Department of Biochemistry, UCS, Osmania University

Approved MSc. CBCS Syllabus

(Effective for 2016 admitted batch)

SEMESTER I					
PAPERS	**TITLE**	**Teaching hrs/week**	**Credits**	**Internal marks**	**Final exam marks**
1	BI101T:Chemistry and Metabolism of Proteins and Lipids and Porphyrins (core)	4	4	20	80
2	BI102T:Chemistry and metabolism of Carbohydrates, Vitamins and Nucleic acids (core)	4	4	20	80
3	BI 103T: Bio-Analytical Techniques (core)	4	4	20	80
4	BI104T:Bioenergetics and Cell Biology (core)	4	4	20	80
5	BI105P:Biomolecules	8	4	--	100
6	BI106P:Bioanalytical Techniques	8	4	--	100
Total		32	24	80	520
SEMESTER II					
PAPERS	**TITLE**	**Teaching hrs/week**	**Credits**	**Internal marks**	**Final exam marks**
1	BI201T:Enzymology (core)	4	4	20	80
2	BI202T:Molecular Biology (core)	4	4	20	80
3	BI203T:Biochemical Genetics and Model Organisms (core)	4	4	20	80
4	BI 204T: Endocrinology and Metabolic Disorders (core)	4	4	20	80
5	BI205P: Enzymology and Molecular **B**iology	8	4	--	100
6	BI206P: Molecular Biology and bioinformatics	8	4	--	100
Total		32	24	80	520
SEMESTER III					
PAPERS	**TITLE**	**Teaching hrs/week**	**Credits**	**Internal marks**	**Final exam marks**
1	BI301T:Gene Regulation and Genetic Engineering (core)	4	4	20	80
2	BI302T:Immunology and Immunotechnology (core)	4	4	20	80
3	BI303T (Elective) A: Nutrition and Clinical Biochemistry B: Advanced Applied Biochemistry	4	4	20	80
4	BI304T: Human Physiology and Xanobiotics (ID/Elective)	4	4	20	80
5	BI305P:Recombinant DNA and Immunotechnology	8	4	--	100
6	BI306P: Elective A: Nutrition, Clinical Biochemistry and Reproductive Biology B: Advanced Applied Biochemistry	8	4	--	100
Total		32	24	80	520
SEMESTER IV					
PAPERS	**TITLE**	**Teaching hrs/week**	**Credits**	**Internal marks**	**Final exam marks**
1	BI401T: Biostatistics and Bioinformatics (core)	4	4	20	80
2	BI402T: Cell-Cell Junctions and Signal Transduction (core)	4	4	20	80
3	BI403T: Bacteriology and Virology (Elective)	4	4	20	80
4	BI404T: Biotechnology (Elective)	4	4	20	80
5	BI405P: Bacteriology and Virology	8	4	--	100
6	BI 406 P: Project	8	4	--	100
Total		32	24	80	520

Note: 1. Seminars should be conducted at the end of the Semester III for 25 marks which is not included in the total marks. Students must discuss on the merits and demerits of a published research paper. Evaluation can be done by the internal staff.

2. No change in examination paper format

Paper-I: BI 101T: Chemistry and Metabolism of Proteins and Lipids &Porphyrins (4 Credits; 100 Marks)

Credit – I: Chemistry of Amino Acids, & Proteins

1. Classification and structure of 20 aa, essential, non–essential, unusual and non-protein
2. General properties of aa, acid – base titrations, pKa
3. Peptide bond – stability and formation, Primary structure, GN Ramachandran plots
4. Secondary structure and motifs, α helix, β sheet, 3-10 helix
5. Leucine zipper, Zinc finger, Trans-membrane regions, LHL
6. Tertiary & Quaternary structure (myoglobin, hemoglobin)
7. Protein-protein interactions (actin, tubulin)
8. Small peptides (glutathione, peptide hormones), Cyclic peptides (Gramicidin)
9. Classification of proteins-globular, fibrous, membrane, metallo-proteins, SCOP, CATH
10. Denaturation (pH, temperature, chaotropic agents), refolding, Role of chaperones in folding

Credit – II: Metabolism of Amino acids, & Proteins

1. Metabolic fate of dietary proteins and amino acids
2. Degradations to glucose and ketone bodies
3. Amino acids degraded to Pyruvate, Oxaloacetate
4. Amino acids degraded to Acetyl-CoA, Succinyl-CoA
5. Metabolism of branched chain amino acids
6. Role of glutamate cycle information & circulation of ammonia
7. Glucose alanine cycle, urea cycle
8. Linking of citric acid and urea cycles, regulation of urea cycle
9. Genetic defects in metabolism of amino acids (albinism, Phenylketonuria, maple syrup urine disease, homocystinuria alkaptonuria, methyl malonic Acidemia)
10. Genetic defects in metabolism of urea (Argininemia, Arignosuccinic Acidemia, Carbamoyl Phosphate Synthetase-I deficiency)

Credit – III: Chemistry of Lipids &Porphyrins

1. Classification & biological significance of lipids & fatty acids
2. Steroids, Sterols, relation to vitamin D and steroid hormones
3. Bile acids and salts, Phospholipids
4. Oils, waxes, isoprene units
5. Lipoproteins
6. Glycolipids, Sphingolipids
7. Structure & function of porphyrins (e.g. Heme, Chlorophyll)
8. Cerebrosides, Gangliosides
9. Prostaglandins, Prostacyclins
10. Thromboxanes, Leukotrienes

Credit – IV: Metabolism of Lipids & Porphyrins

1. Fate of dietary lipids and Apo-lipoproteins
2. Fatty acid biosynthesis, Desaturation of fatty acids
3. Beta oxidation, breakdown of odd chain fatty acids, energy yields
4. Regulation of β – oxidation, ώ – oxidation & α – oxidation
5. Metabolism of phospholipids &Sphingolipids
6. Regulation and Biosynthesis of cholesterol and other steroids
7. Fate of acetyl CoA, formation of ketone bodies and ketosis
8. Biosynthesis of prostaglandins, Prostacyclins, Thromboxanes, Leukotrienes
9. Role of HDL, LDL, and Very-low-density lipoprotein (VLDL) and cholesterol levels in body
10. Catabolism of Porphyrins, Genetic defects in lipid and nucleotide metabolism, Medium chain acyl coenzyme A dehydrogenase deficiency MCAD, Long-chain 3-hydroxyacyl-CoA dehydrogenase (LCHAD) deficiency, Familial hypercholesterolemia, Gout

References:

1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox Publisher: W. H. Freeman.
2. Biochemistry-Jeremy M Berg, John L Tymoczko, and Lubert Stryer.: W H Freeman
3. Biochemistry, 4th Edition - Donald Voet, Judith G. Voet. – Publisher John Wiley & Sons.

Paper - II: BI 102T:Chemistry Metabolism of Carbohydrates, Nucleic Acids and Vitamins (4 Credits; 100 Marks)

Credit – I: Chemistry of Carbohydrates

1. Classification, monosaccharides (aldoses & ketoses)
2. Configuration and conformation of monosaccharides (pyranose & furanose, chair & boat)
3. Reducing and optical properties of sugars
4. Stability of glycosidic bond disaccharides, oligosaccharides
5. Structural polysaccharides-cellulose, hemicellulose, pectin, lignin, chitin, chitosan
6. Storage polysaccharides; starch, glycogen, inulin
7. Steric factors in polysaccharides folding, sugar code and lectin
8. Glycosaminoglycans, mucopolysaccharides, hyaluronic acid
9. Chondriotin sulfate, keratan sulfate, dermatan sulfate
10. Bacterial cell wall – proteoglycans and peptidoglycans

Credit – II: Metabolism of Carbohydrates

1. Reactions and energy balance in Glycolysis
2. Reactions and energy balance in Gluconeogenesis
3. Reactions and energy balance in TCA cycle
4. Pentose phosphate, Pasteur and Crabtree effect
5. Anaplerotic reactions
6. Glyoxylate cycle
7. Glucuronic acid cycle
8. Glycogen metabolism
9. Photosynthesis reactions for biosynthesis of glucose
10. C3 and C4 cycles in plants

Credit – III: Chemistry and Metabolism of Nucleic Acids

1. Purines, pyrimidines, nucleosides, nucleotides, unusual bases
2. Structure of DNA – Watson Crick Model, A- and Z- forms
3. Supercoiling of DNA – negative and positive, linking number
4. Structure of RNA, tRNA, rRNA, siRNA / miRNA
5. Properties of NA – denaturation and renaturation
6. Tm (factors affecting T_m) and $C_o t$ curves
7. Heteroduplex mapping – D loops and R loops
8. Biosynthesis of purines and pyrimidines
9. Degradation of purines and pyrimidines
10. Regulation: *de novo*, salvation, nucleotide analogs

Credit – IV: Chemistry and Metabolism of Vitamins

1. Discovery of vitamins, classification, RDA
2. Vitamin A – source, biological role, deficiency
3. Vitamin B1 – Thiamine – source, biological role, deficiency
4. Vitamin B2 – Riboflavin – source, biological role, deficiency
5. Vitamin B3 – Niacin – and B5 – Pantothenic acid – sources, biological role, deficiency
6. Vitamin B6 – Pyridoxamine – and B7 – Biotin – source, biological role, deficiency
7. Vitamin B9 – Folic acid – and B12 – Cobalamine – source, biological role, deficiency
8. Vitamin C – Ascorbic acid – source. Biological role, deficiency
9. Vitamin D – Calciferol – source, biological role, biological role, deficiency
10. Vitamin E, Vitamin K – source, biological role, deficiency

References:

1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox Publisher: W. H. Freeman.
2. Biochemistry-Jeremy M Berg, John L Tymoczko, and Lubert Stryer.: W H Freeman
3. Biochemistry, 4th Edition - Donald Voet, Judith G. Voet – Publisher John Wiley & Sons
4. Principles of Biochemistry: Mammalian Biochemistry: Smith EL, Hill RL, … White A, McGraw Hill

Paper - III: BI 103T: Bioanalytical Techniques. (4 Credits; 100 Marks)

Credit – I: Spectroscopy

1 Beer Lambert's Law, Molar extinction coefficient, Absorption maximum
2 UV-Vis: Spectroscopy, Colorimetry – principle, instrumentation, application
3 Fluorescence Spectroscopy – principle, instrumentation, application
4 Atomic Absorption Spectrometry – principle, instrumentation, application
5 NMR – principle, instrumentation application
6 ESR – principle, instrumentation application
7 CD – principle, instrumentation, application
8 ORD – principle, instrumentation, application
9 Mass spectroscopy – principle, instrumentation, application
10 X-ray crystallography

Credit – II: Chromatography

1 Partitioning and counter current distribution
2 PC – principle, instrumentation, application
3 TLC – principle, instrumentation, application
4 GC – principle, instrumentation, application
5 Ion–exchange – principle, instrumentation, application
6 Gel filtration (Gel exclusion chromatography) – principle, application
7 Affinity chromatography – principle instrumentation, application; immunoprecipitation
8 HPLC and RP-HPLC – principle, instrumentation, application
9 FPLC, LC – principle, instrumentation, application
10 Peptide mapping and N-terminal sequencing of proteins

Credit – III: Centrifugation and Electrophoresis

1 Centrifugation, RCF and types of rotors
2 Ultracentrifugation – principle, instrumentation, application
3 CsCl density gradient and sucrose gradient centrifugation – principle, application
4 Electrophoresis – moving boundary and zonal electrophoresis
5 Native and SDS PAGE, IEF and 2D PAGE
6 Agarose Gels, PFGE
7 Zymography, PAGE for DNA sequencing
8 DNase-I hypersensitivity mapping
9 DNA-Foot-printing and Chromatin IP methods
10 Denaturing gels for RNA, Southern and Northern Blots

Credit – IV: Tracer Techniques

1 Stable and radioactive isotopes, Radioactivity theory, half life and emission spectra of half life of biologically useful isotopes - ^{2}H, ^{3}H, ^{14}C, ^{18}O, ^{32}P, ^{35}S, ^{125}I
2 Isotopes used for labeling proteins (^{3}H ^{14}C, ^{35}S, ^{125}I) and nucleic acids (^{3}H, ^{32}P)
3 Detection of radioactivity by Scintillation counting
4 Autoradiography, Fluorography, Phosphor-imaging, applications
5 GM counter, gamma counter
6 Radiation hazards and safe disposal of radioactivity waste; luxometry and chemiluminescence as alternative to radioactivity
7 Isotope dilution method – pulse chase
8 Historic examples- ^{14}C and ^{18}O to study photosynthesis
9 Historic examples- ^{32}P and ^{35}S to study viral replication (Hershey-Chase experiment)
10 Historic examples- ^{14}N and ^{15}N in DNA replication (Meselson and Stahl experiment)

References:

1. Principles and Techniques of Practical Biochemistry- Wilson. K. And Walker. J. Pub: Cambridge Press
2. Physical Biochemistry- Friefelder, Publisher D. W.H. Freeman Press
3. Biophysical Chemistry: Principles and Techniques, 2nd edition by A. Upadhyay, K. Upadhyay and N. Nath. Himalaya Publishing House, Delhi.
4. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox Publisher: W. H. Freeman

Paper – IV: BI 104T: Bioenergetics and Cell Biology. (4 Credits; 100 Marks)

Credit – I: Bioenergetics

1. Elements of importance in biochemistry (H, C, N, O, P, S), types and energy of bonds and interactions (ionic, covalent, coordinate, H-bonds, van der Waals, hydrophobic interactions)
2. Laws of thermodynamics, Gibbs free energy, relevance of entropy and enthalpy in biological systems and reactions; first and second-order reactions
3. Log and ln scales in biological processes (exponential growth curves, radioactive decay)
4. Biological oxidation, high energy compounds
5. High energy bonds, redox and phosphate potential
6. Structure of membrane, forces stabilizing membranes
7. Formation of ion gradients across a membrane (proton gradients in organelles), role of transporters and channels
8. ETC in mitochondria and chloroplasts, un-couplers and inhibitors of energy transfer
9. Polarization of cell, resting potential, action potential, propagation of impulse
10. Biological fluorescence (GFP and derivatives), Bioluminescence

Credit – II: Structure of Prokaryotic cells

1. Classification of prokaryotes (systems of classification)
2. Ultra-structure of eubacteria, cyanobacteria, mycoplasma
3. Motility of bacteria, bacterial films, isolation of bacteria from natural sources
4. Sterilization of materials (autoclaving, dry heat, filtration, chemical disinfection, irradiation) and commonly-used media (minimal, enriched, selective) for bacterial growth
5. Staining methods for bacteria; maintenance, and preservation of bacterial cultures
6. Growth curve, Doubling time, Factors effecting growth – pH, temperature, oxygen, agitation
7. Batch and continuous growth of bacteria, chemostat, synchronized cultures
8. Industrial (large-scale) growth of bacteria, fermenter design
9. Bacteria of industrial importance, development of commercially valuable strains
10. Discovery of antibiotics, mode of action of various classes of antibiotics, antibiotic resistance

Credit - III: Structure of Eukaryotic cells

1. Ultra-structure of animal cells
2. Ultra-structure of plant cells
3. Composition of cytoskeleton-microfilaments, microtubules, intermediate filaments
4. Nuclear skeleton-lamina, scaffold
5. Vesicle trafficking (endocytosis, exocytosis), role of Rabs and RabGTPases
6. Structure of chromatin and chromosomes (centromere, telomere, kinetochore)
7. Mitosis, meiosis, and interaction of chromatin with cytoskeleton (attachment of spindle fibers).
8. Formation and structure of special chromosomes (polytene, lampbrush)
9. Cell cycle
10. Apoptosis

Credit – IV: Methods of Cell Study

1. Simple and compound microscope.
2. Phase contrast, dark field and polarization microscopy.
3. Electron microscopy, SEM, TEM; freeze fracture.
4. Fluorescence and Confocal microscopy; imaging live cells.
5. FRET and FRAP.
6. Atomic force microscopy.
7. Flow-Cytometry and cell sorting (FACS).
8. Plant tissue culture.
9. Animal and insect tissue culture.
10. Methods of cell disruption and fractionation, isolation of organelles.

References:

1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox Publisher: W. H. Freeman
2. Molecular Biology of the Cell, 3rd edition. Bruce Alberts, Dennis Bray, Julian Lewis, Martin Raff, Keith Roberts, and James D Watson. Publisher New York: Garland Science;
3. The Cell: A Molecular Approach, Fifth Edition, by Geoffrey M. Cooper and Robert E. Hausman, published by ASM Press

Semester I: Practical's
(Note: Each topic corresponds one practical session)

Paper V: BI 105P: Biomolecules (3 credits; Max Marks 75)	**Paper VI: BI 106P: Bioanalytical Techniques** (4 Credits; Max Marks 100)
1 Lab safety, GLP, calculations and preparation of standard solutions 2 Preparation of buffers, use of balance and pH meter 3 Qualitative analysis of amino acids 4 Determine **pKa** and **pI** of acidic, basic, and neutral amino acids 5 Estimate amino acids by Ninhydrin methods 6 Quantify glycine by formal titration 7 Estimate tryptophan by Spies and Chambers method 8 Qualitative analysis of carbohydrates 9 Estimate total sugars by phenol sulfuric acid method 10 Estimate reducing sugars by DNS 11 Estimate fructose by Roe's method 12 Qualitative analysis of lipids 13 Saponification value of fats 14 Iodine number of oil 15 Peroxide value of fats 16 Acid value of fats 17 Estimate DNA by DPA 18 Estimate RNA by Orcinol- Method 19 SDS PAGE for proteins 20 Agarose gel for DNA	1 Absorption spectrum of tyrosine, determination of molar extinction coefficient, calculations based on Beer Lambert's Law 2 Estimate inorganic phosphate by Fiske-Subbarow method 3 Estimate protein by Biuret method 4 Estimate protein by Lowry method 5 Titrate calcium in milk 6 Titrate vitamin C 7 Photometric analysis of iron 8 AAS analysis of metals 9 Anion-exchange capacity of resin 10 Cation-exchange capacity of resin 11 Separate amino acids by ion-exchange chromatography 12 Separate purines and pyrimidines by paper chromatography 13 1-D PC of amino acids 14 2-D PC of amino acids 15 PC of plant pigments 16 TLC of plant pigments 17 TLC of lipids 18 Desalting proteins by dialysis 19 Gel filtration (size exclusion) 20 Cell fractionation (centrifuge)

Project ideas:

1 Compare pigments in different plant parts, different flowers, plants and algae
2 Compare unsaturation of various oils and fats
3 Determine sugar /vitamin C content in various fruits and soft drinks, calcium content in various milk brands

References:

1. An introduction to practical biochemistry. By: David T Plummer. Publisher Tata McGraw- Hill
2. Biochemical Calculations – Segel, I.H. John Wiley & sons
3. Experimental Biochemistry: A Student companion- Sashidhar Rao, B and Deshpande, V. IK International (P) Ltd
4. Experiments And Techniques In Biochemistry: by Sheel Sharma, Galgotia publications.

Paper-I: BI 201T: Enzymology. (4 Credits; 100 Marks)

Credit – I: Enzymes, Coenzymes, and catalysis

1. Thermodynamics of catalysis, Energy of activation, Relation of □G and K_{eq}
2. Coupled reactions (endergonic and exergonic) in biochemical pathways
3. Methods to isolate and purify enzymes, Assays, Activity Units, Specific activity
4. Nomenclature and classification of enzymes: EC, SCOP, CATH
5. Metal, co-factor, and co-enzyme requirements
6. Vitamin cofactors: TPP, FMN/FAD, NAD/NADP, Pantothenic acid
7. Vitamin cofactors: PLP, Biotin, Folate, Cobalamine, Phylloquinone
8. Factors affecting catalysis (pH, temperature, pressure, enzyme and substrate concentration)
9. Chemicals to identify active site residues: Arg, Cys, Lys, His
10. Site-directed mutagenesis to identify active site residues: Triose Phosphate Isomerase

Credit – II: Enzyme Kinetics

1. Single substrate assumptions, Briggs -Haldane equation.
2. Steady state, Michaelis-Menton kinetics (derive equation and transformations)
3. Transformation of Michaelis-Menton equation.
4. Bi substrate reactions: ordered, random, sequential, Ping-Pong
5. Distinction between ordered and random addition of substrates and products release.
6. Inhibitors (competitive, uncompetitive, noncompetitive, suicide), effect on kinetic constants
7. Enzyme inhibitors as drugs: RT and Protease inhibitors as anti-HIV drugs
8. Cooperativity in binding (oxygen binding to hemoglobin)
9. Multiple sites; Cooperativity: MWC model, KNF model
10. Slow transition and Hysteretic behavior in enzymes

Credit – III: Catalytic Mechanisms

1. Types of catalysis: acid-base, transition state, covalent intermediates
2. Reversible and irreversible activation of enzymes (pro-enzymes, phosphorylation)
3. Enzymes activation by ligand binding and dimerization (protein tyrosine kinase receptors)
4. Catalytic mechanism of RNase
5. Catalytic mechanism of Chymotrypsin, Trypsin
6. Catalytic mechanism of Lysozyme
7. Catalytic mechanism of Carboxypeptidase, Subtilisin
8. Allosteric regulation of Aspartate Transcarbamylase
9. Regulation of Glutamine Synthetase
10. Multi-enzyme Complex: fatty acid synthase

Credit – IV: Enzymes in Physiology and Biotechnology

1. Regulatory enzymes in carbohydrate metabolism (glycolysis, TCA cycle)
2. Regulatory enzymes in nucleotide metabolism
3. Enzyme cascades (blood clotting, complement activation)
4. Enzyme cascades (cell division and apoptosis)
5. Convergent and divergent evolution of enzymes
6. Reporter enzymes for gene expression (□-gal, □-glucuronidases, CAT); Restriction enzymes and ligases in recombinant DNA technology
7. Enzymes in dairy (Rennin, lipases, lactases), brewing (amylases, proteases, glucanases), Food processing technology (invertase, pectinases, papain)
8. Enzymes in detergent (lipases, cellulases, proteases), paper (cellulases), and tanning
9. Enzymes in bioremediation, biofuel industry (cellulases)
10. Enzyme engineering: Catalytic RNA and antibodies; Designing High-Throughput enzyme assays

References:

1. Fundamentals of Enzymology, Price.NC. And Stevens. L., Oxford University Press
2. Enzymes- Biochemistry, Biotechnology, Clinical chemistry- Palmer, T., Affiliated East-West press
3. Fundamentals of Enzyme Kinetics, Segel I H; Wiley Interscience,
4. Biochemical calculations, 2nd Edition By Irwin H. Segel. John Wiley & Sons,
5. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox Publisher: W. H. Freeman

Paper- II: BI 202T:Molecular Biology. (4 Credits; 100 Marks)

Credit – I: DNA Replication

1. Models of replication – random, conservative, semiconservative
2. Prokaryotic and eukaryotic DNA polymerases, helicases, ligases, topoisomerases
3. Initiation – primosome, ori-sequences, accessory proteins
4. Elongation – replisome, leading and lagging strands, Okazaki fragments
5. Termination, Inhibitors of replication
6. Replication of circular chromosomes by theta model-φX174, E. coli
7. Replication of circular chromosomes by rolling circle (lambda phage) and Strand displacement models (mt-DNA)
8. Replication of linear chromosomes, telomeres, telomerase
9. Amplification – Polytene and double minute chromosomes
10. *In vitro* replication - PCR

Credit – II: DNA Repair

1. Types of damage – oxidation, deamination, alkylation, adducts, breaks
2. Direct repair – MGMT, photo-reactivation, AlkB
3. Base Excision Repair (Short and Long Patch)
4. Nucleotide Excision Repair
5. Mismatch Repair
6. Repair of DSBs by NHEJ and Homologous recombination
7. Holliday junctions and repair of collapsed forks
8. SOS and bypass repair
9. Diseases due to defects in DNA repair
10. Roles of ATM, BRCA in DNA repair

Credit – III: Transcription and Translation

1. Prokaryotic and eukaryotic RNA polymerases
2. Initiation – prokaryotic and eukaryotic promoter sequences
3. Elongation, Termination – rho dependent and independent
4. Post-transcriptional modifications - capping, Poly A addition
5. Splicing, RNA editing; Inhibitors of transcription
6. Structure of ribosome, nature of genetic code
7. Initiation of translation (role of cap, IRES IFs)
8. Elongation of translation (role of EFs)
9. Termination of translation (role of RFs)
10. Inhibitors of protein synthesis

Credit – IV: Protein Sorting, Targeting and degradation

1. Post translational modifications of proteins, role in targeting (isoprenylation)
2. Signal peptide (ERLS), role of SRP in translation of secreted proteins
3. NLS, Mitochondrial & chloroplast LS
4. Chaperones, HSPs in protein folding
5. Lysosomal pathways (endocytosis, crinophagy, macroautophagy, microautophagy, direct translocation from cytosol)
6. Lysosomal storage diseases
7. Ubiquitin-proteasome pathway, N-end rule
8. Immuno-proteasomes, Misfolded proteins in neurodegenerative diseases,
9. PEST sequences and proteolysis
10. Action of cytotoxic, hemotoxic, myotoxic & hemorrhagic venoms

References:

1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox Publisher: W. H. Freeman.
2. Molecular Biology of the Cell, 3rd edition. Bruce Alberts, Dennis Bray, Julian Lewis, Martin Raff, Keith Roberts, and James D Watson. Publisher New York: Garland Science;
3. Biochemistry, 4th Edition - Donald Voet, Judith G. Voet – Publisher John Wiley & Sons
4. The Cell: A Molecular Approach, by Geoffrey M. Cooper and Robert E. Hausman, pub. ASM Press

Paper-III: BI 203T: Biochemical Genetics and Model Organisms. (4 Credits; 100 Marks)

Credit – I: Mendelian Genetics

1. Mendel's Laws, Importance of meiosis in heredity
2. Non-Mendelian Inheritance – Maternal effect, Maternal influence, Cytoplasmic inheritance
3. Gene interactions - Epistasis, Expressivity, Penetrance
4. Sex linked, sex limited, and sex influenced genes; Polygenic inheritance and polyploidy
5. Mutations (spontaneous / induced, somatic / germinal, forward / reverse, transition / transversions)
6. Mutations (Silent, missense, nonsense, and frame shift mutations, conditional, leaky)
7. Detection, selection & isolation of microbial mutants, Estimation of mutation rates
8. Reversion and suppression of mutations
9. Mutagens – physical, chemical
10. Transposon mutagenesis, site-directed mutagenesis

Credit – II: Linkage and Mapping

1. Discovery of linkage, Morgan's experiments
2. Cytological proof of crossing over
3. 2- and 3- point crosses
4. Recombination, Interference
5. Tetrad analysis
6. Mapping human genes by pedigree analysis; Fundamentals of population genetics (HW Law)
7. Pedigrees of AR, AD, XR, and XD inherited traits
8. Mobile genetic elements – Zea Ac, Ds and Spm elements
9. *Drosophila copia*, Yeast Ty elements
10. Using recombination to make knockout cells / organisms

Credit – III: Bacterial Genetics

1. Discovery of conjugation
2. Mapping bacterial genes by conjugation
3. Discovery of transformation
4. Mapping bacterial genes by transformation
5. Discovery of transduction
6. Mapping bacterial genes by transduction
7. Discovery of transposition
8. Structure of transposons, replicative and conservative transposition, use as mutagens
9. Mapping phage genes – Fine structure of rII locus: Complementation analysis
10. Fine structure of rII locus: Deletion mapping

Credit – IV: Model Organisms

1. *Dictyostelium* to study cell – cell communication and differentiation.
2. *Saccharomyces* to study homologous recombination in mating type switch; site of formation of buds
3. *Neurospora* to study one gene – one enzyme hypothesis
4. *Drosophila* to study embryonic development (homeotic mutations)
5. *C. elegans* to study development and nervous system
6. *Danio* to study vertebrate development, GLO fish
7. *Xenopus* to study embryogenesis
8. *Mus* inbred and knockout strains, NOD and nude mice
9. *Zea* to demonstrate cytological proof of crossing over
10. *Arabidopsis* to study flower development

References:

1. Microbiology –Prescott LM, Harley JP. & Klein DA, McGraw-Hill
2. Principles of Genetics by Eldon John Gardner, Michael J. Simmons, D. Peter Snustad; John Wiley
3. Modern Genetic Analysis Anthony JF Griffiths, William M Gilbert, Jeffrey H Miller, and Richard C Lewontin. Pub. W. H. Freeman

Paper-IV: BI 204T: Endocrinology and Metabolic Disorders. (4 Credits; 100 Marks)

Credit – I: Hormones and Endocrine glands

1 History of endocrinology
2 Organization and classification of hormones and endocrine systems
3 Basic mechanism of action of peptide hormones and receptors
4 Basic mechanism of action of steroid hormones and receptors
5 Chemistry, physiology, and disorders related to Hypothalamus-Pituitary axis
6 Chemistry, physiology, and disorders related to thyroid and parathyroid glands
7 Glycoprotein hormones (LSH, FSH, TH, hCG, POMC)
8 Growth hormone family (GH, hCS, Prolactin)
9 Adrenal hormones
10 Gonadal hormones

Credit – II: Endocrine regulation

1 Regulatory pathways (positive, negative, feedback loops), Regulation of biosynthesis of steroid hormones by peptide hormones (LH, FSH, ACTH)
2 Endocrine regulation of growth
3 Endocrine regulation of stress
4 Endocrinology of Ca homeostasis
5 Endocrinology of blood sugar, hunger, digestion, and obesity
6 Endocrine regulation of renal function
7 Endocrine regulation of cardiovascular system (angiotensin, BNP, ET1)
8 Endocrinology of fertility (changes in menstruation, pregnancy, and menopause)
9 Medical uses of steroid hormones (contraception, HRT, hydrocortisone, anabolic steroids)
10 Erythropoietin, Adipo-cytokines, Orexins

Credit – III: Disorders of Amino Acid and Carbohydrate Metabolism

1 Hyperphenylalaninemia
2 Disorders of proline and hydroxyproline metabolism
3 Alcaptonuria
4 Disorders of lysine metabolism
5 Disorders of tyrosine metabolism
6 Hemoglobinopathies; Thalassemia
7 Disorders of glycogen storage
8 Disorders of fructose metabolism
9 Disorders of Galactose metabolism
10 Pentosuria, Diabetes

Credit – IV: Disorders of Lipids and Nucleic Acids Metabolism

1 Disorders of acid Lipase deficiency
2 Farber's disease
3 Neeman-Picks disease
4 Goucher's disease
5 Krabbe disease
6 Sulphatide-lipdosis disease
7 Fabry disease
8 Downs and Turner's syndrome
9 Hyperuricemia and Gout
10 Heriditary Xanthine Urea and Lesch-Nyhan syndrome

References:

1. Williams Textbook of Endocrinology –Larsen, R.P. Korenberg, H.N.Melmed, S. and Polensky, K.S.Saunders.
2. Human Physiology –Chatterjee.C.C, Medical Allied Agency
3. Principles of Biochemistry: Mammalian Biochemistry: Smith EL, Hill RL, … White A, McGraw Hill
4. The metabolic basis of Inherited diseases (Vol I & II) Scriver CR..Valle D, Pub McGraw Hill

Semester II: Practicals
(Note: Each topic corresponds one practical Session)

Paper-V: BI 205P: Enzymology, Molecular Biology (3 credits; Max marks 75**)**	**Paper-VI: BI 206P: Molecular biology and bioinformatics** (4 credits; Max marks
1 N-terminal residue of proteins 2 Purify casein from milk, calculate yield at each step 3 Purify albumin from egg, calculate yield at each step 4 Fractionate BSA by salt precipitation 5 Assay urease (horse gram / any source) 6 Assay catalase (liver / any source) 7 Assay □□amylase (saliva) 8 Assay □□amylase (sweet potato) 9 Purify the enzyme; calculate yield, total activity and specific activity at each stage 10 Time course and enzyme concentration (salivary amylase) 11 Effect of pH on enzyme activity 12 Effect of temperature on enzyme activity 13 Effect of [S], determine K_m and V_{max} 14 Competitive inhibition 15 Saturation of Glutamine Synthetase or ATCase (cooperative enzyme) 16 Absorption spectrum, molar extinction coefficient of purine/pyrimidine 17 Isolate DNA (onion/thymus/other source), absorption spectrum to assess purity (A260/A280 ratio) 18 Determine T_m 19 Prepare RNA (yeast/other source) 20 Agarose gel for RNA, DNA, blot the gel	1. OMIM database and human genetic disorders 2. Retrieve DNA sequence from database (NCBI) 3. Retrieve protein sequence from database (NCBI) 4. Retrieve protein structure from database (PDB) 5. KEGG database for pathways 6. Local alignment of DNA, protein 7. Global alignment of DNA, protein 8. Multiple sequence alignments 9. Primer design for PCR 10. *in silico* PCR 11. *In silico* restriction mapping 12. *In silico* translation 13. HapMap and disease association 14. Preparation of competent E.coli cells 15. Bacterial transformation and calculating transformation efficiency. 16. Cloning desired gene into plasmid - Plasmid isolation 17. Cloning desired gene into plasmid - Restriction digestion 18. Cloning desired gene into plasmid - Ligation 19. Screening for positive clones by SDS-PAGE 20. Screening for positive clones by colony PCR

Project ideas:

1 Compare abundance of an enzyme in various sources
2 Compare sensitivity and/or specificity of different assays for the same enzyme
3 Find the effect of some treatment (drug) on your model organism
4 Screen natural sources for biodiversity (bacteria, phage, algae, antibiotic-resistant bacteria)
5 Use MS Excel or other software (R, SPSS) to analyze publicly available dataset, or do a population survey to generate your own dataset and analyze for correlation (age and BP, Physical exercise and weight, BP and blood glucose)

References:

1. Enzyme assays- A Practical Approach, Eisenthal, R and Dawson, MJ, IRL press
2. Practical Biochemistry- Rameshwar. A, Kalyani Publisher
3. Principles of Genetics by Eldon John Gardner, Michael J. Simmons, D. Peter Snustad; John Wiley
4. Modern Genetic Analysis Anthony JF Griffiths, William M Gelbart, Jeffrey H Miller, and Richard C Lewontin. Pub. W. H. Freeman;
5. Statistics, Basic Concepts and Methodology for the Health Sciences Daniel WW, Pub Wiley India
6. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox Publisher: W. H. Freeman.

Model paper: Theory

Duration 3 hours Max. Marks 80

Section - A (Short Answer Type)

Answer all Questions 8 x 4 = 32 Marks

1.

2.

3.

4.

5.

6.

7.

8.

Section - B (Essay Answer Type)

Answer all Questions 4 x 12 = 48 Marks

9. (A).

(OR)

(B)

10. (A)

(OR)

(B)

11. (A)

(OR)

(B)

12. (A)

(OR)

(B)

Model Paper Practicals (End of semester)

Time: 10.00 AM to 4.00 PM **Max. Marks 100**

1. Write the Principles for the following experiments 20 Marks
2. Major Experiment 40 Marks
3. Minor Experiment 20 Marks
4. Viva-Voce 10 Marks
5. Record 10 Marks

Department of Biochemistry, UCS, Osmania University

Approved MSc. CBCS Syllabus

(Effective for 2016 admitted batch)

SEMESTER I					
PAPERS	**TITLE**	**Teaching hrs/week**	**Credits**	**Internal marks**	**Final exam marks**
1	BI101T:Chemistry and Metabolism of Proteins and Lipids and Porphyrins (core)	4	4	20	80
2	BI102T:Chemistry and metabolism of Carbohydrates Vitamins and Nucleic acids (core)	4	4	20	80
3	BI 103T: Bio-Analytical Techniques (core)	4	4	20	80
4	BI104T:Bioenergetics and Cell Biology (core)	4	4	20	80
5	BI105P:Biomolecules	8	4	--	100
6	BI106P:Bioanalytical Techniques	8	4	--	100
Total		32	24	80	520
SEMESTER II					
PAPERS	**TITLE**	**Teaching hrs/week**	**Credits**	**Internal marks**	**Final exam marks**
1	BI201T:Enzymology (core)	4	4	20	80
2	BI202T:Molecular Biology (core)	4	4	20	80
3	BI203T:Biochemical Genetics and Model Organisms (core)	4	4	20	80
4	BI 204T: Endocrinology and Metabolic Disorders (core)	4	4	20	80
5	BI205P: Enzymology and Molecular **B**iology	8	4	--	100
6	BI206P: Molecular Biology and bioinformatics	8	4	--	100
Total		32	24	80	520
SEMESTER III					
PAPERS	**TITLE**	**Teaching hrs/week**	**Credits**	**Internal marks**	**Final exam marks**
1	BI301T:Gene Regulation and Genetic Engineering (core)	4	4	20	80
2	BI302T:Immunology and Immunotechnology (core)	4	4	20	80
3	BI303T (Elective) A: Nutrition and Clinical Biochemistry B: Advanced Applied Biochemistry	4	4	20	80
4	BI304T: Human Physiology and Xenobiotics (ID/Elective)	4	4	20	80
5	BI305P:Recombinant DNA and Immunotechnology	8	4	--	100
6	BI306P (Elective) A: Nutrition, Clinical Biochemistry and Reproductive Biology B: Advanced Applied Biochemistry	8	4	--	100
Total		32	24	80	520
SEMESTER IV					
PAPERS	**TITLE**	**Teaching hrs/week**	**Credits**	**Internal marks**	**Final exam marks**
1	BI401T: Biostatistics and Bioinformatics (core)	4	4	20	80
2	BI402T: Cell-Cell Junctions and Signal Transduction (core)	4	4	20	80
3	BI403T: Bacteriology and Virology (Elective)	4	4	20	80
4	BI404T: Biotechnology (Elective)	4	4	20	80
5	BI405P: Bacteriology and Virology	8	4	--	100
6	BI 406 P: Project	8	4	--	100
Total		32	24	80	520

Note: 1. Seminars should be conducted at the end of the Semester III for 25 marks which is not included in the total marks. Students must discuss on the merits and demerits of a published research paper. Evaluation can be done by the internal staff.

2. No change in examination paper format

Paper-I: BI 301T: Gene Regulation and Genetic Engineering. (4 Credits; 100 Marks) (Core)

Credit – I: Gene Regulation in Prokaryotes and Viruses

1. Operon concept for gene regulation
2. Positive (+ve) & Negative (-ve) control – Lac operon
3. Attenuation – Trp operon
4. Dual promoters – gal operon: Dual function of repressor – ara operon
5. Phase variation in Salmonella flagellar protein synthesis
6. Sporulation gene expression in Bacillus
7. Riboswitch
8. Anti – termination in lambda phage
9. Lytic / lysogenic switch in lambda phage
10. Control of plasmid copy number

Credit – II: Gene Regulation in Eukaryotes

1. Chromatin structure in active and inactive regions – DNA methylation.
2. Eu-chromatin, histone acetylation, H2AX foci, histone code
3. Transcriptional control – cell specific expression – promoters, enhancers, Transcription factors
4. Post- transcriptional control – alternative splicing RNA editing.
5. RNA transport and stability.
6. Translational feedback.
7. Gene silencing – inactivation of mammalian X chromosome.
8. Regulation by siRNA
9. Gal operon of yeast.
10. MAT locus and mating type switch in yeast, Antigenic variation in Trypanosoma

Credit–III: Recombinant DNA Technology

1. Enzymes in rDNA technology: Restriction endonucleases (discovery, properties)
2. Enzymes in rDNA technology: DNA and RNA polymerases
3. Enzymes in rDNA technology: Nucleases, Kinases, Phosphatases and Ligases
4. Prokaryotic and Eukaryotic vectors (plasmids, cosmids, phage, phagemid, BAC,YAC)
5. Shuttle vectors, Targeting vectors, Expression vectors(insect, plant and mammalian cells)
6. Construction of cDNA andgenomic DNA libraries
7. Screening library (+ve) & (-ve) selection strategies, Preparation of probes
8. Creating KO cells, Cre–Lox systems.
9. Sequencing DNA by Maxam-Gilbert and Sanger's method.
10. Sequencing DNA by Pyrosequencing, Solexa, SoLiD, Helicos, SMaRT, IonTorrent

Credit–IV: Genetic Engineering

1. Yeast 2 hybrid
2. Phage display
3. Reporter genes–GFP, b–gal, luciferase
4. Expression in heterologous systems–bacteria
5. Expression in heterologous system–yeast cells
6. Expression in heterologous system–insect cells
7. Expression in heterologous system–mammalian cells
8. Molecular markers–RFLP, AFLP
9. Random amplification of polymorphic DNA (RAPD).
10. Short tandem repeat, single-nucleotide polymorphism (SNP), Ribo-typing

References:

1. Genes VIII, Lewin, B, Publish Oxford University Press
2. Principles of Gene Manipulation: An introduction to GE – Old, R. and Primrose, S.B. Blackwell Sci. Pub
3. Molecular Biotechnology Glick, BR and Paternak, JJ. Publish ASM Press
4. Molecular Biology of the Gene by Whatson JD, …..Losick R. Pub Pearson Education

Paper-II: BI 302T: Immunology and Immunotechnology (4 Credits; 100 Marks) (Core)

Credit – I: Components of the Immune System

1. Brief history of immunology
2. Elements of Immune system - Natural & acquired immunity, Specific & non-specific immune response.
3. Cells & organs induced in immune system
4. Antigenic determinants, Epitopes, Concept of haptens. T-Cell and B-Cell epitopes, Super-antigens
5. Adjuvants – types of and their applications.
6. Classification, structure, and biological properties of immunoglobulins
7. Isotypes, allotype, idiotypes variations
8. Mucosal and neonatal immunity
9. Theories of antibody formation, Generation of antibody diversity
10. Genomic rearrangements & genes involved in antibody production

Credit – II: Immune Response

1. Humoral& cell-mediated immune response
2. T cell& B cell activation. T cell and B cell receptors
3. Antigen processing & presentation
4. MHC proteins structure & functions
5. Kinetics and regulation of immune response. Assembly and secretion of Ig. Class switching regulation
6. of immune response (brief out line)
7. Cytokines in immune response
8. Complement system – Biological consequences of complement fixation. Complement activation and types
9. (alternate, classical, Mannan-binding lectin pathway) and its regulation, Complement fixation test
10. Transplantation immunology (Types of graft rejection, mechanism of graft rejection, Graft vs host disease)Immune response to tumours

Credit – III: Immune Disorders

1. Hypersensitivity – Gell & Coombs classification. Allergen
2. Type I, II, III and V Hypersensitivity
3. Mechanism of activation
4. Tests for diagnosis of hypersensitivity, Tuberculin test
5. Auto immune diseases; classification
6. Mechanism and study of selected autoimmune diseases
7. Immuno- deficiency disorders – primary and secondary. AIDS
8. Immunosuppressive drugs/agents & their mechanism of action
9. ADA Deficiency
10. Microbial evasion of immune response

Credit – IV: Immunotechnology

1. Production of polyclonal antibodies. Experimental animals models for production of antibodies
2. Methods of antibody purification (Salt precipitation, Affinity chromatography)
3. Antigen-antibody binding analysis - Equilibrium dialysis; Affinity and Avidity of antibodies
4. Antigen-antibody interactions and visualization - gel diffusion (Ouchterlony, Mancini techniques),
5. Agglutination reaction.
6. Immune-electrophoresis (Rocket, counter-, 2-D), Immuno-fluorescence, RIA, Enzyme immune assay and their types
7. Western blotting and FACS techniques
8. Hybridoma technology – production of monoclonal antibodies and their applications; antibody engineering
9. Vaccines – Types, traditional vaccines and their applications Newer vaccine strategies (DNA, recombinant DNA, peptide and anti-idiotypic vaccines)
10. Vaccination schedules. Benefits and adverse consequences of vaccination

References:

1. Kuby Immunology – Edited Thomas J. Kindt, Richard A Goldsby, Publisher WH Freeman & Co
2. Roitt's Essential Immunology, Tenth Edition, Ivan Roitt, Peter Delves
3. Veterinary Immunology: Ian R. Tizard, I.R. Thomson press
4. The Immune System. By Peter Parham Publisher Garland publishing

Paper-III: BI 303 T: (Elective)
A: Nutrition and Clinical Biochemistry (4 Credits; 100 Marks)

Credit I: Nutrition

1. Balanced diet, Macro & Micro Nutrients, Caloric values (carbohydrates, proteins, lipids, alcohol)
2. Nutritional assessment by clinical testing; Anthropometric and Biochemical testing
3. BMR, measurement of BMR, factors affecting BMR and BMI
4. Organs of digestive system; Enzymes (amylases, proteases, lipases)
5. Hormones in digestion (stomach, pancreas; gastrin, secretin, CCK); Role of bile acids
6. Absorption; Control of food intake (leptin, ghrelin, peptide YY)
7. Malnutrition (PEM, Marasmus, Kwashiorkor), Obesity (BMI and other metrics)
8. Diabetes (Type 1, 2 and 3), Jaundice, Hepatitis
9. Cholesterol, sodium, and blood pressure
10. Eating disorders; Anorexia and bulimia; Diet and longevity, ageing.

Credit II : Food Science

1. Proximate analysis of common foods
2. Foods and their Nutrient content – cereals, pulses, nuts and fibre
3. Foods and their Nutrient content – fruits, vegetables, milk and milk products
4. Food spoilage and preservation
5. Food adulteration and hygiene, Principles of quality control
6. Food contaminants (metals, pesticides and aflatoxins) and food additives
7. Pre-biotics, Probiotics and Dietary fibres
8. Nutraceuticals – Bioactive components of - Amla, Cucumber, Fenugreek, dates, alfa-alfa, garlic, karela, onion, rice bran and spirulina
9. RDA for infants, children, adults and expectant / nursing mothers
10. National Nutritional policies and Nutritional Interventional programmes

Credit III: Clinical biochemistry

1. Sample collection, serum, plasma and anticoagulants, factors affecting the sample collection – Place, time, temperature and posture, Deproteinization, Identification, transport and storage
2. Quality control and assurance in clinical biochemistry
3. Complete Blood picture, prothrombin time, ESR and Erythrocyte metabolic disorders
4. Composition (including formed elements) and Coagulation of blood
5. Haemoglobin determination, Types and Abnormal Hbs. Hemoglobinopathies – Sickle cell Anaemia and Thalassemia, Thrombosis and Thrombolysis
6. Complete Urine Examination – Normal and abnormal constituents
7. Acid and Bases in the body; Plasma buffers and electrolytes; Mechanism of acid-base balance
8. Water and Electrolyte balance. Assessment of Na^+, K^+ and Cl^- levels in the body
9. Respiratory and renal regulation of pH, Acidosis and alkalosis (both metabolic and respiratory)
10. Oral rehydration therapy

Credit IV: Organ Function Tests and clinical enzymology

1. Tests for diagnosis of Gastrointestinal disorders
2. Liver function tests- conjugated and total bilurubin in serum, albumin: globulin ratio, hippuric acid and bromsulphthalein tests, Bile pigments in urine/faeces, carbohydrate tolerance tests, Cholesterol-cholesteryl ester ratio
3. Biochemical tests in acute and chronic kidney failure – Creatinine, Urea and Insulin clearance tests, phenol red test, Measurement of renal plasma flow
4. Biochemical tests for the diagnosis of heart diseases- HDL/LDL cholesterol, SGOT, LDH, CK, C-reactive protein, cardiac troponins.
5. Thyroid function tests
6. Pregnancy test
7. Hormone tests – Glucocorticoids including Cortisol, DHEA, Estrogen, Progesterone, FSH, Testosterone and Prostate Specific Antigen (PSA)

8. Serum enzymes in liver diseases- SGPT, GGT, alkaline phosphatase, Leucine amino peptidase
9. Prognostic and diagnostic importance of Amylase, phosphatase, cholinesterase, Aldolase Phosphohexose isomerase, lipoprotein lipase and isocitrate dehydrogenase
10. Enzymes as Tumour markers

References:

1 Nutritive value of Indian foods by C. Gopalan, B.V. Rama Sastri and S.C. Balasubramanian. National Institute of Nutrition, ICMR.

2 Essentials of Food and Nutrition –Swaminathan M. Bangalore Press

3 Manual of Nutritional Therapeutics, 2nd edition, Alpers (1991), Little Brown Publications, Washington.

4 Textbook of Medical Biochemistry by MN Chatterjea and Rana Shinde, Jaypee Brothers

5 Teitz Fundamentals of Clinical Biochemistry by Carl A. Burtis, Edward R. Ashwood and David E. Bruns. Saunders, Elsevier

6 Clinical Biochemistry: An Illustrated Colour Text (Paperback) 3rd Ed by Allan Gaw, Michael Murphy, Robert Cowan, Denis O'Reilly, Michael Stewart and James Shepherd. Churchill Livingstone.

7 Davidson's Principles and Practice of Medicine: A Textbook for Students and Doctors (Hardcover) 15th Ed by LSP Davidson, J MacLeod and CRW Edwards. Publisher: Churchill Livingstone.

Paper-III: BI 303 T: (Elective)
B: Advanced Applied Biochemistry (4 Credits; 100 Marks)

Credit – I: Molecular Diagnostics

1. Molecular Diagnostics – Evolution of the technology
2. Nucleic acid hybridizations – Principles and applications
3. PCR, RT-PCR, relative RT-PCR, competitive RT-PCR. Ligation assay – SNP detection by probe ligation and amplification (MLPA)
4. Genomic instability and mutations. PCR-based mutation detection - single-stranded conformational polymorphism analysis, heteroduplex analysis
5. RAPD, Rapid Amplification of cDNA ends (RACE), RNA fingerprinting. DNA chips, automation, gene therapy and diagnosis of various genetic disorders
6. DNA sequencing and genotyping; genetic mapping and linkage analysis
7. Molecular diagnosis of single-gene disorders – Factor V Leiden, lysosomal diseases, Hemochromatosis and Cystic fibrosis
8. DNA polymorphisms and Human Identification – RFLP and STR typing
9. Gene rearrangements in leukemia and lymphoma – V(D)J recombination, detection of clonality and translocations in hematological malignancies
10. DNA based tissue typing, Molecular analysis of MHC.

Credit – II: Nanotechnology

1. Introduction to Nano Science and Nanotechnology
2. Nanomaterials, structure, properties, nano-surface and nano-thermodynamics
3. Carbon based nano-materials
4. Chemical Synthesis and Modification of Nanomaterials
5. Natural Nanomaterials
6. Nanobiotechnology and its applications
7. Nanoencapsulation for Medical Applications, Nanomedicine
8. Nano-sensors and Applications
9. Cantilevers as Nano-Biosensors, Optical Nano-sensors
10. Biomimetic Design of Molecules, Biomimetic Nanomaterials, Biomimetic Nanoengineering

Credit – III: Metabolomics

1. Introduction to Metabolomics
2. Sample preparation for metabolomic investigation
3. Tools for imaging and analysing metabolomics data
4. Analytical methods for metabolomics: NMR, LC, MS, High resolution MS, ICPMS and GC
5. Metabolite Profiling of Blood Plasma
6. Integrative Profiling of Metabolites, Biomarkers
7. Microfluidic and single cell analysis
8. Metabolome of plant and animal tissues, Microbial and Nutritional metabolomics
9. Metabolomics-Edited Transcriptomics Analysis (META), Metabolic flux and its analysis
10. Tracer based metabolomics in cancer (*in vitro*/ *in vivo*)

Credit – IV: Cell and Tissue Engineering

1. Introduction to tissue engineering
2. Growth and Differentiation, Tissue Development (*in vitro*/ *in vivo*)
3. Biomaterials in Tissue Engineering
4. Transplantation of Engineered Cells and Tissues
5. Somatic cell programming
6. Stem cells and wound repair, mesenchymal stem cells for tissue regeneration
7. Strategies for repairing cartilage, bone and spinal cord
8. Enzyme signalling – Implications for tissue engineering
9. Hydrogels and their applications
10. Regulated challenges in cell based therapeutics

References

1. Molecular Diagnostics – Fundamentals, methods and clinical applications by Lela Buckingham, F.A. Davis Company
2. Molecular Diagnostics by George P. Patrinos, Wilhelm Ansorge, Phillip B. Danielson, Academic Press
3. Text book of Nanoscience and Nanotechnology by Murty B.S., Shankar, P., Raj, B., Rath, B.B and Murday, J. Springer
4. Text book of Nanoscience and Nanotechnology by T. Pradeep, McGraw Hill Education (India) Private Limited
5. Metabolomics in practice: Successful strategies to generate and analyse metabolic data by Michael Lammerhofer and Wolfram Weckwerth, WILEY-VCH
6. The hand book of metabolomics by Teresa Whei-Mei Fan, Andrew N. Lane, Richard M. Higashi, Springer protocols, Humana press.
7. Metabolomics – Methods and protocols by Wolfram Weckwerth, Springer protocols, Humana press
8. Stem cell and tissue engineering by Song Li, Nicolas L'Heureux, Jennifer H. Elisseeff, Worldd Scientific Press
9. Cell and tissue engineering by Obradović, Bojana, Springer

Paper-IV: BI 304 T: Physiology and Xenobiotics (4 Credits; 100 Marks)
(ID/Elective)

Credit– I: Neurophysiology

1. Types of neuronal cells – Neuroglia, microglia, astrocytes, oligodendrocytes, Schwann, satellite and epididymal cells
2. Nerves: regeneration of nerve fibers, generation of nerve impulse, all or none principle.
3. Mechanism of synaptic transmission, transmission of nerve impulse.
4. Types of neurotransmitters and their receptors, mode of signaling
5. Electrical synapse and giant neurons
6. Division of vertebrate nervous system: CNS, PNS, ANS, regions of the brain
7. Sensory organs – eye, ear, skin, tongue
8. Vision: visual system, rhodopsin and classical GPCR mechanism, termination of visual signal
9. Cone cells, specialization in color vision, physiology of colour blindness
10. Similarity between vision, olfaction and gustation

Credit – II: Structure and Physiology of Muscle

1. Structure of various types of muscle: striated, cardiac, smooth, fast twitch, slow twitch
2. Mechanism of muscle contraction, regulation of contraction
3. Role of actin and myosin in non-muscle cells.
4. Cytochalasins and cytokinesis.
5. Muscle gene expression, regulation at transcriptional and posttranscriptional level.
6. Role of muscle proteins in cell locomotion
7. Neuro-muscular transmission
8. Electromyography, Sherrington starling Kymograph (recording drum)
9. Disorders of muscle (dystrophy, myopathy, monocytisis, myotonia, paralysis, Myasthenia gravis)
10. Detection and treatment of muscle disorders

Credit – III: Human Reproductive Biology

1. Female reproductive system: anatomy and endocrinology
2. Causes of female infertility (acquired and genetic), treatments
3. Male reproductive system: anatomy and endocrinology
4. Causes of male infertility (environmental and genetic), treatments
5. Puberty, reproductive aging (menopause and andropause)
6. Gametogenesis and fertilization (natural and assisted (*in vitro*))
7. Implantation and Placenta
8. Endocrinology of pregnancy and parturition
9. Methods of Birth control
10. Placenta as source of stem cells, cord banking

Credit – IV: Liver and Xenobiotics

1. Liver functions, pharmacopeia drug deposition and mechanisms of drug detoxification
2. Cytochrome P450 enzymes, molecular biology, catalytic cycle, isozymes, inhibitors
3. Dose response relationship, drug-receptors interactions
4. Pharmacodynamics; pharmacokinetics
5. Phase I reactions - modifications
6. Phase II reactions - conjugation
7. Phase III reactions - modifications and elimination,
8. Environmental factors influencing drug metabolism
9. Effects and metabolism of model toxins: aflatoxins, bacterial exotoxins (types I, II, and III)
10. Nutrient drug interactions

References:

1. Human Physiology by Guyton and Hall Press Pub Saunders
2. Biochemistry, 4th Edition - Donald Voet, Judith G. Voet – Publisher John Wiley & Sons.
3. Human reproductive Biology by Jones and Lopez Pub
4. Principles of Biochemistry: Mammalian Biochemistry: Smith EL, Hill RL, … White A, McGraw Hill

Semester III: Practicals
(Note: Each topic corresponds one Practical Session)

Paper-V: BI 305P: Recombinant DNA, Immunotechnology	**Paper-VI: BI 306P: (Elective) A: Clinical Biochemistry, Nutrition and Reproductive Biology**
1 Isolation of plasmid DNA 2 Restriction mapping of DNA (experiment and problems) 3 Overexpression of desired gene by IPTG 4 Purification of expressed protein by Affinity chromatography 5 Purity of expressed protein by SDS-PAGE 6 Purity of expressed protein by western blotting 7 RFLP (experiment and problems) 8 Isolate Ig from serum (human/bovine) 9 Purify IgG by gel filtration 10 Purify IgG by affinity chromatography 11 Characterize IgG by specific antibody (Western blot) 12 SDS PAGE of Ig fractions 13 Agglutination: ABO and D Ag typing 14 RID 15 ODD 16 Rocket immunoelectrophoresis 17 ELISA, sandwich ELISA 18 Prepare and characterize carrier protein (BSA-benzidine)	1 Qualitative analysis of abnormal constituents in urine 2 Determine urinary titrable activity 3 Determine PCV, ESR, differential count 4 Determine osmotic fragility of RBC 5 Determine urinary glucose, creatinine 6 Determine blood hemoglobin (Drabkins) and glycosylated hemoglobin 7 Determine blood urea 8 Determine blood glucose (POD-DOD method, enzymatic method) 9 Determine A:G ratio 10 Assay serum alkaline phosphatase 11 Assay serum ALT (SGPT) 12 Assay of serum AST (SGOT) 13 Assay serum LDH 14 Serum lipid profile 15 Determine total carbohydrate and lipid content in a food item 16 Detection of adulterants in Milk 17 Detection of adulterants in oils and food stuffs 18 Pregnancy test 19 Histopathology of Uterus, Ovary, Oviduct and Placenta 20 Histopathology of Testes

Project ideas:

1 Compare nutritive values of food items (example various (daals), milk from various sources, various nuts)
2 Determine your own BMI and various parameters in blood and/or urine
3 Partner with a clinic or hospital to find out prevalence of diseases such as Cardiovascular disease, diabetes
4 Test for adulterants in food items

References:

1. Molecular Cloning (Lab manual) by Maniatis T, Fritsch EF, Sambrook J, Volume –I, CSH
2. Practical Clinical Biochemistry –Varley, H. CBS Publications
3. Practical Clinical Biochemistry-Methods and Interpretations – Ranjna Chawla- Jaypee
4. Lab Manual in Biochemistry, Immunology and Biotechnology – Arti Nigam and Archana Ayyagari – Tata McGraw-Hill New Delhi

Paper-VI: BI 306P: (Elective) B: Advanced Applied Biochemistry
1 Isolation of DNA 2 Agarose gel electrophoresis 3 Restriction mapping of DNA 4 PCR and RT-PCR 5 RFLP 6 RAPD 7 Construction of cDNA and genomic libraries 8 Gene mapping 9 Linkage analysis 10 Analysis of nanomaterials by spectrophotometry 11 Metabolite Profiling of Blood Plasma 12 Metabolite profiling of Animal tissues 13 Metabolite profiling of Microorganisms 14 Metabolite profiling of various food stuffs 15 Analysis of Metabolic flux ratio 16 Basic methods of Animal cell culture techniques 17 Maintenance of cell lines 18 Study of characteristics of cells in culture – Microscopic methods 19 Cell viability test – trypan blue and MTT assay 20 Regulatory pathways and FDA

References:

1. Molecular Cloning (Lab manual) by Maniatis T, Fritsch EF, Sambrook J, Volume –I, CSH
2. Culture of cells for tissue engineering by Gordana Vunjak-Novakovic, R. Ian Freshney, WILEY
3. Mass spectrometry based metabolomics – A practical guide by Sastia Prama Putri, Eiichiro Fukusaki, CRC Press

Paper-I: BI 401T: Biostatistics and Bioinformatics (4 Credits; 100 Marks) (Core)

Credit – I: Principles of Biostatistics

1. Biostatistics fundamentals (sample, population, variable); Types of variables, Measurement and measurement scales
2. Measures of central tendency (mean, median, mode)
3. Measurement of dispersion (range, variance, standard distribution)
4. Study of bivariate data: correlation and regression; Regression to calculate concentration of DNA/protein, molecular weight of DNA/protein
5. Graphical methods to depict data (histograms, bar-plots, pie charts, line graphs)
6. Probability in biology, Laws of Probability
7. Bayesian probability
8. Normal distribution.
9. Binominal distribution.
10. Poisson distribution

Credit – II: Statistical tests of significance

1. Design of experiments: factorial experiments
2. Student's t – test
3. F – test
4. Chi – square test; Contingency tests
5. CRD: Completely Randomized Design; 1-way ANOVA
6. RCBD: Randomized Complete Block Design; 2-way ANOVA
7. Non-parametric tests: sign test
8. Wilcoxon signed rank test, Mann-Whitney test
9. Kruskal-Wallis test, and Friedman tests
10. Quality control in biochemistry

Credit – III: Genomics

1. Genomics and branches of genomics
2. HGP and Strategies for sequencing genomes (shotgun and hierarchical sequencing)
3. 1st generation sequencing methods (Maxam and Gilbert Method; Sanger's method)
4. 2nd and 3rd Generation DNA sequencing methods (Next Generation Sequencing)
5. Genetic and Physical maps of the genome, EST, STS
6. DNA sequence databases, Use of databases; data mining
7. Comparing DNA sequences, pairwise local and global alignment
8. BLAST, FASTA, PAM and BLOSUM matrices
9. Multiple sequence alignments (Phylogenetic trees, Clustal-W, COBALT)
10. Epigenomics and metagenomics

Credit – IV: Proteomics

1. Relation of proteome to genome and transcriptome
2. HUPO goals and accomplishments
3. Methods for sequencing proteins: Edman degradation
4. 2D gels and peptide maps
5. MS – MALDI. LC-MS, Tandem MS (MS-MS)
6. Micro-arrays for proteins
7. Proteins motifs, sequences, and structure databases; Peptide sequence and MS profiles databases
8. Comparing protein sequences, alignment
9. Predicting secondary structure-ab initio, Homology folding, threading
10. Post-translational modification (kinome, glycosylation)

References:

1. Statistics, Basic Concepts and Methodology for the Health Sciences Daniel WW, Pub Wiley India
2. Biostatistics – Arora & Malhan, Himalaya Publishing House
3. Introduction to Bioinformatics- Attwood T K and parry –smith, D.J. Pearson Education
4. Bioinformatics (Sequence and Genome Analysis) Mount David W, Press CSH
5. Discovering Genomics, Proteomics and Bioinformatics – Campell & Heyer, Benjamin / Cummings pub

Paper-II: BI 402T: Cell-Cell Junctions and Signal Transduction (4 Credits; 100 Marks) (Core)

Credit–I: Extra Cellular Matrix(ECM) and cytoskeleton

1. Molecules in ECM of animal tissue.
2. Cell-Cell junctions and cadherin's
3. Functions and origin of cytoskeleton
4. Actin and actin binding proteins
5. Myosin and actin
6. Microtubules, Intermediate filaments and septins
7. Cell polarization and cell migration
8. Transport across cell membrane, Ficks Law.
9. Types of transport-simple, passive, facilitated. Active transport, primary and secondary active Transport system.
10. Ionophores, gated channels (Voltage and Ligand).

Credit–II: Cell Signaling and second messengers

1. Cell communication and type of signaling molecules.
2. Types of receptors and their structure.
3. Signal cascades their importance
4. GPCR, mechanism of signal transduction; inhibitory and stimulatory G alpha (one eg each)
5. GPCR signal termination
6. Tyrosine kinase receptors mediated signaling (eg Insulin, growth factors EGF, VEGF)
7. MAPK pathway, role in signaling
8. Second messengers–Ca and calmodulin
9. Phosphoinositides
10. NO, cAMP, cGMP

Credit – III: Signal Transduction and Cancer

1. Regulation of Cell cycle
2. Discovery of oncogenes, proto-oncogenes
3. Modes of action of oncogenes– monomeric G-proteins, Ras, p53
4. c-Myc and leukemia
5. RB and retinoblastoma
6. BRCA and breast cancer
7. Discovery of tumor suppressor genes
8. Important signaling enzymes and their regulation: PKC, CAM-kinases
9. PI3-kinase, phospholipases
10. Phosphatases

Credit–IV: Signal Transduction in Bacteria and Plants

1. Introduction of signaling components in bacteria
2. Chemotaxis, Protein kinases in bacteria
3. His-kinases: structure and role
4. Plant signaling system : an overview
5. Stress signaling in plants (biotic)
6. Stress signaling in plants (abiotic)
7. Signaling in yeast
8. STAT pathway in yeast
9. Protein-Protein interactions in signaling
10. Drugs targeting signaling molecules

References:

1. The Biochemistry of Cell Signaling, Helmreich JM, Oxford Press
2. Cell signaling – John T Hancock, Oxford University press
3. Cell biology. Second edition: Edited by C A Smith and E J Wood. Chapman & Hall publ
4. Molecular Cell Biology, 4th edition. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. New York: W. H Freeman

Paper-III:BI 403T: Bacteriology and Virology (4 Credits; 100Marks) (Elective)

Credit – I : General Microbiology and Microbial Diversity

1. Introduction and History of Microbiology
2. Classification of Microorganisms – Prokaryotic and eukaryotic microorganisms
3. General Characters of Bacteria, Fungi, Viruses and Algae
4. Type of media – Selective and Enriched media
5. Methods of sterilization - Physical and chemical methods
6. Isolation of pure cultures
7. Bacterial growth curve and kinetics of growth. Batch, Continuous and synchronous cultures
8. Microbial metabolism – Autotrophs and Heterotrophs
9. Bacterial Photosynthesis
10. Industrial Uses of microorganisms

Credit – II: Bacteriology

1. Introduction to medical bacteriology. Infections – Types and transmission
2. Gram positive pathogens – *Staphylococcus*
3. Gram negative pathogens – *E.coli* and *Salmonella*
4. *Mycobacterium tuberculosis*
5. Analysis of air, water and milk borne bacteria
6. Probiotic bacteria and their relevance to health
7. Domestic, municipal and industrial wastes Disposal. Microorganisms in the recycling process
8. Biodegradation of lignocellulosic waste, phenolic compounds and hydrocarbons.
9. Biotransformation of antibiotics and steroids.
10. Bioremediation of pollutants, metals and metallothioneins

Credit – III: Prokaryotic Viruses

1. Discovery of bacteriophages, Structure and composition of bacteriophages, Classification system of Baltimore& ICTV
2. Phage biodiversity, Genome diversity and host- specific interactions
3. Isolation and purification by filtration, ultracentrifugation and affinity chromatography
4. Plaque assays
5. One step growth, single burst and eclipse experiments
6. Life cycle of model bacteriophages infecting *E coli* – λ (lytic lysogenic)
7. Life cycle of model bacteriophages: ϕ X 174, M13
8. Life cycle of model bacteriophages: T4, T7
9. Life cycle of model bacteriophages: Qß, Mu
10. Applications of phages - therapy; Concern over phage contamination in industry (dairy)

Credit – IV: Eukaryotic Viruses

1. Discovery and classification of plant and animal viruses, structure of viruses, viroids, virusoids
2. Classification of viruses – ICTV and Baltimore classifications
3. Host – viruses interactions, permissive/non – permissive hosts; Cytopathic effects
4. Isolation and purification of viruses, Cultivation and propagation
   Assay methods – pock assay, hemagglutination assay, transformation assay.
5. Structure, Life cycle and Pathogenicity of Gemini virus
6. Structure, Life cycle and Pathogenicity of TMV
7. Structure, Life cycle and Pathogenicity of Adenovirus
8. Structure, Life cycle and Pathogenicity of Rotavirus
9. Structure, Life cycle and Pathogenicity of Rubella, Influenza and Measles viruses
10. Structure, Life cycle and Pathogenicity of HIV and Hepatitis B Virus

References:

1. Microbiology by Pelczar M.J., Ried, RD and Chan, ECS.
2. Microbiology by Gerard J. Tortora, Berdell Ra. Funke and Christine L. Case. Publ: Pearson Education Inc
3. Medical Microbiology-David Green wood
4. Jawetz-Medical Microbiology-Geo F.Brooks,Janet S Butel.
5. Principles of Virology, (Vol I & II) Flint SJ, Enquist LW, Racaniello VR, Skalka AM Pub ASN Press
6. Introduction to Modern Virology – Dimmock

7. Basic Virology – Wagner
8. Virology – Saravanan
9. Virology – Maharajan
10. Molecular Virology – A. J. Cann
11. An introduction to Viruses – Biswas

Paper-IV: BI 404T: Biotechnology. (4 Credits; 100 Marks) (Elective)

Credit – I: Microbial Biotechnology

1. Large scale cultivation of microbes; Fermenter design and control of growth
2. Downstream processing, Production of biomass, single cell protein
3. Production of low molecular weight primary and secondary metabolites, Microbial insecticides
4. Production of enzymes for research (restriction enzymes)
5. Production of enzymes for industry (high fructose corn syrup, cheese, food processing)
6. Microbial polysaccharides-Xanthan gum, Dextran, Pullulan, Mannan, Curdlan, Alginate
7. Microbial mining (heavy metal mining, mineral leaching, Sulfur cycle)
8. Microbial production of human insulin, human growth hormone
9. Microbial production of interferon, tissue plasminogen activator
10. Superbug and microbial degradation of oil (bioremediation)

Credit – II: Plant Biotechnology

1. Plant cell culture: callus, protoplast fusion, differentiation into plantlets
2. Plant vectors, Ti plasmids
3. GM plants, GM foods
4. Terminator technology
5. Anti sense RNA and DNA
6. Plantibodies (example dental caries)
7. Case studies (genes involved, commercial value, problems) of StarLink corn, Bt cotton
8. Case studies of Zeneca tomato paste, FlavrSavr tomato
9. Case studies of Golden rice, Herbicide resistant plants (Roundup Ready)
10. Virus resistant plants (papaya)

Credit – III: Animal Biotechnology

1. Development, maintenance and growth of animal cell lines
2. Cloning of mammalian and non-mammalian species (Polly, Molly, and Dolly)
3. Production of viral vaccines
4. Production high value therapeutics, interferon
5. Plaminogen activator, urokinase
6. Chimeric antibodies and antibody engineering
7. Immunotoxins as therapeutic agents
8. Gene knockouts
9. Human gene therapy
10. "Humanized" animals as organ farms

Credit – IV: Protein Engineering

1. Methods and applications of immobilized cells
2. Methods and applications of immobilized enzymes
3. Large-scale and site-directed mutagenesis, high throughput screening tools in protein engineering
4. Rational protein design, Engineering a new fold: case study of Top7
5. Natural and recombinant fusion proteins, tags for protein purification
6. Altering kinetic properties and pH dependence of enzymes
7. Increasing stability, enhancing specific activity of enzymes
8. Directed enzyme evolution
9. PEGylated interferon
10. Methods of drug design and delivery

References:

1. Introduction to Biotechnology, William J. Thieman, Michael A. Palladino, Benjamin Cummings Publ
2. Biotechnology- Arora, Himalaya pub. House
3. Principles of Gene Manipulation, by R.W. Old, S.B. Primrose, Wiley-Blackwell Publications

Semester IV: Practicals
(Note: Each topic corresponds one Practical Session)

Paper-V: BI 405P: Bacteriology and Virology	**Paper-VI: BI 406P: Project Work**
1 Preparation of culture media and sterilization methods. 2 Isolation of pure cultures: Streak plate method and Serial dilution method. 3 Gram Staining 4 Differential staining: Acid fast staining, Giemsa staining, Leishmann staining. 5 Methods of isolation and identification of gram+ve and gram -ve bacteria 6 Methods of isolation and identification of Fungi (Soil fungi) 7 Bacterial growth curve 8 Widal test, VDRL test 9 Antibiotic sensitivity by Disc diffusion and Broth dilution Methods 10 Assay of pencillin and streptomycin as secondary metabolites 11 Biotransformation of Antibiotics and Steroids 12 Biodegradation of lignocellulosic waste 13 Biodegradation of phenolic compounds 14 Biodegradation of hydrocarbons 15 Dye decolourization by microorganisms 16 Isolation of bacteriophages from sewage / waste water 17 Reactivation of lysogenic viruses 18 Plaque assay 19 One-step growth assay 20 Plaque reduction neutralization test	**Duration: Not more than 12 weeks** Suitable project work to be carried out by the student under the mentorship of departmental staff, within the department or in recognized institutions. The distribution of marks for the project is as follows. Dissertation – 50 Marks Project presentation – 25 Marks Response to queries – 25 Marks

Project ideas:

1 Isolate and characterize phages from natural sources
2 Partner with a clinic or hospital to find out prevalence of various diseases, culture methods and diagnosis
3 Collect various industrial effluents for analysis of microbial degradation

References:

1 Practical Medical Microbiology by R Panjarathinam. Jaypee Brothers Medical Publishers (P) Ltd.
2 Practical Medical Microbiology by Mackie & Mc Cartney. Elsevier
3 Microbiology – A Laboratory Manual by Cappuccino and Sherman. Pearson Education India.
3 Practical Medical Microbiology by Chandra Prakash Bhatt. A.K. Books and Educational Enterprises
4 A Practical guide to Clinical Virology by L. R. Haaheem, John R. Pattison and Richard J. Whitley
5 Virology Methods Manual by Brian WJ Mahy and Hillar O Kangro. Elsevier

Model paper: Theory

Duration 3 hours Max. Marks 80

Section - A (Short Answer Type)
Answer all Questions 8 x 4 = 32 Marks

1.

2.

3.

4.

5.

6.

7.

8.

Section - B (Essay Answer Type)

Answer all Questions 4 x 12 = 48 Marks

9. (A).

(OR)

(B)

10. (A)

(OR)

(B)

11. (A)

(OR)

(B)

12. (A)

(OR)

(B)

Model Paper Practicals (End of semester)

Time: 10.00 AM to 4.00 PM **Max. Marks 100**

1. Write the Principles for the following experiments 20 Marks
2. Major Experiment 40 Marks
3. Minor Experiment 20 Marks
4. Viva-Voce 10 Marks
5. Record 10 Marks