Paper- 401: Recombinant DNA Technology	50 marks (45 + 5*)	50
Paper - 402: Bioinformatics & Bioethics	50 marks (45 + 5*)	50
Paper- 403: Agricultural & Environmental Microbiology	50 marks (45 + 5*)	50

Practical

Paper- 404: Recombinant DNA Technology & Bioinformatics	50 marks
Paper- 405: Agricultural, Environmental Microbiology	35 marks
& Report on Industrial Visit	15 marks
	(Total – 50 marks)

***=Internal Assessment**

Paper- 406- Project Work - 50 marks (Project Report 35 marks + Viva 15 marks)

Syllabus for Semester-I

Paper 101 – Bacteriology FM-50 (45 + 5*)

1. History and major events in the development of microbiology (1 L)
2. Origin of life, Prokaryotic diversity, theory of endosymbiogenesis. Prokaryotic taxonomy- classical and modern. Prokaryote and eukaryote species concept.(7 L)
3. Morphology and structure : Morphological types, cell walls of Gram positive, Gram negative, archaea and eukaryotic micro organisms and L-forms ; antigenic properties of cell wall ; capsule types, composition and function ; cell membrane ; structure composition and properties.(7 L)
4. Function of flagella, Pili, Fimbriae; Phototaxis, magnetotaxis. (3L)
5. Control of bacteria: Physical, chemical and biological control. (4 L)
6. Maintenance of microbial culture: Principles and techniques. (2 L)
7. Perennating bodies- Cysts, myxospores with special references to endosporogenesis, their structure; ecological significance of such perennating bodies.(3 L)
8. Cell cycle, cell division, binary fission, multiple fission, budding. (2 L)
9. Cultivation of bacteria: Nutritional types, culture media used; kinetics, aerobic and anaerobic cultures, synchronous and asynchronous culture, batch, fed batch and continuous culture. Measurement of growth, factors affecting growth. (5L)
10. Archaea: General characters including membrane and cell wall.(2)
11. Extreamophiles: halophiles, thermophiles, psychrophiles, mechanisms of resistance, alkalophiles and acidophiles. (6L)
12. General account of major groups of bacteria like Spirochetes, Mycoplasmas, Actinomycetes, Rickettsias, Chlamydias, Myxobacteria, Cyanobacteria, Prochlorones, Cyanales. (8 L)

Paper-102 Acellular and eukaryotic microorganisms 50 marks (45 + 5*)

1. Micro algae: Diversity, distribution, nutrition, mode of reproduction, ecological significance, phycotoxins, economic importance including role in human affairs.(6 L)
2. Fungi: Diversity, modes of reproduction, ecological significances, economic importance, sex hormones, mycotoxins, fungal associations with plants, animals and humans,.(6 L)
3. Protozoa: Diversity, reproduction, classification, importance to human affairs.(3 L)
4. Helminthes: General account, reproduction, classification, importance.(3 L)
5. History and development of virology, distinctive, properties of virus, morphology, architecture, capsid arrangement, types of envelope and their composition.(5 L)
6. Viral nomenclature, classification of virus including Baltimore's classification, assay of virus – plant, animal and bacteriophage, (5 L)
7. Transmission of plant, animal and bacterial viruses.(2 L)
8. Viral nucleic acid types, replication of viral DNA and RNA types.(4 L)
9. Variations in structure of bacteriophages, lytic cycle of bacteriophages with reference. (7 L)
10. Lysogeny: molecular mechanism of lytic-lysogenic conversion, significance.(2 L)
11. Life cycles and replication of Ebola virus, Cauliflower Mosaic Virus, Mimi virus, Potato Spindle virus. (5 L)
12. Prions, Viroids and Virusoids.(2 L)

Paper 103 - Biomolecules, Biochemistry & Enzymology 50 marks (45 + 5*)

1. Concept of chemical interactions such as covalent, hydrogen, and dihedral bond; electrostatic, hydrophobic and Vanderwaals interaction in biological system.(2 L)
2. Physical properties of water, structure of water molecules, weak interactions in aqueous solution, Ionization of water, Bronsted – Lowry concept of acid and bases, concept of pH and Buffer, Henderson – Hasselbatch equation, biological buffer system (4 L)
3. Carbohydrates: Classification, asymmetry, optical isomerism, mutarotation, homo and hetero-polysaccharides. (4 L).
4. Amino acids: Nature (Non-polar, polar, neutral, acidic basic) specific rotation, electrochemical properties, iso-electric properties, non-protein amino acids, absorption in UV-range (4 L).
5. Proteins: Classification of proteins, primary, secondary, tertiary and quaternary structure, Ramchandran plot. Classification based on functions ; enzyme, storage, regulatory, transport protein, classification based on composition, based on molecular shape ; globular, fibrous, determination of N- and C- terminals, protein folding and denaturation of proteins, purification of proteins, assessment of purity of protein. Protein sequencing. (7 L).
6. Nucleic acids : Physical properties of DNA and RNA, structure of DNA and RNA, double helical A-form, B-form, Z-form of DNA, DNA denaturation and renaturation, DNA super coiling, bonding pattern of DNA, DNA sequencing (5 L).
7. Lipids and cell membrane: Nomenclature, classification, properties, membrane structure (4 L).
8. Vitamins and co-enzymes: water soluble vitamins and their co-enzymes, lipid soluble vitamins; metal co-factors (3 L).
9. Thermodynamics in biology : heat, work, energy – first law of thermodynamics & molecular interpretation of thermodynamic quantities, entropy, enthalpy, free energy & equilibrium, 2^{nd} law of thermodynamics in relation to cell function (5 L).
10. Enzymes : Classes of enzymes ; active and binding sites; co-enzymes, co-factors, holo and apoenzymes, enzyme activity, units; enzyme inhibitors and activators, enzyme kinetics – Michaelis –Menten derivation, km values, association and dissociation constant, inhibition and its kinetics, effect of pH and temperatures on enzymes action, enzyme regulation, allosteric, covalent modification, isoenzyme, abzymes, ribozymes other non-protein biocatalysts (12 L).

Paper 104: Microbial Metabolism 50 marks (45 + 5*)

1. Photosynthesis: Types of photosynthetic pigments, photosynthetic apparatus in bacteria and algae, oxic and anoxic photosynthesis, light reaction & electron flow in photosynthesis, photophosphorylation, and bioenergetics. Dark reaction and carbon assimilation, Calvin cycle, RUBISCO-structure and molecular regulation, (8 L).
2. Regulation and energetics of hexose and pentose metabolism. Peptidoglycan synthesis. (8 L)
3. Mitochondrial Electron Transport chain and bioenergetics of ETC and oxidative phosphorylation, mechanism of oxidative phosphorylation. Inhibitors of electron Transport chain. (4 L)

4. Anaerobic respiration- electron transport & bioenergetics, importance (NO_3 respiration, SO_4 respiration, Iron respiration) and fermentation (ethanol, lactic acid, butyric acid mixed acid fermentation). (4 L)
5. Biological N_2-fixation: Types (symbiotic; asymbiotic, associative and endophytic); Molecular mechanism and Genetic regulation of N_2-fixation; nitrogenase structure, alternate nitrogenase (4 L).
6. Biosynthesis and oxidation of saturated and unsaturated fatty acids. (4 L)
7. Amino acid biosynthesis and degradation with reference to aspartate and aromatic amino acid families. (5 L).
8. Chemolithotrophy: Carbon, Hydrogen, Sulphur, Phosphorus bacteria; Acetogenesis, Methanogenesis, Anammox, ATP synthesis in *Halobacterium.* (6 L)
9. Nutrient transport: Transport of solutes across the membrane, Active and Passive transport, Group Translocation, Carrier mediated transport mechanism, thermodynamics of transport process. (4 L)
10. Nucleotide Metabolism: Synthesis and degradation of nucleotides. (3 L)

Paper 105 (Practical)– General Microbiology FM-50marks

1. Laboratory rules, safety and regulation, First Aid and ethics.
2. Standardization of microscope, measurement of microbes and direct cell counting.
3. Culture techniques and microbe handling: adjustment of pH of the media, broth, solid, slant & slab and Plate culture technique. Aerobic and anaerobic culture.
4. Enrichment culture of Nitrogen fixer, Spore former, cellulose decomposer, sulphate reducing bacteria and phosphate solubilizer.
5. Plating of environmental samples on culture media, isolation of pure culture.
6. Observation of the different morphology, shape, size of bacteria, yeast, micro algae, Protozoa & Fungi, under light field, Phase contrast, Fluorescence microscope and SEM/ TEM.
7. Staining method: Simple staining. Gram staining, Endospore staining, Acid-fast staining, Flagella staining, Capsule staining.
8. Determination of MIC of antibiotics by tube dilution method. Assay of antibiotics by agar cup method.
9. Phenol co-efficient.
10. Identification of pure prokaryote isolates following Bergey's Manual.
11. Microbial Growth measurement – turbidity, total counts, MPN technique, estimation of dry wt, Bacterial growth curve and generation time. Effect of pH and temperature on bacterial growth.

Paper 106 (Practical) Biochemistry & Bacterial Metabolism FM-50

1. pH, pK, Henderson – Hassel batch equation. Preparation of buffer; DNA estimation, denaturation & renaturation, RNA estimation.
2. Estimation of sugar by DNS method, Estimation of Protein by Bradford Method.
3. Qualitative study of Photosynthesis in Photosynthetic bacteria & Cyanobacteria.
4. Estimation of lipid & their separation. Determination of saponification values of fat.
5. Identification and estimation of amino acid, Organic acid.

6. Isolation of Protein, protein estimation by Bradford method, denaturation of Protein.
7. Isolation of microbial cell wall, membrane, ribosome.
8. Isolation of Photosynthetic pigment & study of absorption spectra.
9. Isolation and purification of bacterial alkaline phosphatase/amylase/ cellulase / xylanase/ Protease; determination of specific activity & stability.
10. Effect of pH, temperature, Salt concentration, activators and inhibitors of bacterial alkaline phosphatase/ amylase.
11. Determination of Km, Vmax with and without competitive, non-competitive inhibitors using bacterial alkaline phosphatase or any other enzyme.

Syllabus for Semester-II

Paper 201: Molecular Biology 50 marks (45 + 5*)

1. Relationship between Biochemistry, Biophysics, genetics, Cell Biology and Molecular Biology. (1 L)
2. DNA replication: Prokaryotic and Eukaryotic DNA replication; mechanism, Initiation, elongation and termination of replication, DNA polymerases, Uni and bi-directional replication, and rolling Circle model of replication. Maintaining the ends of Linear DNA molecule, cell cycle and regulation of genome replication (6 L).
3. DNA damage and repair and recombination: Direct repair, base excision repair, nucleotide excision repair, mismatch repair, recombination repair, SOS repair, Holliday model of recombination. (5 L)
4. Transcription : Pro & Eukaryotic RNA Polymerase, Subunits, different (sigma) factors related to stress, Transcription Initiation, elongation and termination (Rho-dependent & Rho-independent), Regulatory elements of transcription ; mRNA capping, polyadenylation, splicing and editing of RNA. RNA content of a cell, coding and non-coding RNAs precursor RNA: mRNA stability; turnover of mRNA, synthesis and splicing of tRNAand rRNA. General discussion on SnRNAs (Snurps and Snorps), Ribozymes; RNAi – miRNA, Genetic Code. (12 L).
5. Synthesis and Processing of Protein: tRNA structure, *amino acid* acylation. Codon-anticodon interaction ; Ribosome structure; Pro-eukaryotic initiation of translation, elongation, translation termination; regulation of termination; regulation of translation initiation; Post-translation process of protein, protein folding, chemical modification. (5 L)
6. Protein localization and targeting – chaperones and protein folding, leader or signal sequence, translocation apparatus (Signal recognition particle), co-translation and post translation translocation. Signal peptides for organellar protein targeting in eukaryotes, general idea. (4L).
7. Regulation of transcription: Strategies for controlling bacterial transcription initiation, the operons, promoters, repressor, Positive and negative control. Inducible & repressible system, attenuation (6 L).
8. Molecular biology of cancer, Physical, chemical mechanism and microbial induction of cancer; biochemical and molecular changes in transformed cells. Mechanism of molecular disruption; Oncogenes, Oncoprotein; tumor suppressor genes – PRB and P^{53} protein; Plant tumors – *A. tumefaciens* induced tumorogenesis in plants. (6 L)

9. Signal Transduction: mechanism in bacteria and Eukaryotic microbes in relation to man. Quorum sensing in prokaryotes- molecular mechanism. (5 L).

Paper-202: Microbial Genetics 50 marks (45 + 5*)

1. Plasmid: Naturally occurring plasmids, size and copy number, replication and control of copy numbers, incompatibility plasmid maintenance, Plasmid curing, plasmid types and traits they endow to the host cell – F, R, Col, degradative plasmids. Use of plasmid in genetic analysis. Genetic mapping of *E. coli,* Overlapping gene. Ti-plasmid, conjugating & Non-congugating Plasmid (10 L).

2. Transposons : Is elements, composite transposons, replicative and non-replicative transposons, Tn-transposons and evolution; used of transposons in genetic analysis (6 L)
3. Strain Construction: Isolation and Characterization of mutants. Sugar utilizing auxotrophs, amino acid utilizing auxotrophs, Mutation enrichment technique, Production of single & multiple mutations ; Use of transposons, mutagenesis in strain construction (4 L).
4. Bacterial Genetic Systems :
    a) Transformation: Competence development in G(+) and G(-) bacteria; DNA uptake, Transformation in *E. coli*. Natural and artificial transformation. Transfection
    b) Transduction: Generalized transduction, Phase Mu based generalized transduction, specialized transduction – model.
    c) Conjugation : F´ -factor, structure & function, F^+ X F^- mating, mating outcomes, F-mediated conjugation ; Hfr formation Hfr mediated conjugation ; F´ and F´ –mediated conjugation, Sexduction or F´ duction, Gene mapping, other conjugative plasmids (15 L).
5. Gene, mutation and Mutagens – evolutionary concept :
    a) Mendalian genetics in relation to microbes. Central dogma ; evolving concepts and definitions of gene and mutation. Types of mutation ; i) Changes in Primary DNA sequence; substitution, deletion, insertion, DNA rearranging ii) Change in gene function : Polar mutation, loss of function, gain of function ; reverse mutation suppressor mutation,
    b) Origin of mutation – Spontaneous Induced. Mechanisms of spontaneous mutation – 5 – major mechanisms. Mutagenes – Physical, chemical, biological, Luria and Delbruck's fluctuation test. Ames test (detection of mutagen in the environment) sequence based method for mutation detection, complementation test, Mutation rate and mutation frequencies, Hot spot of mutation (15 L).

Paper 203:Biostatistics 50 marks (45 + 5*)

1. Linear Algebra, solution of simultaneous equation. Concept of matrix, Matrix as operator, Types of matrices, matrix diagonalization, Determinant of a matrix, Rank of a matrix, Vector space, space scanned by linearly independent vectors, eigen value equations, Determination of eigen value and eigen functions, Utility of linear algebra in microbiology (10 L).

2. Limit and continuity. Concept of a derivative, Methods of differentiation, Integration as the limit of a sum, Standard indefinite integrals, Definite integrals; Functions of several variables. Partial derivatives, Determination of maximum and minimum of a function several variables. Differential equations, Methods of solving differential equations of first order and first degree. Integrating factors, Differential equation of second order and first degree; Utility of calculus in the problems of microbiology (10 L).
3. Sample and population: Sampling methods, construction of histogram, interpretation of histogram, sample mean, sample standard deviation, the normal distribution, the mean, mode, median and standard deviation of the normal distribution, Uncertainties in estimation of a mean. Testing of hypothesis, Comparison of population means and variances – F test, notion of confidence limit (10 L).
4. Laws of probability, theorem of total probability (3 L).
5. Analysis of proportion data ; examples of proportion data MPN, sterility testing of medicine, animal toxicity, therapeutic trials of drugs and vaccine, infection and immunization studies, x^2-test, goodness of fit and the test of independence of two attributes ; count data, examples of count data – bacterial cell count, radio activity count, colony and plaque counts. Statistical treatment to count data (8 L).
6. Poisson distribution, standard error, confidence limits of counts; test of significances, difference of means in large samples, t-test (small samples), paired and unpaired data with computation of critical difference: Binomial, Gaussian distribution fitting on observed data. Analysis of variance of one way and two – way classified data with one observation parcel, simple linear regression. (9)

Paper 204: Physiochemical Principles and techniques for microbiology :

50 marks (45 + 5*)

1. Microscopy: - Basic principles and application of bright field, Phase Contrast and Confocal microscopes, fluorescence and electron microscope (SEM & TEM) (8 L).
2. Electrophoresis: Vertical and Slab gel electrophoresis, SDS – PAGE electrophoresis, 2-D gel and Pulse field gel electrophoresis, isoelectric focusing. (6L)
3. Chromatrography : Gas chromatography, HPLC, Column chromatography- gel filtration, Affinity, Ion exchange chromatography. (7L)
4. PCR, ELISA, DNA finger printing, Radio-immuno-assay RAST, RIST, Immuno fluorescence, Auto radiography, Scintillation counting, flow cytometry. (10L)
5. Laws of radio active transformation, half life. Mean Life, Types of radiation, uses in biology, GM counter, Liquid scintillation counter. (6 L)
6. Centrifugation: Basic Principles, Ultra centrifugation and separation of cell organelles, Theory of velocity of sedimentation, Sedimentation co-efficient, ultra centrifugation, Density gradient sedimentation. (4 L)
7. Beer –Lambert law, UV-VIS Spectrophotometry, Spectrofluorometry, Atomic Absorption Spectrometry, Mass spectrometry; MALDITOF. (6L)
8. Viscosity: Macromolecules and viscosity. Raynold's no., measurement of viscosity, Oswald capillary viscometer. (2 L)
9. Laser and their application (1 L)

Paper 205 – Practical : Molecular Genetics **50 marks**

1. Isolation of Phage from sewage using *E. coli.*
2. Induced mutation by irradiation (UV) & chemicals, Ames Test.
3. Replica Planting technique.
4. Bacterial transformation.
5. Isolation and culturing of auxotrophic mutant strains.
6. Isolation and culturing of antibiotic resistant.
7. SDS-page Separation of Protein & determination of Molecular wt.
8. 2-dimensional Gel Electrophoresis of Protein (3 L).
9. Enrichment culture of nitrogen fixer, spore former, cellulose decomposer, sulfate reducing bacteria, phosphate solubiliser (3 L)

Paper 206: Practical **: Molecular Biology** **FM-50**

1. Isolation of, nucleic acid (DNA/RNA) from micro organisms and other sources. Determination of G +C content of DNA
2. Isolation of Plasmid DNA from different bacteria.
3. Agarose gel Electrophoresis of DNA.
4. Curing of Plasmid by acridine Orange or Ethidium bromide or heat treatment.
5. Transposon mutagenesis using Tn.
6. Isolation of Poly A mRNA by affinity chromatography (3 L)
7. Northern Blotting (3 L)
8. Lac-permease assay (3 L)
9. Isolation of genomic DNA & determination of its Tm value/ Preparation of cot curve (3 L)
10. Techniques: Thin layer chromatography (amino acid), column chromatography (Pigment/ albumin) (3 L).

Tools & Techniques for Microbiology **(Demonstration)**

1. Scanning Electron microscopy
2. Fluorescent Microscopy (3 L)
3. GLC or GC-MS (2 L)
4. HPLC (2 L)
5. Lyophilizer (1 L)
6. Chemostat (1 L)
7. Fluorescence spectroscopy of ANS at different solvents (3 L)
8. DNA & Protein sequencing (3 L)
9. Demonstration of S-value of macromolecules (3 L)

Syllabus for Semester-III

Paper-301 Fermentation Technology **50 marks (45 + 5*)**

1. Prerequisites of potentially useful industrial Microorganisms, Isolation, Screening / selection, purification and improvement of industrial microbial strains. Methods of preservations and maintenance of microbial strains and stock culture. (7 L)
2. Types of fermentation: liquid state fermentation (surface and submerged) and solid state fermentation. (4 L)
3. Fermenter: Basic principle and function, design, types, components and their function. (4 L)
4. Mass transfer in aerobic fermenter, Mass transfer coefficient (K_{LA}). (3 L)
5. Formulation of medium: Medium optimization, typical media. (3 L)
6. Sterilization of fermenter and bulk medium (3 L)
7. Detection & quantitative and qualitative assay of fermentation products. (3 L)
8. Determination of factors depending on scale up process. Principle & different methods of scale up process. (4 L)
9. Types of inoculum, development of inoculum & process of inoculum. (3 L)
10. Fermentation condition, measures of process variables and control systems. (3 L)
11. Removal of microbial cells and solid matters, microbial cell disruption method, fome separation, precipitation, flocculation, centrifugation, liquid-liquid extraction, chromatography, membrane process, drying and crystallization. (8 L)
12. Enzyme & whole cell immobilization and their industrial application (5 L)

Paper 302 Food & Industrial Microbiology **50 marks (45 + 5*)**

Food Microbiology

1. Microbial contamination of food, food poisoning- microbial agents, food borne illness & poisoning. (3 L)
2. Food production using microbes- Sufu, Saurkraut. (3 L)
3. Microbial processing of fish & fish products. (1 L)
4. Methods for Microbiological examination of Foods and controlling their quality (HACCP). (3L)
5. Food preservation- Heat processing, low temperature processing, irradiation, high pressure processing, canning, chemical preservation, modification of atmosphere- merits and demerits. (3 L)
6. Biological preservation of Food, Bacteriocin (colicin, radiobacterin, lantibiotics- nisine). (2 L)
7. Probiotics- Definition, microorganisms used application. (1 L)
8. Microbiology of milk & Dairy products. (2 L)

Industrial Microbiology

9. Development & scope of Industrial Microbiology. (1 L)
10. Industrial production,. Process development & biotechnological approach to scale up production of enzymes (glucose isomerase & protease), alcoholic beverage (wines),

non-alcoholic beverage (tea), aminoacids (Lysine), vinegar, organic acids (citric acid), food additives (vitamin-riboflavin; biopolymers- xanthan gum), organic solvents (butanol), steroids (pretnisolone), antibiotics (streptomycin), lantibiotics (nisin)(15 L).

11. Biomining. (2 L)
12. Microbial transformation of flavor compounds, petrochemicals & perfumery chemicals. (6 L)
13. Biotechnological process of leather, Jute. (4 L)
14. Microbial production of biofuel, microbial biofuel cell. (4 L)

Paper-303- Immunology **50 marks (45 + 5*)**

1. Overview of Immunology: Cardinal features of immune system. Innate immunity. Types of immune response- humoral and cell mediated. (5 L)
2. Antigen: Nature of antigen, hapten, Ag-presentation and induction of immune response; types of immune response- humoral and cell mediated. (5 L)
3. Antibody: Antibody diversity, organization and expression of Ig genes, Ig gene rearrangement, allelic exclusion, affinity maturation. (8 L)
4. Antigen antibody reactions and serological tests.
5. Interleukins, Interferons, Cytokines, Lymphokines. (4 L)
6. Maturation of Lymphocytes: B-Cells and T-Cells; Negative and Positive Selection, T-Cell activation. (5 L)
7. Complement system: Types and pathways of fixation. (2 L)
8. Hypersensitivity reaction: immediate and delayed type, Mechanism of Hypersensitivity reaction. (4L)
9. Autoimmunity, Transplantation immunity, Opportunistic infection, Tumour immunology. (5 L)
10. Monoclonal and Polyclonal Ab, Immune haematology- iso-antigen, Ab and their significance in blood transfusion. Serological tests. (5 L)
11. Vaccines, Live microorganisms, attenuated organisms, toxoids, synthetic vaccines, peptide vaccines, recombinant DNA vaccines and designing. (7 L)

Paper-304: Medical Microbiology **50 marks (45 + 5*)**

1. Concept of Health and Disease: Concept of control and prevention, Concept of community and health (2 L).
2. Study of pathogenesis, epidemiology, symptomotology, clinical diagnosis, prevention and therapy of the following diseases: Cholera, Typhoid, Tuberculosis, Tetanus, Ulcer by Helicobacter pylori, AIDS, Rabies, Hepataitis-B, Dengue, Encephalitis, Giardiasis, Candidiasis, Dermatomycoses, Kuru, Mad Cow, Cadang Cadang (20 L).
3. Life cycle, mode of transmission, Pthogenicity and control of protozoan and helminth parasites *, , Leishmania, Giardia, Wuchereria bancrofti, Ascaris lumbricoides* (14 L).
4. Antibiotic and chemotherapeutic agents: Sulfur drugs, Antibiotics and their classification, Mode of action, chemical nature of different antibiotics, antibiotic assay and sensitivity test, non-medical uses of antibiotics. (5 L)
5. Antibiotic/Drug resistance- origin, cause and clinical implication (7 L).
6. Pharmacogenomics: General concept, implication (2 L).

Paper 305: Practical- Microbial Biotechnology FM-50

1. Detection & enumeration of non-pathogenic / pathogenic microorganisms in different food samples (serial based, meat based, milk based & vegetable based).
2. Detection and enumeration of indicator and index microorganisms for food borne pathogens (total enterobacteria, total coliform & aerobic spore former)
3. Determination of microbial spoilage of sores food samples.
4. Bioassay of vitamin B12 / amino acids using auxotrophic strain.
5. Production of aminoacid & lactic acid by fermentation in laboratory fermenter.
6. Production of rhizobium inoculant in laboratory fermenter.
7. Preparation of Yogart.
8. Preparation of spawn for mushroom cultivation.

Paper-306 : Practical-Medical Microbiology and Immunology **FM-50**

1. Preparation of media used in diagnostic Medical Microbiology.
2. Ioslation and identification of pathogenic microorganism from clinical sample using selected media.
3. Estimation of urine by pour plate method.
4. Urine culture and analysis of antibiotic sensitivity of bacteria present in urine.
5. Hemaglutination test for presence of Ag (Bacteria)
6. Ochtarlony double diffusion agar cup assay.
7. Immuno electrophoresis.
8. Serological test-Tuberculin Test, ELISA.

Syllabus for Semester-IV

Paper-401 -Recombinant DNA Technology 50 marks (45 + 5*)

1. **Manipulation of Purified DNA**: DNA manipulative enzymes (nucleases, ligases, polymerases, modifying enzymes), restriction endonucleases, restriction mapping, different methods of formation of recombinant DNA (use of linkers, adaptors, homopolymers). (4 L)
2. **Introduction of DNA into Living cells**: Chemical (PEG, liposomes), Physical (electroporation, microinjection, biolistic) and biological (transformation, transfection & use of vectors). (5 L)
3. **Cloning Vectors**: Vectors based on *E. coli* plasmid like PBR and PUC groups and their derivatives, Vectors based on bacteriophage M13, λ & μ, insertion and replacement vectors. Cosmids and Phagmid, yeast 2 μ plasmid, Yeast (episomal, integrative and replicative) plasmid, Yeast Artificial Chromosomes (YAC) vector, shuttle vector, BAC, cloning vectors of higher plant (*A. tumefacians*) and Ti plasmid, use of plant viruses as cloning vectors. Vectors used on animal viruses. (10 L)
4. **Clone Identification**: Genomic library, c-DNA library, identification of clone of a specific gene from libraries through hybridization probing and immunological screening methods, radioactive & non-radioactive labelling of probes. (4 L)
5. **Studying Gene & Genome Structure**: Locating the position of a cloned gene or a small DNA molecule (Southern transfer & hybridization). Localization of the position of a cloned gene or a large DNA molecule (Pulse Field Gel Electrophoresis) insitu hybridization, walking along chromosome, automated DNA sequencing, RFLP analysis & its application. (7 L)
6. **Expression of Cloned Gene**: Special vectors for expression of foreign genes in *E. coli*. Problems with the production of recombinant proteins in *E. coli* with inserted eukaryotic DNA, techniques of Gel retardation and foot printing to study gene regulation. Invitro mutagenesis & protein engineering. (7 L)
7. **Genomics & Proteomics**: Functional genomics and proteomics, proteomics in disease, transcriptosomes. (6 L)
8. **Application of Genetic Engineering**: General account of application in medicine, food and agriculture. Production of insulin, B-virus vaccine (medicine & health care); single cell protein / single cell fat (food) and disease resistant plant (agriculture) by using recombinant DNA technology. (7 L)

Paper 402: Bioinformatic & Bioethics 50 marks (45 + 5*)

Bioinformatics: 35 marks

1. Introduction to digital computer: MS-DOS and Microsoft Office. (5 L)
2. Computer languages in Bioinformatics, application of C language in Bioinformatics. A brief account of PERL. (5 L).
3. Biological Sequence submission in different databases. Different sequence format (GenBank, FASTA, NBRF); DBMS in Bioinformatics. (7 L)
4. Definition and significance of pair wise sequence alignment, Methods involved in Pair wise sequence alignment. Dot matrix and Dynamic programming, Algorithm and K-Tuple method. (6 L)

5. Concept of scoring matrix: PAM and BLOSUM (3 L)
6. Definition and significance of Multiple sequence Alignment, Methods for scoring MSA. (4 L)
7. Database searching for similar sequences, Algorithms used in BLAST and FASTA, CLUSTAL- X. (5 L)
8. Phylogenetic analysis, concept of phylogenetic tree, NJ method, Fitch-Margoliash method for phylogenetic analysis. Parsimony analysis. (5 L)

Bioethics: 10 marks

1. **Social and Economic Effects of Micro-biotechnology**: Micro-business involving Micro-biotechnology and consumer acceptance of Micro-biotechnology. (2 L)
2. **Environmental Safety**: Balance of genetically altered and natural microbial population in an ecology, bio-safety guidelines for industrial operation with GMOs. Biodiversity in relation to GMOs. (2 L)
3. **Regulation Issues**: Pros an cons of gene modification / transfer, health dilemmas, protection of consumers. (2 L)
4. **Intellectual Property Right**: Issues, protection, trade secretes, trademarks, copy right, Indian Patent Law 1970, GATT, TRIP, patenting of biological material, farmer's right, implication of patenting, Cartagene Protocol. Modified Indian Patent Law 2001. (4 L)

Paper 403-Agriculture & Environmental Microbiology **50 marks (45 + 5*)**

Agricultural Microbiology:

1. Microbial biofertilizer, types and microbes used, characteristics of inoculant production, production of inoculant biomass, formulation & packaging technology, application of microbial inoculant, PGPR (plant growth promoting bacteria of rhizosphere). (4 L)
2. Microbial insecticides- types, microbes used production of inoculants and application. (2 L)
3. Host-parasite interaction. Important diseases in agricultural crops by bacteria (crown gall), viruses (CaMV) and fungi (rust of wheat) and their control (chemical & biological). Microbial diseases of aquacultural animals- finfish and shell fish.(5 L)
4. Plant-Microbe interaction: molecular mechanism of disease development (enzyme, toxin, hormonal disturbances). Resistance by hosts- anatomical & biochemical mechanisms. Role of phytoalexins, PR proteins; control of diseases (chemical, physical, biological & biotechnological). (7 L)

Environmental Microbiology:

5. Microbial ecology- Concept, development of microbial community in biosphere, biofilm and its ecological implication. Microbial diversity, extremophiles- ecological adjustment and molecular adaptations in extreme conditions. (6 L)
6. Interaction of microbes in food web and energy flow in food web (2 L)
7. Tools of studying microbial ecology-traditional techniques, molecular tools, biosensor technology, BIOPOL, multispecies modeling. (4 L)
8. Microbe- microbe interaction and microbial survival. (4 L)

9. Microflora of various soil types, subterranean microbes. (2 L)
10. Microbial assessment of water quality, microbes as bio-indicators, potability of water, treatment of municipal water. (3 L)
11. Solid and liquid based treatment, biological (aerobic, anaerobic, primary, secondary & tertiary) treatment. (5 L)
12. Bioremediation of xenobiotics, pollutants, recalcitrants; bioaccumulation, biomagnifications of toxicants including heavy metals and their detoxification.(6 L)

Paper- 404: Practical -Recombinant DNA Technology and Bioinformatics

50 marks

Recombinant DNA Technology **35 marks**

1. Restriction enzyme digestion of DNA, electrophoresis and documentation.
2. Reporter gene assay by kit (β-gal).
3. Bacterial transformation by heat shock method.
4. Southern blotting technique and labeling of DNA.
5. DNA amplification by PCR
6. Isolation of total RNA from bacterial cell.

Bioinformatics **15 marks**

7. Programming of different languages, Data analysis and modeling, NET working. Searching of BLAST and FASTA known sequence.
8. Autoposis- Mathematics of complexity.
9. Sequence analysis of DNA and protein by bioinformatics.

Paper-405: Practical- Agriculture and environmental microbiology and report on industrial visit. FM-50

Group A 35 marks

1. Isolation of Cellulose and pectin decomposing bacteria from different habitat.
2. Study of VAM fungi.
3. Isolation of Iron & Sulphur oxidizing bacteria.
4. Isolation of free living Nitrogen fixers.
5. Physico- chemical analysis of water- pH, DO, phosphate, BOD & COD.
6. Demonstration of sewage treatment.
7. Isolation of TMV from infected plant & its electron microscopy.
8. Isolation of Metagenome from environmental samples.

Group B- Industrial Visit 15 marks

Paper 406- Project Work 50 marks