Ph.D. Biosciences
Entrance Test
Syllabus

BIOCHEMISTRY

Unit I- Carbohydrate and Lipid Metabolism
Glycolysis, HMP pathway, Glycogenolysis, PDH reaction, Tricarboxylic Acid Cycle: Kreb's discovery, isotopic tests, amphibolic nature, energetics and regulation. Gluconeogenesis, Synthesis of Glycogen and important disaccharides, hormonal regulation of Carbohydrate metabolism. Oxidation of lipids: beta-oxidation, oxidation of unsaturated and odd chain fatty acids, regulation of Fatty acid oxidation, Formation and oxidation of Ketone bodies. Biosynthesis of saturated fatty acids: carbon sources, acetyl CoA carboxylase and reaction of Fatty acid synthase. Synthesis of odd chain and unsaturated fatty acids. Biosynthesis of Triacylglycerol and phosphoglycerides. Biosynthesis of cholesterol and its regulation.

Unit II- Amino Acid Metabolism Amino acid oxidation
flow sheet, deamination and transamination reactions, alpha- ketoglutarate, succinate, fumarate and oxaloacetate pathways of amino acid oxidation. Metabolic fates of amino groups, role of glutamate and glutamine. Urea Cycle: reaction and regulation, Biosynthesis of standard essential and non-essential amino acids. Regulation of amino acid biosynthesis. Genetic defects in amino acid metabolism.

Unit III- Nucleotide and Heme Metabolism
Degradation of purinc & pyrimidine ribonucleotides and its regulation. Biosynthesis of purine & pyrimidine 4 ribonucleotides: de-novo pathways and salvage. Reactions and regulation of ribonucleotide reductase and thymidylate synthase, purine nucleotide cycle. Genetic defects, in nucleotide metabolism. Enzymes of Nucleotide metabolism as chemotherapeutic targets. Heme biosynthesis and degradation

Unit IV- Enzymology
Enzyme catalysis: Acid-Base, metal ion, covalent and electrostatic catalysis, Reaction coordinates. Transition state stabilization and entropy reduction by enzymes. Enzyme kinetics: Substrate velocity curve, MichaelisMenten mechanism for single substrate reactions, Meaning and significance of Km, Ks, Kcat and specificity constant. Lineweaver-Burk and Eadie-Hofstee plots, kinetics of bisubstrate reactions. Enzyme Inhibition: Mechanism and kinetics of competitive, uncompetetitve, mixed and noncompetitive inhibitions.

Recommended Books:

1. Nelson, David L., Albert L. Lehninger, and Michael M. Cox. Lehninger principles of biochemistry. Macmillan, 2008. Berg, Jeremy M., John L. Tymoczko, and Lubert Stryer. "Biochemistry 5th ed." (2002).
2. Voet, Donald, Judith G. Voet, and Charlotte W. Pratt. Fundamentals of Biochemistry 2002 Update. John Wiley & Sons, 2002.

CELL BIOLOGY

Unit I- Cytoskeletal Network Intramembrane System
Cytoskeletal network, alpha and beta tubulins, actin-myosin system intermediatary filaments and Dynein activator complex. Structure and Function of Endoplasmic Reticulum, Golgi body and Lysosome.

Unit II- Nucleus, Cell cycle and Molecular Structure of Gene
The nuclear envelop and traffic between nucleus and cytoplasm, internal organization of the nucleus, the nucleolus, nucleus during mitosis. The eukaryotic cell cycle, regulation of cell cycle progression. Nuclear compartment chromosomal organization of genes, functional rearrangement in chromosomal DNA, Morphology and functional elements of eukaryotic chromosome, mitochondrial DNA.

Unit III- Cell to Cell Signaling
Overview of extracellular signaling, Arachadanic acid Nitriconide based signaling, G-protein coupled receptors and their effectors, Receptor tyrosine kinase and RAS, MAP kinase pathways. Program cell death.

Unit IV- Molecular basis of Cancer
Tumor cells and onset of cancer, Protooncogene and tumor suppressor gene, oncogenic mutations affecting cell proliferation, mutation causing loss of cell cycle control, mutation affecting genome stability.

Recommended Books

1. The Cell, A Molecular Approach – 6th Edition – Geoffrey M. Cooper/Robert E. Hausman- Sinauer Associates, Inc.
2. Molecular Biology of the Cell - 5th Edition - Bruce Alberts et al - Garland Science
3. Molecular Cell Biology - 7th Edition - Harvey Lodish, Arnold Berk & Chris A. Kaiser - W.H. Freeman
4. Lewin's Cells – 2nd Edition – Cassimeris/Lingappa/Plopper – Johns & Bartlett Publishers
5. Cell Biology, A Short Course – 3rd Edition – Stephen R. Bolsover et al – John Wiley& Sons
6. Microbial Physiology: Moat, Foster and Spector
7. Cell and molecular biology: Gerald Karp.
8. Cell and molecular biology: DeRobertis and DeRobertis

GENETICS

Unit I

Chromatin structure, Nucleosome, Chromosome structure-centromere and telomere. Tandomly repeated non-coding DNA Interspersed repeated non-coding DNA Expression and processing of heterogeneous nuclèar RNA, r RNA, t RNA. Alternate transcription and processing on individual genes. Mitochondrial genome and diseases.

Unit II

General homologous recombination. Non-homologous end joining. Site specific recombination, Transposable elements, Mechanism of Transposition. The Lac -operon positive, negative and repression. Arabinose operon.Tryptophan operon. The lambda phase: a complex of operon.

Unit III

Molecular basis of gene mutation. Gain of function mutation. Loss of function mutation and their consequences. Chemical mutagenesis in higher organism.Repair of DNA damage. Photoreactivatrion. SOS repair mechanism. Base excision repair. Nucleotide excision repair. Stability of the genome.

Unit IV

Population and gene pool. Calculating allele frequencies. The Hardy-Weinberg law. Extension of Hardy -Weinberg law, Natural selection, Mutation, Migration,Genetic drift, Non-random mating. Adaptive radiation and modification, Isolating mechanism, Speciation- Allopatric and Sympatric, Convergent evolution, Sexual selection, Co-evolution.

Recommended Books:

1. Introduction to Genetic Analysis. 9th Edition by Griffiths et al. 2008.
2. Concept of Genetics. 9th Edition, by Klug et al.2009.
3. Principles of Genetics by Snustad et al. 2004.
4. Genes IX Lewin 2008.
5. Molecular Biology of the Gene Watson et al. 6th Edition 2009.
6. Molecular Cell Biology by Lodish et al. 2008
7. Molecular Biology of the Cell Alberts et al. 5th Edition. 2007.

BIOINFORMATICS & BIOSTATISTICS

Unit I

What is Bioinformatics, Biosciences, Emerging areas in Bioinformatics, Future prospects of Bioinformatics, Introduction to Genomics, Introduction to Proteomics, Human Genome Project, Public Database, Gene Bank, Using Public Database? Computer Basics: Computer and its components, Characteristics of computer, Classification of Computers, Hardware: Processor/CPU, Input/Output devices, motherboard slots/cards, bus parallel and serial ports, various storage devices/media, Client-Server concepts, Memory. Software basics: Data vs. information, Software: types of software's, Firmware, Operating system, Programming Languages, Compilers, Interpreters, Ideas of portability and platform dependence, MS-DOS, Windows, UNIX, Linux.

Unit II

DNA and Protein sequence analysis, tools, BLAST, FASTA, Protein Visualization tools, Ras Mol. VMDL, Chime, ORF finder, Gene finder, Gene Scan. Biological databases: Medline EMBL Gene bank, Pub Med, PDB, Entry and retrieval of Data from public databases. Database: Database basics, RDBMS, MS Access, My SQL, ER- Diagram, Relationship. Internet: Computer networking: LAN & WAN, Internet and its application, Major features, WWW and its attributes, web browsers & web server, websites/ address/ pages, Client Server Principles, Protocols and search engines/tools, Bioinformatics resources on internet.

Unit III

Measures of central tendency- average, mean, median, mode, measures of location-percentile, graphic method, Arithmetical method, application and uses of percentiles, Types, biological, real, experimental, measures of variability, range, semi-inter quartile range (Q), mean deviation, standard deviation (SD), and coefficient of variation (CV), Probability: Addition law of probability, multiplication law, binomial probability distribution, Poisson distribution, probability chance from shape of normal distribution or normal curve. Basic introduction to Muetrovariate statistics.

Unit IV

Idea of parametric and non parametric statistics, Hypothesis testing (Large and small samples test), types of errors and level of significance, confidence interval, test of significance (F-test & T-test), chi-square test, Significance of difference in proportions of large samples, Correlation and regression, Design and methodology of an experiment or a study: Step and methodology, format for presentation of any research work.

Recommended Books:

1. Fundamental Concepts of Bioinformatics Dan E. Krane, Wright State University Michael L. Raymer, Wright State University
2. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins By Andreas Baxevanis and Francis Ouellette'
3. Bioinformatics: A Biologist's Guide to Biocomputing and the Internet By Stuart Brown
4. All of Statistics: A Concise Course in Statistical Inference by Larry Wasserman
5. Biostatistics: The Bare Essentials Geoffrey R. Norman PhD, David L. Streiner PhD
6. Principles and Practice of Biostatistics B Antonisamy, Prasanna S. Premkumar

ANIMAL PHYSIOLOGY

Unit I- Cardiovascular System and Respiratory System

Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG-its principle and significance, cardiac cycle, blood pressure, regulation of blood pressure.

Comparison of respiration in different species, transport of gases (oxygen transport, oxygen–haemoglobin dissociation curve, carbon dioxide transport), exchange of gases,waste elimination,regulation of respiration.

Unit II- Digestive System and Excretory System

Physiological anatomy of Gastro-Intestinal Tract (GIT), Digestion and absorption of food (carbohydrates, proteins and fats) in the GIT, Energy balance, BMR.

Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, acid-base balance, homeostasis,Renin-Angiotensin System.

Unit III- Nervous System

Neurons,action potential,gross neuroanatomy of the brain and spinal chord,central and peripheral nervous system.Vision , Hearing and Tactile response.

Unit IV- Endocrine system and Reproductive System

Endocrine glands(Hypothalamus, pituitary gland,pineal gland, thyroid gland,parathyroid gland,thymus,adrenal gland, pancreas,testis, ovary), basic mechanism of hormone action, hormones and diseases. Male reproductive system, female reproductive system, reproductive processes (spermatogenesis, oogenesis), Neuroendocrine regulation.

Recommended Books

1. Barret Kim E., Boitano Scott, Barman Susan M., Brooks Heddwen L. Ganong's Review of Medical Physiology. 25th ed.New York:McGraw Hill Medical,2015.
2. Hall John E.Guyton and Hall Textbook of Medical Physiology. 13th ed. Philadelphia, PA: Saunders Elseviar, 2015.

MICROBIOLOGY

Unit I

Bacterial taxonomy: Characteristics used in classification of microorganisms, Bergey's Manual Trust, A brief account of Bergey's Manual of Determinative Bacteriology and Bergey's Manual of Systematic Bacteriology, Structure and functions of bacterial cell wall: Gram positive bacteria, Gram Negative bacteria, Archaebacteria. Bacterial Endospore: Structure, formation and germination.

Unit II

Electron Microscopy: Transmission Electron Microscope, Scanning Electron Microscope. Cultivation of bacteria: Bacteriological media, Physical conditions required for growth, Batch culture, Continuous cultures, Chemostat, Turbidostat. Measurement of growth. Control of microorganisms: Definitions and fundamentals of control, mode of action of antimicrobial agents, Conditions influencing antimicrobial action.

Unit III

Human microbe interaction: Normal microbiota of Skin, Eye, Respiratory tract, Intestinal tract, and Genitourinary tract. Gnotobiotic animals. Determinants of infectious diseases: Transmission, Attachment, Colonization, Entry, Growth and multiplication, Exotoxins, Endotoxins, Leucocidins and Hemolysins. Antibacterial drugs. Drug Resistance: Mechanism of drug resistance, Origin and transmission.

Unit IV

Morphology and Ultrastructure of Viruses: Icosahedral, Helical and complex symmetry. Viral genome, Capsid and capsomers, Envelope and enzymes. Replication of Viruses: Replication of animal viruses (HIV and Poliovirus), Transmission and Replication of plant viruses with special reference to TMV. Bacteriophage (T4 Phage): Adsorption, Penetration, Synthesis of nucleic acid and protein, Assembly and release.

Recommended Books

1. Prescott, Harley & Klein, Microbiology (WCB)
2. Ronald M. Atlas, Microbiology, Fundamentals and Application (McGraw Hill)
3. Tortora, Funke & Case, Microbiology, An Introduction (Addison Wesley and Longman Inc.)
4. Volk, Beniganin, Kodner & Parsons. Essentials of Medical Microbiology.
5. Alcamo's, Fudamentals of Microbiology, Addition Wesley Long Inc.
6. R.E.F. Mathews, Plant Virology (Academic Press)

GENOME BIOLOGY

Unit I- Genome Organization & Transgenesis
Elements of eukaryotic genome organization; Human genome and organization of genes; Epigenome and regulation of genes through epigenetic mechanism, genomic imprinting; Uni Parenta Disomy(UPD).Principle, methods and types of gene transfer in animal oocytes and embryonic stem cells. Production of transgenic/gene knock out animal (Mice), applications of transgenic animal; animal cloning and its broad spectrum applications, advantages, disadvantages and ethical concern.

Unit II- Molecular Pathology
Understanding chromosomal and molecular basis of genetic diseases in man. Molecular pathology of single gene multifactorial and sex linked diseases with special reference to Marfan Syndrome, Prader Willi Syndrome, Fragile 'X' Syndrome, sickle cell anemia, and DMD. Cancer and characteristics of cancer cells, involvement of tumor suppressor genes and oncogenes in cancer.

Unit III- Molecular Diagnosis
Prenatal diagnosis, Chorionic Villi Sampling Amniocentesi, Cordocentesis. Application of molecular, Cytogenetic and immunohistochemical techniques in diagnosis of various chromosomal and molecular pathogenesis.

Unit IV- Molecular Therapeutics
Types and models of gene therapy; gene delivery system, viruses in delivery system. Application of gene therapy in correction of different genetic diseases. Ethics associated with somatic and germ cell gene therapy. Interferon and other cytokines in therapeutics. Therapeutical application and ethical implication of cloned animals.

Recommended Books

1. Human Genetics: Proceedings of the 7th International Congress Berlin 1986Paperback – Import, 17 Nov 2011
2. Vogel and Motulsky's Human Genetics: Problems and Approaches Hardcover – Import, 1 Feb 1982
3. Genetics of Sex Determination (Advances in Genome Biology Book 4) Kindle Edition by R. S. Verma (Editor)
4. Genomes 4 Paperback – 21 Jun 2017 by T. A. Brown (Author)
5. Genome Refactoring (Synthesis Lectures on Synthetic Biology) Paperback – Import, 1 Jun 2009
6. Lewin's GENES XII Hardcover – 1 Feb 2017 by Jocelyn E. Krebs (Author), Elliott S. Goldstein (Author), Stephen T. Kilpatrick (Author)

BIOPHYSICS

Unit I- Bioenergetics

Free energy changes, Gibbs energy, Flow of energy in the biological system, concepts of chemical energy, Redox Potential, Nernst Equation, Ion electrochemical potential, Proton electrochemical potential, Membrane potential, equilibrium across a semi-permeable membrane, Donnan potential, respiratory chains , mitochondrial respiratory chains, respiratory control and oxidative phosphorylation, photosynthetic generators of proton motive force.

Unit II- Membrane Biophysics

Structure and organization of cell membrane, membrane models and drug delivery system.Energy transducing membranes, measurement of driving forces, metabolite and ion transport, active and passive transport, influx and efflux mechanisms, proton circuit and electrochemical gradient, Ionophores, Uniport, antiport and symport mechanisms, Shuttle systems.ATP synthase, Transport ATPases, Na+/K+ATPase and H+/K+ATPase, Molecular mechanisms of calcium transport, use of Na+ as an alternative to H+ in energy transduction.

Unit III- Radiation Biophysics

Electromagnetic spectrum, properties of non-ionizing and ionizing radiation, radiation units, principles of detection and measurement, Interaction of radiation with matter, free radicals, ions pair and dosimetry, dose effect graphs and target theory, direct and indirect radiation action, radiation effects on proteins, nucleic acids, carbohydrates, cell and whole organism, genetic effects of radiation, repair of radiation induced damages, radiation in diagnosis and therapeutics.

Unit IV- Biophysical Techniques

Spectroscopy: Principle instrumentation and applications of UV-visible Fluorescence, Infra Red, Raman and CD spectroscopies. Basic concept of NMR and X-ray crystallography. Dynamic Light Scattering, Surface Plasmon Resonance, Differential scanning and Isothermal Calorimetry.Mass Spectrometry; MALDI-TOF, ESI/MS. **Microscopy:** Optical, Phase Contrast, Fluorescence Microscopy, Scanning Electron, Transmission Electron.

Recommended Books

1. Keith Wilson and John Walker. Practical Biochemistry Principles and Techniques. Cambridge University Press.,1997
2. Creighton TE. Proteins Structures and Molecular Properties. W.H. freeman & Company, New York.,2006
3. David Freifelder. Physical Biochemistry: applications to Biochemistry and Molecular Biology. W.H. freeman and Company.,2006
4. New Era of Bioenergetics, by YasuoMukohata, Publisher Academic Press, 2012, ISBN 0323140297, 9780323140294.
5. Principles of Bioenergetics: Authors, Vladimir P. Skulachev, Alexander V. Bogachev, Felix.

6. Fundamentals of Molecular Spectroscopy, 5th Edn, McGraw Hill, ISBN-10 1259062597, ISBN-13 9781259062599, 2013 May.
7. Chadwick K.H. &Leenbouts H.P. Molecular Theory of Radiation Biology, Springer Verlag.
8. Atlik F.H. Introduction to Radiological Physics and Radiation Dosimetry, John Wiley

RECOMBINANT DNA TECHNOLOGY

Unit I

History of recombinant technology, restriction modification system in bacteria, DNA modifying enzymes and their mechanisms of action, functions of adapters, linkers and homopolymer linking in molecular cloning, purification of DNA from living cells, construction of genomic and cDNA libraries, screening of libraries, substrative hybridization for tissue specific DNA libraries

Unit II

Expression of foreign genes in *E. coli*, production of recombinant protein by prokaryotic expression vectors, eukaryotic expression vectors, mammalian expression vectors; fusion tags, role in purification of recombinant proteins, detection of expressed proteins

Unit III

Chemical synthesis of DNA, changing gene: Random and site-directed mutagenesis, strategies for gene transfer to animal cells, genetic manipulation of mammals, genetic transformation of plant cells - biolistics and *Agrobacterium* mediated, next generation and advanced sequencing, pyrosequencing, recent advances in protein engineering and metabolic engineering

Unit IV

Nucleic acid sequences as diagnostic tools, new drugs and new therapies for genetic diseases, gene therapy for genetic diseases, production of recombinant pharmaceuticals, hormones, recombinant vaccines, antisense therapy, gene knockout

Recommended Books

1. Singh BD (2010) Biotechnology 4 th Edition, Kalyani Publications
2. Nair AJ (2008) Introduction to Genetic Engineering and Biotechnology. Infinity Science Press
3. Brown T (2010) Gene cloning and DNA analysis: an introduction. John Willey & Sons

IMMUNOLOGY

Unit I

Introduction and Overview of the Immune System. Origin of Immunology and its evolution. Infection and immunity. Types of immunity- Innate and acquired, active and passive, humoral and cell mediated. Clonal selection theory. Organs and cells of the immune system: structure and function. Hematopoesis. Lymphocyte traffic. Antigens and immunogens. Adjuvants. Requirements for immunogenicity.

Unit II

Structure and function of immunoglobulins. Antibody variants- isotypes, allotypes and idiotypes. Monoclonal antibodies. Hybridoma technology. Organization of immunoglobulin genes. Theories and genetic basis of antibody diversity. Antibody –antigen binding: affinity, avidity, cross reactivity. Antigen-antibody interactions; agglutination, hemagglutination. Precipitation reactions in solution and in gels. Immunoassays: Radioimmunoassay, ELISA, ELISPOT, immunoflourescent assays. Fluorescence activated cell sorting. Western blotting.

Unit III

Major histocompatibility complex. MHC genes and Histocompatibility antigens. Role of MHC in T cell selection. Cytokines and their role in immune regulation. Complement system. Mechanism of its fixation; complement activation and its biological activities. Classical, alternative and lectin pathways; Regulation of complement.

Unit IV

Immunological tolerance to self and to antigens; its induction and features. Immunosuppression- specific and non-specific. Allergy and hypersensitivity. Effector mechanisms and examples of each type of hypersensitivity. Transplantation immunology. Tumor immunology. Immunodeficiencies; primary and secondary. Autoimmunity: factors contributing to autoimmunity; examples and diagnosis. Immunization and Vaccines.

Recommended Books

1. Basic Immunology by Abul Abbas Andrew H. Lichtman and Shiv Pillai, Elsevier
2. Basic immunology by Jacqueline Sharon, Williams & Wilkins
3. Kuby Immunology. W. H. Freeman & Co.
4. Immunology by Ivan Roitt, Jonathan Brostoff, and David Male, Elsevier
5. How the Immune System Works, by Lauren M. Sompayrac, Wiley
6. The Elements of Immunology by Fahim Halim Khan Pearson Education India, 2009
7. Kuby Immunology, Sixth Edition 6th Edition by Thomas J. Kindt (Author), Barbara A. Osborne (Author), Richard A. Goldsby (Author)

PLANT PHYSIOLOGY

Unit I

Plant water relations, mechanism of water transport through xylem, transpiration, stomatal physiology, factors affecting transpiration, guttation. Photosynthesis: Historical background, photosynthetic pigments and light harvesting complex, photosystems I & II, mechanism of quantum capture and energy transfer system, Calvin cycle, C4 cycle and CAM pathway, translocation of solutes. Carbon allocation. Mechanism of loading and unloading of photoassimilates.

Unit II

Hydrolytic and phosphorolytic degradation of starch and sucrose. Respiration: respiratory quotient, ATP generation, factors influencing the rate of respiration (light, temperature, oxygen availability). Electron Transport system in mitochondria, oxidative phosphorylation.

Unit III

Nitrogen metabolism, biological nitrogen fixation and ammonia assimilation, nitrate reduction and its incorporation in to amino acids. Study of various plant stress, resistant strategies, plant defense mechanism against biotic and abiotic stress.

Unit IV

Tissue cultures, general tissue culture techniques, totipotency, roles of tissue culture techniques in haploid and triploid production. Biosynthesis, Physiological role and mechanism of action of various plant growth regulators like auxin, gibbrellins, cytokinin, abscissic acid and ethylene etc.

Recommended Books

1. Introduction to Plant Physiology16 December 2008 by William G. Hopkins and Norman P. A. Hüner
2. Fundamentals of Plant Physiology2017 by V. K. Jain
3. Principles of Plant Physiology6 July 2017 by B.P. Nautiyal
4. Plant Physiology and Biochemistry 1 December 2005 | Import by H. S. Srivastava and N. Shankar

MOLECULAR BIOLOGY

Unit I

Enzymes used in Molecular Cloning: Restriction enzymes, DNA polymerases, ligase, kinase, phosphatase, nuclease; molecular cloning of DNA or RNA; Cloning Vectors: Lamda phage, plasmid, M13 phage, cosmid, shuttle vectors, yeast and viral vectors, construction of genomic and DNA library. DNA Sequencing and Amplification of DNA: DNA Sequencing and Amplification of DNA by polymerase chain reaction, types of PCR: RT-PCR, inverse PCR, asymmetric PCR.

Unit II

RNA Synthesis: Types of RNA polymerases, mechanism of transcription, RNA processing, capping, polyadenylation, splicing; micro RNA. Protein Synthesis: Ribosome, formation of initiation complex, initiation, elongation and termination of protein synthesis.

Unit III

Replication of DNA: DNA polymerase and other enzymes involved, replication origin, replication fork, semi conservative replication of double stranded DNA, mechanism of replication.

Unit IV

Gene Expression and Regulation: Prokaryotic and eukaryotic gene expression; gene silencing: transcriptional, post transcriptional, antisense RNA, oligonucleotide technology. Methods of Gene Transfer: Analysis of gene expression, micro arrays, restriction fragment length polymorphism, DNA finger printing, production of GMO.

Recommended Books

1. Principles of Gene Manipulations & Genomics, S.B. Primrose, M. Twyman, John & Willey Publishers
2. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Bernard R.Glick and Jack J.Pasternack, Panima Publishing Corporation.
3. Gene Cloning – An Introduction. Blackwell Publishing, Brown, T. A. , 2016, (7th edition).
4. Krebs E, J., Goldstein S, E. and Kilpatrick, T. S. (2013). Lewins Gene XI. Jones and Bartlett publishers, Inc.
5. Molecular Cell Biology, Lodish, H., Berk, A., Zipursky, S., Matsudaira, P., Baltimore, D. and Darnell, J. (2016), W. H. Freeman and Company, 8th Ed.
6. Molecular Biology, David P. Clark & Nanette J. Pazdernik, Elsevier Academic Press, UK, (2013), 2nd Ed.

ENVIRONMENTAL BIOLOGY

Unit I

Ecosystem Degradation by Deforestation, Overgrazing , Agriculture, Mining, Urbanisation, Shifting Cultivation, Development Projects, Fuel and Industrial Raw Material Requirements, Threat to Wild Life Through Hunting, Habitat Destruction, Selective Destruction, Domestication, Introduction of New Species, Pesticide Use, Pets Trade, Medical Research Experimentations and Captivity in Zoos , Extinct Species Categories - Threathened Species, Endangered Species, Rare Species, Depleted Species and Intermediate Species, Endemic Species, Habitat Conservation, Providing Critical Resources, Captive Breeding, Development of Biological Reserves, National Parks, Forest Reserves, Wild Life Refuges and Biosphere Reserves, Controlling Introduction of Allien Species, Pollution Reduction, Research and Development, Legal Actions, Public Participation and Awareness, Traditional and Modern Approaches Used In India for Conservation, Project Tiger, Chipko Movement, Appiko Movement, Indian Biosphere Reserve Programme.

Unit II

Municipal water Treatment, Waste water treatment - Pre treatment, Primary Treatment, Secondary or Biological and Tertiory Treatments_ Trickling Filters, Rotating Biological Contractors, Activated Sludge Process, Oxidation Ponds. Infectious and Medical Waste Pollution and Management, Solid waste pollution and management

Unit III

Microbial degradation of xenobiotics, Genetic engineering of biodegradative pathways – manipulation by plasmid transfer and gene alterations, Biomass utilization (Starch, Sugar, Cellulose) for commercial production of fructose, alcohol and biofuel (biodiesel & bioethanol).

Unit IV

Microbial insecticides (*Bacillus thuringiensis & Baculo virus*) mode of action, toxin gene isolation and genetic engineering; Biofertlizers – Bacterial and Cyanobacterial nitrogen fixers, bacterial, cyanobacterial and mycorhizal phosphate solubulizers nitrogen fixing gene and their manipulations, composting, green manuring.

Recommended Books

1. Climate Change Biology by Lee Hannah, Academic Press Elsevier 2011
2. Environmental Based Management edited by Ramchandra, CRC Press Teller & Francis Group
3. Molecular Biotechnology; Principles & Applications of Recombinant DNA by Bernard R Glick & Jack J Pasternak, ASM Press 2010
4. Biodegradation & Bioremediation by Martin Alexender, Academic Press 1999
5. Microbial Biotechnology; Fundamentals of Applied Microbiology by Alexender N Glazer & Hiroshi Ni Raido, Cambridge University Press 2007

PHYSICAL CHEMISTRY OF MACROMOLECULES

Unit I- Macromolecules Proteins

Amino acids their physical & chemical properties, Peptides and polypeptides. Peptide group, charges on peptides (pH dependence), Handersen-Haselbalch equation, buffers. Primary structure of proteins, separation of amino acids, end group analysis, reduction, modification and location of disulfide bonds, sequencing of polypeptide.

Nucleic acids: Primary, secondary and tertiary structures of Nucleic acids, polymorphism of DNA (A, B, Z forms), denaturation and renaturation of DNA, supercoiled DNA, superhelix topology, measurements of supercoiling.

Unit II- Structure and function of Protein

Different levels in protein structure, Ramachandran plot, Secondary structure (α-helix, β-strand, β-sheet, turns and loops), Super secondary structures, tertiary structure, quaternary structure, globular and fibrous proteins.

Functions of different protein, Hemoglobin function, oxygen binding, hill equation, Bohr effect, binding of BPG.

Unit III- Protein folding

Forces stabilizing the native state of proteins (electrostatic, hydrophobic and hydrogen bonding). The denatured state, modes of denaturation. Protein folding. Landmark experiments in protein renaturation, folding pathways, techniques to monitor protein folding, landscape theory of protein folding. Accessory proteins in folding: protein disulfide isomerase, Rotamases and molecular chaperones.

Unit IV- Biophysical Techniques Chromatography

Paper, TLC, adsorption, partition, ion exchange, gel filtration, affinity, GLC, HPLC.

Electrophoresis: paper electrophoresis, gel electrophoresis SDS-PAGE, isoelectric focussing, gel electrophoresis of nucleic acids.

Viscosity and Sedimentation: Viscosity of macromolecules, measurement of viscosity, velocity and equilibrium sedimentation of macromolecules, diffusion of macromolecules, centrifugation techniques and their applications, ultracentrifugation (analytical and preparative), boundary and band sedimentation, estimation of molecular weight.

Recommended Books

1. Principles and Techniques of Biochemistry and Molecular Biology by Wilson and Walker 2005
2. Nelson, David L., Albert L. Lehninger, and Michael M. Cox. Lehninger principles of biochemistry. Macmillan, 2008. Berg, Jeremy M., John L. Tymoczko, and Lubert Stryer. "Biochemistry 5th ed." (2002).
3. Voet, Donald, Judith G. Voet, and Charlotte W. Pratt. Fundamentals of Biochemistry 2002 Update. John Wiley & Sons, 2002.

TOXICOLOGY

Unit I

History, general principles and scope of toxicology. Dose response relationships. LD_{50}, ED_{50}, LC_{50}, EC_{50}. General mechanisms of toxicity. Disposition of toxicants – adsorption, distribution, and elimination of toxicants. Biotransformation of Xenobiotics – basic properties, categories and distribution of xenobiotic biotransforming enzymes.

Unit II

Toxic agents – Toxic effects of pesticides & metals with special reference to DDT, lindane, cyclodienes, lead, arsenic, mercury, cadmium, aluminum. Health effects of radiation and radioactive materials. Important radiation episodes.

Unit III

Environmental Toxicology – air pollution & health effects, pollutants of the outdoor ambient air with special reference to sulfur dioxide, sulfuric acid, particulate matter, smog, ozone, nitrogen dioxides and carbon monoxides.

Unit IV

Applications of Toxicology : *Food Toxicology* – Safety standards for foods, food ingredients & contaminants; *Forensic Toxicology* – analytic role, toxicological investigation of a poison death, criminal poisoning of the living; *Clinical Toxicology* – strategy for treatment of the poisoned patient; *Cosmetic Toxicology* , *Occupational Toxicology* – Occupational diseases, worker health surveillance, exposure monitoring

Recommended Books

1. A Textbook of Modern Toxicology by Ernest Hodgson & Patricia E Levi, III Ed. Appleton & Lange 1997
2. A Textbook of Modern Toxicology IV Edition, edited by Ernest Hodgson Wiley, 2010
3. Principles of Biochemical Toxicology by John Timbrell, IV Edition
4. Principles of Toxicology, III Edition 2015 by Karen E Sine & Thomas M Brown, CRC Press Teller & Francis GroupEnvironmental Toxicology; Current Developments Edition J. Rose 1998, CRC PressTeller & Francis Group

DEPARTMENT OF COMPUTER SCIENCE

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PhD (Computer Science / Bioinformatics) Entrance Test, 2021-2022

Syllabus for Part-B

Multiple-ChoiceQuestions	**(Compulsory Component: 50Questions)**	**50 Marks**
	(For Computer Science and Bioinformatics Both)	
Subjective Questions	**(Elective Component: 5 Questions out of 10)**	**50 Marks**

- ---------- **(COMPULSORY COMPONENT)** ----------
- Set, Relation, Function, Pigeonhole Principle, Inclusion-Exclusion Principle, Partial and Total Ordering, Lattice, Elementary Counting Techniques, RecurrenceEquations.
- Mathematical Logic, Preposition, Connectives, Truth tables; Well-formed formulas, Tautology, Contradiction, Equivalence of Formulas, Duality, Normal Forms, Theory of inference, Predicate Calculus.
- Measuring Central Tendency and Dispersion of Data, Correlation Analysis, Regression Analysis, Analysis of Variance, Hypothesis Testing, Probability and Distributions - Sample Space and Events, Types of Events, Addition and Multiplication Rules, Conditional Probability and Bayes Theorem.
- Logic Gates, Boolean Functions, Combinational and Sequential Circuits, Number System, Integer/Real Data Representation, Instruction Formats, Addressing Modes, Memory Organization, I/O Organization. Von-Neumann Architecture, Number System, Complements, Binary Arithmetic, Numeric and Character Data Representation, Memory and I/ODevices.
- Operating Systems and its Types, OS Structure, Components and Services. MemoryManagement – Swapping, Memory Allocation, Paging and Segmentation; IPC, Deadlocks and Security.
- Network Fundamentals, LAN, MAN, WAN, Network Topologies, Reference Models: OSI and TCP/IP Models, TransmissionMedia.
- Programming in C: Identifiers, Variables and Constants, Data Types, Operators, Control Structures, Structured Data Types: Array, Struct, Union, String, Enum, and Pointers. File Handling inC.
- OOP using C++: Class, Object, Inheritance, Polymorphism, and Overloading; Constructors and Destructors; Virtual Functions, Templates and ExceptionHandling.
- Linear Data Structures: Array, Linked-Lists, Stack, Queue. Non-Linear Data Structures: Tree and Graph, Hashing and Tables. File Structures: Fields, Records and Files; Sequential, Direct, Index-Sequential and Relative Files, Inverted Lists and Multi-Lists. Linear Data Structures: Array, Linked-Lists, Stack, Queue. Non-Linear Data Structures: Tree andGraph.
- Asymptotic Notations for Complexity, Best, Average and Worst Case Analyses, Searching and Sorting, Design Techniques: Divide-and-Conquer Approach, Dynamic Programming, Greedy Techniques.
- DBMS and Types; Database Concepts, Data Models, ER Diagram, Design of Relational Database, Functional Dependency, Database Decomposition and Normalization, Relational Algebra and Structured QueryLanguage.

DEPARTMENT OF COMPUTER SCIENCE

FACULTY OF NATURAL SCIENCES, JAMIA MILLIA ISLAMIA, NEW DELHI-110025

TEL.: +91-11-26980014 (DIRECT), +91-11-26981717 EXTN 3450/ 3452

----------ELECTIVE COMPONENT (Section EC: COMPUTER SCIENCE)----------

1. Relational Database Management System, ER and EER Models, Database Constraints, Database Decomposition and Normalization, Relational Algebra and SQL, Query Processing and Optimization, Transaction Management, Serializability and Recoverability, Concurrency Control Techniques, Deadlock, Time Stamping, Database RecoveryTechniques.
2. System Development Life Cycle, Software Process Models. Software Metrics, Software Design: System Design, Detailed Design, Function-Oriented Design, Object-Oriented Design,User-Interface Design. Design Level Metrics. Software Testing and Quality Assurance, Testing Metrics, Software Quality and Reliability, Risk Management, Software Re-engineering, Software Architecture.
3. Arrays and Matrices: Single and Multi-Dimensional Arrays, Matrix Representation using 2D Arrays, Diagonal, Tri-diagonal, Lower Triangular, Upper Triangular, and Sparse Matrices. Linked Lists: Singly, Doubly, and Circular Linked Lists. Stack and Queue, Priority Queue. Binary Tree, Binary Search Tree, AVL Tree, B and B+ Tree. Graph Representation and Traversals, Spanning Tree, Skip List andHashing.
4. Computer Networks, OSI and TCP/IP Model, TCP and UDP, IP, Datagram, Addressing, Subnetting and Masking; ARP, RARP, ICMP, IGMP. Client-Server Model: BOOTP and DHCP. Domain Name System (DNS), Internet and Intranet, Internet Services: E-mail, World Wide Web (WWW) etc. Asynchronous Transmission Mode (ATM): Architecture, Switching, Layers, andApplications.
5. Analysis and Design of Algorithms, Asymptotic Notations, Master Theorem, Searching Techniques: Linear and Binary Search. Sorting Techniques. Divide and Conquer Approach - Strassen's Matrix Multiplication, Dynamic Programming and Optimization - Binomial Coefficient Finding, Chained Matrix Multiplication, Longest Common Subsequence Problem, and Travelling Salesman Problem. Greedy Techniques - Prim's, Kruskal's, and Dijkstra's Algorithms, Huffman Code. Backtracking Algorithms for n-Queens, Sum-of-Subsets, Graph Coloring, and 0-1 Knapsack Problems. Branch and Bound Methods for 0-1 Knapsack and Travelling SalesmanProblems.

----------ELECTIVE COMPONENT (Section EC:BIOINFORMATICS)----------

1. Genome Evolution and Phylogenetics, DNA Sequencing, The Human Genome Project, Genomic Variations. Structural Genomics Technology: Genome Annotation, SNPs and TOGA, RAPD, AFLP and RFLP Analyses, DNA and RNA Fingerprinting, Functional Genomics. Metabolic Reconstruction: Metabolic Pathway, Metabolic Regulation, Genome-Proteome Connection, Interaction Networks. Proteomics: Protein Function and Expression, 2D-gel Electrophoresis, Amino Acid Sequencing. Protein-Protein Interaction: Protein-Ligand Interaction, Large Molecular Complexes, Phage Display, Protein Chips. Microarray: cDNA Microarrays, Oligonucleotide Microarray Chips, Cancer and Genomic Microarrays, DNA Microarrays and Analysis of Metabolic Control. Cancer and GenomicMicroarrays.
2. Systems Biology, Biological Systems, Measurement Technologies and Experimental Methods, System Structure Identification. System Behavior Analysis Methods, System Control, Modular Design, Structural Stability. Modeling Genetic Networks: Gene Regulatory Network, Biochemical Processes, Transcription, Exons & Introns, Splicing, Translation, Post Translation Modification. Boolean, Differential Equation, Stochastic, and Kinetic Logic Models. Genetic Algorithms, Generative Models. Reverse Engineering and Data Mining from Gene Expression Data. Automated Reverse Engineering of Metabolic Pathways by Means of Genetic Programming: Representation of Chemical Reaction Networks, Repertoire of Functions, Repertoire of Terminals, Constrained Syntactic Structure, FitnessMeasures.

DEPARTMENT OF COMPUTER SCIENCE

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3. Computer-Aided Drug Design, Molecular Modeling, Prediction of Tertiary Structures of Proteins, Minimization of Peptide Energy, Ramachandran Plot, Torsional Space Minimization, Molecular Dynamics. Molecular Visualization Tools: Visualization of Tertiary and Quaternary Structures, Architectures and Topologies of Proteins and DNA. Drug design: Drug discovery process, Target Identification and Validation, Lead Optimization and Validation. Structure Activity Relationship – QSARs and QSPRs. Quantum Chemical Based Descriptors. Structure-Based Drug Design and Ligand-Based Drug Design: Docking, Lock and Key Hypothesis, Ligand Docking, High Throughput Screening, Virtual Screening, Protein-Ligand Docking, Protein-Protein Docking, Energy Minimization. Biomolecular SimulationsTechniques

Computational Methods for Data Analysis, Pair-Wise Alignment, Statistical Analysis of Alignment Score, Local vs. Global Alignment, Multiple Sequence Analysis. Scoring Matrices: Derivation and Comparison of PAM and BLOSUM Matrices. Protein Secondary StructurePredictions.

4. Phylogenetic Analysis: Phylogenetic Trees, Phenotypic and Molecular Phylogeny. Cladogram, Similarities and Distances. Orthologs, Paralogs and Xenologs. Tree Evalualtion. Markov Chains and Hidden Markov Model (HMM), Pairwise Alignment using HMMS, Profiles, and HMMER. Structure Analysis: Covariance Models, SCFG-Based RNA Profiles. Protein Folding Problem, Protein Structure Alignment and Analysis.

5. Modern Biology Experimental Techniques, Separation of Proteins, Chromatography, Gel Filtration, HPLC, Reverse Phase HPLC, Electrophoresis. Characterization of Proteins: Amino Acid Composition Analysis, N-terminal Analysis, Peptide Mapping, Sequencing Strategies. Spectroscopy: UV/Visible Spectrometry, Fluorescence, Circular Dichroism, IR, FTIR and Raman Spectroscopies, Dynamic Light Scattering, Laser Spectroscopy, Surface Plasmon Resonance, Differential Scanning Calorimetry, Isothermal Calorimetry. Methods for Protein Structure Determination: NMR Data Analysis, NOESY and COESY, SAXS, X-ray Crystallography, Protein Crystallization and X-ray Diffraction, DNA Sequencing Methods. Methods for Analysis of Gene Expression at RNA and Protein Level, Large-Scale Expression Analysis. Protein Engineering. Microscopy Techniques.

NOTE : *Candidates will have to choose their area of PhD as either Computer Science or Bioinformatics. The Multiple choice question (MCQ) Compulsory paper will be common for Computer Science and Bioinformatics both. For the Elective Component, if they opt Computer Science then they will have to opt Section EC: Computer Science of Elective Paper and attempt any five questions out of 10 from it and if they opt Bioinformatics then they will have to opt Section EC: Bioinformatics of Elective Paper and attempt any five questions out of 10 from it.*

PROFORMA

DETAILS OF Ph.D ENTRANCE TEST –

Name of the Faculty: **Faculty of Natural Sciences**

Department/Centre: **Centre for Nanoscience and Nanotechnlogy**

Name of the Program: Ph.D Entrance Test

Summary of Entrance Test

S.No.	Test-Component	Test Duration	Max. Marks	Passing Marks	Negative Marking
1.	Multiple Choice Questions	2hr	100		Yes

Any other information about the Entrance Test:

Important Instructions for Test (Pl. add/modify as required)

Permissible Material/equipment for Entrance Test (as required):

- Black/Blue Ball Pen,
- Pencil

Detailed Syllabus for the Entrance Test

A. SOLIDSTATE PHYSICS

Crystal structure-Lattice representation-simple symmetry operations-Diffraction-Bragg's law-Reciprocal lattice-X-ray diffraction methods--Rotation,Laue and powder methods -Brillouin Zones-Binding in crystals.

Theory of elastic vibrations in monoatomic- Diatomic lattice-Phonons-Dispersion relations-Thermal Properties- Vibrational modes-Einstein model-Density of modes in 1 and 3 dimensions. Einestein and Debye model for specific heat of solids.

Free electron models –origin and magnitude of energy gap-Bloch functions-Kronig Penney model-Wave equation of electron in a periodic potential.

Semiconductors- Intrinsic and extrinsic semiconductors- carrier concentration at normal equilibrium- Drift and diffusion of carriers, donors- acceptors, minority carriers, dependence of Fermi level on temperature and doping concentration, relationship between mobility, carrier concentration and conductivity.

Quantum dots-Optical transitions-absorption-interband transitions-quantum confinement intraband transitions -fluorescence/luminescence-photoluminescence /fluorescence optically excited emission- electroluminescence emission.

CHEMISTRY ASPECTS

Photochemistry; Photoconductivity; Electrochemistry of Nanomaterials- Diffusion in Nanomaterials; Nanoscale Heat Transfer; Transport in Semiconductor Nanostructures; Transition Metal Atoms on Nanocarbon Surfaces; Nanodeposition of Soft Materials; Nanocatalysis.

STATISTICAL DISTRIBUTIONS

Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics- Fermi energy- . Comparison of three statistics Application of MB, BE and FD statistics (qualitative).

LAWS OF THERMODYNAMICS

Thermal Equilibrium –Concept of temperature (Zeroth Law of Thermodynamics) – Concept of Heat and Work as a path function – First Law of Thermodynamics – Isothermal Process – Adiabatic Process – Isobaric process – Isochoric Process – Second Law of Thermodynamics – Entropy – Third Law of Thermodynamics

NANO MATERIALS AND NANOTECHNOLOGY

Basic concepts of Nano science and technology – Quantum wire – Quantum well – Quantum dot – Properties and technological advantages of Nano materials – Graphene and carbon nanostructures. Composites – Nanocomposite and applications.

SYNTHESIS OF NANOMATERIALS

Fundamentals of film growth – Physical vapor Deposition (PVD) – Chemcial vapour Deposition (CVD) - Atomic layer Deposition (ALD) – Self Assembly- LB technique.

Template based synthesis - Electrochemcial deposition – Electrophoretic deposition – Template filling – Electro spinning – Micro emulsion – Reverse micelles method. Photolithography – Optical and e-beam, ion-beam lithography, Oxidation and metallization - Mask fabrication and its application.

CHARACTERIZATION OF NANOMATERIALS

Absorption and emission spectroscopy, IR and Raman spectroscopy, Nuclear Magnetic Resonance spectroscopy, XRD, SEM, TEM, EDAX, STM and AFM.

NANOELECTRONIC APPLICATIONS

Memory devices and sensors – Nano ferroelectrics – Ferroelectric random access memory –Fe-RAM circuit design – ferroelectric thin film properties and integration – calorimetric -sensors – electrochemical cells – surface and bulk
acoustic devices – gas sensitive FETs – resistive semiconductor gas sensors – electronic noses – identification of hazardous solvents and gases – semiconductor sensor array - Imaging Sensors (Far-Field and Near-Field) - Position Sensors - Capacitive Sensors - Linear Variable Differential Transformer - Interferometric Sensors – Acceleration, Force and Pressure Sensors, flow sensors.

A. MATHEMATICS

PARTIAL DIFFERENTIAL EQUATIONS

Formation – Solution of standard types of first order equations – Lagrange's equation – Linear homogeneous partial differential equations of second and higher order with constant coefficients - Classification of second order linear partial differential equations.

FOURIER TRANSFORMS

Statement of Fourier integral theorem – Fourier transform pairs – Fourier Sine and Cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.

Eligibility Criteria:

M.Sc in Physics/ Chemistry/ Material Science/ Electronics/ Nanoscience/ Nanotechnology/ Nanoscience and Nanotechnology

OR

M.Tech in Nanoscience and Nanotechnology/ Nanotechnology

OR

M.Sc. Tech in Nanoscience/ Nanotechnology/ Nanoscience and Nanotechnology

OR,
M-Tech in Solid State technology, VLSI, Microelectronics, Nanoelectronics, Electronics, MEMS can also be looked into

PhD - Physics

Syllabus for PhD Entrance Test

CLASSICAL MECHANICS

Newtonian mechanics and its limitations. Constrained motion. Constraints and their classication. Principle of virtual work. D' Alembert's principle. Generalised coordinates. Deduction of Lagrange's equations from D' Alembert's Principle. Generalised momenta and energy. Cyclic or ignorable coordinates. Rayleigh' s dissipation function. Integrals of motion. Symmetries of space and time with conservation laws.

Central force. Definition and properties of central force. Two-body central force problem. Stability of orbits. Conditions for closure. General analysis of orbits. Kepler's laws. Kepler's equation. Articial satellites. Rutherford scattering.

Principle of least action. Hamilton's principle. The calculus of variations. Derivation of Hamilton's equations of motion for holonomic systems from Hamilton's principle. Hamilton's principle and characteristic functions.

Canonical Transformations. Generating functions. Poisson bracket (PB). Poisson's Theorem. Invariance of PB under canonical transformations. Angular momentum PBs. Hamilton-Jacobi equation. Connection with canonical transformation.

Small Oscillations. Normal modes and coordinates.

QUANTUM MECHANICS

Mathematical tools : Brief introduction to origins of quantum Physics. Wave packets. Dirac notation. Operators, their eigenvalues and eigenfunctions, orthonormality, completeness and closure. Generalized Uncertainty Principle. Unitary transformations, change of basis. Matrix Representation of operators. Continuous basis, position and momentum representation and their connection. Parity operator.

Fundamental Concepts of Quantum Mechanics : Basic postulates of quantum mechanics. Measurement. Time evolution of system's state. Discrete and continuous spetra in 1-D. Solution of 1-D harmonic oscillator using matrix mechanics.

Angular Momentum : Orbital, Spin and total angular momentum operators. Pauli spin matrices, their Commutation relations. Eigenvalues and eigenfunctions of L^2 and L_z.

Identical Particles : Many particle systems, systems of identical particles, exchange degeneracy, symmetrization postulate, construction of symmetric and anti-symmetric wave functions from unsymmetrized functions. The Pauli exclusion principle.

MATHEMATICAL PHYSICS

Review of Basic Methods : Real and complex numbers; Euclidean space; Dierentiability; Series and convergence. Function of a complex variable; Analytic functions; Cauchy's theorem; calculus of residues and applications. Advanced vector calculus; multiple integrals.

Linear Dierential Equations & Special Functions : Series solutions of ordinary differential equations; ordinary, regular and irregular singular points; Gamma function; Special functions (Legendre, Bessel, Laguerre, Hermite); Hypergeometric and conuent hypergeometric functions.

Partial Dierential Equations and Green Function Method : Classication of PDE's and boundary conditions; method of separation of variables; Green function method for Laplace, Poisson, wave, Klein-Gordon and heat equations; solutions of boundary value problems using Fourier series and Bessel functions.

Elements of Group Theory : Definitions and examples of a group; subgroup, cosets, conjugate classes, invariant subgroups and factor group; isomorphism and homomorphism; Permutation groups; Representations of a group, Reducible and irreducible representations, orthogonality relations; Topological groups and Lie groups, SO(2), SO(3), Lorentz group, Generators of U(n) and SU(n), SU(2), SU(3). Integral Equations : Homogeneous and Inhomogeneous equations, Method of successive approximations, Hilbert-Schmidt method.

ELECTRONICS

Semiconductor Devices I : Semiconducting Materials, conduction in semiconductors, Charge densities in a semiconductors, PN junction, space charge and electric field distribution at junctions, forward and reverse biased conditions, Space charge capacitance, varactor diode, Zener and avalanche breakdowns, zener diodes, Schottky barrier, tunnel diode, photodiode, LED, p-n-p-n devices and their characteristics, SCR.

Semiconductor Devices II Transistors : Bipolar junction Transistor (BJT), Ebers Moll Model, Analysis of CE amplier using h-parameters, The T-network equivalent circuit, constants of CB and CE amplier using emitter, base, collector resistance, Biasing technique to BJT, stabilization factor, temperature stabilization, operating point, fixed bias, emitter feedback bias, voltage feedback bias. Field-Eect Transistors (FET) and MOSFET: Structure, Working, Derivations of the equations for I-V characteristics under dierent conditions.

Feedback Principle : Negative feedback, effect of negative feedback on input/output resistances and voltage gain, gain stabilization, effect of negative feedback on band width, voltage series feedback, voltage shunt feedback applied to BJT.

Microwave Electronics : Microwaves, Principle of velocity modulation and bunching of electrons, Basic principles of two cavity klystrons and Reflex Klystrons, operation of magnetrons, characteristics of microwave diode.

CONDENSED MATTER PHYSICS

Bonding in crystals : covalent, ionic, metallic, hydrogen bond, van der Waal's bond and the Madelung constant. Crystalline solids, unit cell, primitive cell, Bravais lattices, Miller indices, closed packed structures. Atomic radius, lattice constant and density. Connection between orbital symmetry and crystal structure. Scattering from periodic structures, reciprocal lattice, Brillouin Zones.

Free electrons in solids, density of states, Fermi surface, Fermi gas at T=0 K, Fermi statistics, specific heat capacity of electrons in metals, thermionic emission of electrons from metals.

Electronic band structure in solids, Electrons in periodic potentials, Bloch's Theorem, Kronig-Penney model, Nearly free electron model, Tight-binding model : density of states, examples of band structures. Fermi surfaces of metals and semiconductors.

Transport properties: Motion of electrons in bands and the eective mass, currents in bands and holes, scattering of electrons in bands, Boltzman equation and relaxation time, electrical conductivity of metals, thermoelectric effect, the Wiedemann-Franz Law.

Lattice dynamics of atoms in crystals, vibrations of monoatomic and diatomic linear chains, acoustic and optical phonon modes, density of states, thermal properties of crystal lattices, thermal energy of the harmonic oscillator, specic heat capacity of the lattice, Debye theory of specic heats.

ELECTRODYNAMICS

Maxwells equations. Continuity Equation. Lorentz force. Poynting theorem. Conservation of energy and momentum. Scalar and vector potentials. Gauge transformations. Coulomb and Lorentz gauge.

Generalized functions. Green's functions for Poisson, Helmholtz and Wave equations. Retarded and Advenced solutions for Maxwell's equations. Jemencko formulas for fields for charge and current distriubutions. Lienard-Wiechert Potentials. Electromagnetic field

of a moving point charge. Feynman formulas.

Review of Special Theory of Relativity. Lorentz transformations. Energy and momentum. Covariant formulation of electrodynamics. Transformation of electromagnetic fields. Lorentz group. Infinitesimal generators. Lie algebra of Lorentz group. Action Principle. Stess-energy tensor.

Equations of motion of a point charge in electromagnetic fields. Radiations emitted by an accelerated charge. Energy radiation formula and radiative reaction.

ATOMIC AND MOLECULAR PHYSICS

Review of Solution of Schroedinger's equation for Coulomb field and Hydrogen atom, dipole approximation, spectroscopic terms and selection rules, intensities of spectral lines.

Fine structure of Hydrogen like atoms: spin-orbit interaction, relativistic correction, Lamb shift. Interaction with external fields: Zeeman, Paschen-Back and Stark effect.

The LS-coupling approximation, J-J coupling, hyperfine structures. The central field approximation: the central field, Thomas Fermi-potential, alkali atom spectra, Na doublet.

Born-Oppenheimer Approximation, Rotational, Vibrational, Rotational-Vibrational and Electronic spectra of Di-atomic molecules, Selection rules, Frank-Condon principle, Raman spectra, NMR, ESR.

Lasers : Spontaneous and stimulated emission, optical pumping, population inversion, rate equations, properties of laser beams: temporal and spatial coherence, simple description of Ammonia maser, $C0_2$ and He-Ne lasers.

NUCLEAR AND PARTICLE PHYSICS

Basic Nuclear Concepts Mass, Charge, and Constituents of the nucleus, Nuclear size and distribution of nucleons, Energies of nucleons in the nucleus, Angular momentum, Parity and symmetry, Magnetic dipole moment and electric quadrupole moment, Energy levels and mirror nuclei.

Nuclear Forces Characteristics of nuclear forces -Range and strength, Simple theory of two nucleon system -deuterons, Spin states of two nucleon system, effect of Pauli's exclusion principle, Magnetic dipole moment and electric quadrupole moment of deuteron -The tensor forces.

Experimental Methods of Nuclear & Particle Physics Interaction of charged particles with matter. Stopping power and range. Detectors for energetic charged particles; Solid State or Semiconductor detector.

Particle Accelerators Need for accelerator of charged particles, Classification of types of accelerators, Proton Synchrotron, Betatron; Alternating gradient accelerator, Colliding beam accelerator.

Elementary particles Classication and properties of elementary particles -Leptons, Baryons, mesons particles and antiparticles excited states and resonances. Various types of interactions gravitational, electromagnetic, weak and strong interactions and their mediating quanta, Conservation rules in fundamental interactions. Charge symmetry and charge independence, Parity and charge conjugation, Conservation of parity and its violation in dierent types of interactions. Strange particles, associated production, strangeness and decay modes of charged Kaons, Isospin and its conservation. Idea of eight fold way and quarks.

STATISTICAL MECHANICS

Statistical basis of thermodynamics The macroscopic and the microscopic states, phase space, trajectories and density of states, Liouville's theorem, ensemble theory, the principle of maximum entropy, contact between statistical mechanics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox.

Canonical and grand-canonical ensembles Classical canonical ensemble, partition function, calculation of statistical quantities, Energy uctuations. The grand canonical ensemble, particle number uctuation. Entropy in grand canonical ensemble, thermodynamic potentials.

Quantum Statistical Mechanics Postulates of quantum statistical mechanics, density matrix, statistics of ensembles. Statistics of indistinguishable particles, Maxwell-Boltzmann, Fermi-Dirac and Bose Einstein statistics, properties of ideal Bose and Fermi gases, Bose-Einstein condensation.

Phase transitions Type of phase transitions, rst and second order phase transitions. Ising model, mean-eld theories of the Ising model in two and three dimensions, exact solution in one dimension. Connection of Ising model to lattice gas and binary alloy models. Landau theory of phase transition, Landau free energy for second and rst order transitions, critical exponents and universality classes.

Geography

PAPER-I
REASEARCH METHODOLOGY

Unit 1: INTRODUCTION

Epistemology: science as the way of knowing: Reality: Objective and subjective; Basic concepts: abstraction, observations and measurements; Rationality: limits of human mind ; Natural and social laws ; Objectivity and verifiability ; Induction and deduction ; Hypothesis , models and theory in research

Unit 2: SCIENTIFIC METHODS

Socratic (classical) methods vs. conventional scientific method; Steps in conventional scientific method; Evaluation theory: criteria and characteristics; Critical thinking

Unit 3: METHODS AND DATA COLLECTION

Sample design and sampling techniques; Instrumental measurements; Collection and preservation of samples from natural environment; Schedule, questionnaires, and interviews: purpose ,types and essentials; Agent base information, oral tradition, memoire, diaries, newspaper and texts.

Unit 4: METHODS AND DATA ANALYSIS

Empiricism and logical positivism; Statistical and mathematical induction and determinism (cause and effect analysis); Models and analogies: statistical and mathematical models, simulation and analogies in physical and human geography

Books recommended :

1. Andres, A.C. (1987) : The Analogy Theme in Geography; *Journal of Geography* 86 (55) : 194-197
2. Campbell, D.T. eds. And Overman, E.S.(1988): *Methodology and Epistemology for Social Science: Chicago:* The University of Chicago Press
3. Crano, W.D. and Brewer, M.B. (2002) : *Principles and Methods of Social Research*; New York : Routledge
4. Czaja, R. and Blair, J. (1996) : *Designing Surveys;* Thousand Oaks : Pine Forge Press
5. Denzin, N.K. and Lincoln, Y.S. eds. (1994) : *Handsood of Qualitative Research;* Thousand Oaks : Sage
6. Fowler, F.J. (1995) : *Improving Survey Questions;* Thousand Oaks : Sage
7. Gomez, B and J Jones III J.P. eds. (2010) : *Research Methods in Geography: A critical Introduction;* West Sussex : Wiley-Blackwell

8. Hay, I. ed. (2000) : *Qualitative Research Methods in Human Geography;* Oxford : Oxford University Press
9. Hemper, C.G. ed. (1983): *Methodology, Epistemology, and Philosophy of Science;* New York : Springer
10. Limb, M. and Dwyer, C. eds. (2001) : *Qualitative Methodologies for Geography;* London : Arnold.
11. Livingstone, D.N., and Withers, C.W. (2005) : *Geography and Revolution;* Chicago : The University of Chicago Press
12. Montello, D.R., and Suttor, P.C. (2006): *An Introduction to Scientific Research Methods in Geography;* New Delhi : Sage Publications India Pvt. Ltd.,
13. Rahman, S., Symon, J, and Gabby D.M. Van Bendogem, J.P.eds. (2009): *Logic Epistemology and the University of Science;* New York: Springer
14. Scim, S. and ed. (2005) *The Routledge Companion to Postmodernism;* New York: Routledge
15. Valentine, G. and Chifford, N. eds. (2010) : *Key Methods in Geography;* New Delhi: Sage Publications Pvt. Ltd.

PAPER-II RESEARCH METHODOLOGY
REMOTE SENSING AND GIS

Unit 1: Research Methodology
History of Research; Principle of Parsimony; Paradigm And Paradigm Shift; Postmodernism; Ethnographic Research; Plagiarism

Unit 2: Remote Sensing
Introduction: Stages of Remote Sensing; Types of Orbital Characteristics and Types Of Sensors; Physics of Remote Sensing And EMR; Satellites and Its Resolution (Spatial, Temporal, Radiometric, Spectral); Digital Data Formats; Image Restoration: Geometric and Radiometric Correction; Filtering; Band Combination; Image Classification: Supervised and Unsupervised; Applications of Remote Sensing in Geosciences, Urban, Agriculture, Forest, Ecology.

Unit 3: Geographical Information System
Definition and Scope of GIS; Functional Requirements of GIS; GIS Components; Recent Trends and Applications of GIS; Open Source GIS; Geographical Data: Spatial and Non-Spatial; Data Models: Raster and Vector; Database Management Systems (DBMS) Spatial Analysis, Overlay; Network Analysis and Proximity Analysis; 3d Models, GPS Fundamentals

Unit 4: Statistical Methods and Application
Hypothesis Formulation and Test of Significance: T-Test, F-Test, and Chi-Square Test; Correction; Correction and Regression: Bi-Variate and Multiple Correction and Regression; Principal Component Analysis

Syllabus for the Ph.D. Entrance Test – 2022 - Paper-II

DEPARTMENT OF CHEMISTRY
Jamia Millia Islamia
New Delhi - 110025

Step wise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH metry and spectrophotometry.

Role of solvents in chemical reactions, physical properties of a solvent, types of solvents and their general characteristics, reactions in non-aqueous solvents with reference to liquid NH_3 and liquid SO_2

Spectroscopic ground states, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), calculation of Dq, B and β parameters, charge transfer spectra, spectroscopic method for assignment of absolute configuration in optically active metal chelate and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

VSEPR, Walsh diagram (tri-and penta atomic molecules), drt-pn bonds, Bent rule and energetics of hybridization, simple reactions of covalently bonded molecules.

Isopoly and heteropoly acids and salts, isopolymolybdates, isopolytungstates, isopolyvanadates, heteropoly anions, organoheteropoly anions and heteropoly blues.

Higher boranes, carboranes and metalloboranes, compounds with, metal-metal multiple bonds, metal carbonyls and halide clusters.

Name Reactions and their Mechanisms: Formations and stabilities of carbonium ions, carbanions, carbenes, nitrenes, radicals and arynes, Reactive intermediates, Nucleophilic, Electrophilic, Radical substitution, Addition and Elimination reactions. Barton, Baeyer-villigier, Birch, Chichibabin, Clemmensen Diels-alder, Friedel crafts, Hoffmann, Hofmann-Loffler-Freytag, Hydroboration, Lossen, Mannich, Michael addition, Meerwein-Ponndorf-Verley, Perkin, Grignard, Reimer-Tiemann, Reformatsky, Stork enamine, Wittig, Wolff-Kishner, Oppenaur oxidations, Robinson annulations, Routine functional group transformations and inter-conversions of simple functionalities, Aldol, Clasien, Stobbe and Dieckmann, Schmidt, Condensations, Beckmann and Fries, Favorski, Curtius Rearrangements.

Stereochemistry and Conformational Analysis: Concept of chirality, Asymmetric synthesis (including enzymatic and catalytic nexus) enantio and diastereo-selective synthesis, racemization, resolution, Walden inversion. Effects of conformation on reactivity in acyclic compounds and cyclohexanes, Conformational analysis of cyclohexane.

Pericyclic Reactions: Selection rules and stereochemistry of electrocyclic reactions, cycloaddition and sigmatropic shifts, sommelet, Hauser and Cope rearrangements.

Photochemistry: Cis and trans isomerisation, Paterno buchi reaction, Norrish type I and II reactions, Photo-reduction of ketones, Di-pimethane rearrangements, Photochemistry of areanes.

Spectroscopic Methods for Elucidation of Organic Compounds: IR, UV, Mass, and NMR (^{1}H and ^{13}C)

Dyes: Colour and Constitution, Classification of Dyes, Chemistry of Methyl Orange, Malachite Green, Crystal Violet, Phenolphthalein.

Chemical Thermodynamics: Laws of thermodynamics, state and path functions, concept of entropy and residual entropy, free energy and its temperature dependence, spontaneity, equilibria and free energy functions, physical equilibria involving phase transitions, Maxwell's relations, chemical potential, partial molar quantities, thermodynamic functions of mixing – ideal and non-ideal gases and solutions, colligative properties.

Non-equilibrium and Statistical Thermodynamics: Steady state and equilibrium state, Onsager theory, phenomenological laws and equations, Onsager reciprocal relations, theorem of minimum entropy production, electro-kinetic phenomena; partition functions and calculation of thermodynamic properties, Maxwell-Boltzamann, Fermi-Dirac and Bose-Einstein statistics.

Adsorption: Surface tension, Laplace equation, Gibbs adsorption isotherm, BET adsorption isotherm, surface films, catalytic activity at surfaces, on metal and metal oxide surfaces, photoelectron spectroscopy ESCA and Auger electron spectroscopy used for the study of surfaces.

Catalysis: General characteristics of catalytic reactions, acid-base and enzyme catalysis.

Micelles: Surface active agents, micellization factors affecting CMC of surfactants, thermodynamics of micellization, mass action model, solubilization, micro-emulsions, phase diagram of ternary microemulsion systems.

Macromolecules: Classification of polymers electrically polymers, graft polymers, kinetics and mechanism of polymerization reactions, molar mass of polymers and its determination by osmometry, viscosity, and light scattering methods, calculation of average dimensions of various chain structures.

Quantum Mechanics: Postulates, operators, particle-in-a box, harmonic oscillator, hydrogen atom, shpes of atomic orbitals, variations principles, perturbation theory up to second order in energy, Molecular Orbital Theory (MOT).

Spectroscopy : Theoretical treatment of rotational, vibrational, and electronic spectroscopy. Principles of NMR, EPR, Mossbauer and photoelectron spectroscopy.

Reaction Kinetics: Methods of determining rate laws, mechanisms of photochemical, chain, and oscillatory reactions, theories of reactions rates.

Chemical and Ionic Equilibria: Gibbs-Duhem equation, temperature-dependence of equilibrium constants, phase diagram of one and two-component systems.

Electrochemistry: Specific and molar conductivities, Debye-Huckel-Onsager treatment of dilute electrolyte solutions, electrochemical cells, Nernst equation, electrical double layers.

Nano structured, Compoite and Multiphase Materials: Definition, Nanoscale regime, Nano-

particles, Nanoprous materials, Gas phase cluster, Condensed phase nanoparticles, Inorganic nanoparticles, nanoparticle preparation by Alkali metal reduction method, Zeolite method and Sol-Gel method, concept of Composite: matrix, filler, Classification of Composite based on distribution pattern of fillers, scope and application. Two component phase equilibria, eutectic phase formation (Pb-Sn), Solid solution, Cu-Ni, peritectic phase formation: Fe-Ni, Fe-C phase diagram, phase transformation in Fe-C alloys, solid solutions and intermetallic compound.

Corrosion: Definition, Classification, units and rate of corrosion, Electrochemical corrosion reaction, Rusting, Polarization, Activation Polarization, Concentration Polarization, Passivity, Inhibitors, Electrochemical series of metals, Galvanic series of metals and Alloys, Galvanic corrosion Ceramic corrosion, Pitting corrosion, Intergranular corrosion, Stress corrosion.

Imperfection and deformation in solid: Introduction, Types of crystal defects and non-stoichiometry thermodynamic of line and point imperfections, colour centers and defect clusters, Twinning and stacking fault, edge and screw dislocations, slip, motion of dislocations, modulus of elasticity as a parameter of design, plastic deformation, relationship of slip and crystal structure of materials,

Electronic properties of solid: Band structure of metals, insulators and semiconductors, the concept of hole, extrinsic (imparity) semiconductors, Fermi energy, position of Fermi level, free carrier concentration in intrinsic and extrinsic semiconductors, applications of semiconductors.

Magnetic properties of solids: Classification of magnetic materials, diamagnetism, paramagnetism, ferromagnetism, magnetic anisotropy, ferromagnetic domains, origin of domain wall anti-ferromagnetic, domains, ferromagnetism, normal spinels.

Glass and Ceramics: Introduction, Types of ceramics, Chemical bonding in ceramics, Physical properties of ceramics (Specific Gravity, Porosity, Crystallinity), Electronic configuration of atoms, bonding, polymorphic forms and transformations, Physical, thermal, electrical, magnetic properties of ceramics.

Polymer Chemistry: General characteristics of chain growth polymerization; alkene polymerization by free radical, anionic and cationic initiators. General characteristics of step growth polymerization; synthesis of polymers by step growth polymerization: polyesters, polycarbonates, polyamides and polysiloxanes. Ring opening polymerization of cyclic monomers. Zeigler-Natta co-ordination polymerization. Copolymerization, different types of copolymers, copolymer equation, monomer reactivity ratios and copolymer structure. Polymers of commercial importance; Additives for plastics: stabilizers filler, plasticizers, and cross-linking agents. Manufacture, properties and applications of major thermoplastic and thermosetting polymers: PE, PP, PVC, PS, Phenolic resins, Amino resins, Unsaturated polyesters and epoxy resins.

Department of Mathematics

FACULTY OF NATURAL SCIENCES, JAMIA MILLIA ISLAMIA, NEW DELHI – 110 025

SYLLABUS: PAPER – I

M.Phil/Ph.D. Entrance Test

TEACHING & RESEARCH APTITUDE

- Methods of teaching
- Teaching aids
- **Research:** Meaning, Characteristics and types
- Steps of research
- Methods of research
- Research Ethics,
- Paper, article, workshop, seminar, conference and symposium

GENERAL ENGLISH

- Reasoning, Comprehension, Writing & analytical skills
- Communication: Nature, characteristics, types, barriers and effective classroom communication.

Reasoning (Elementary)

- Number series, letter series, codes
- Relationships, classification
- Evaluating and distinguishing deductive and inductive reasoning
- Verbal analogies: Word analogy-Applied analogy
- Verbal classification
- Reasoning
- Analytical Reasoning

Data Interpretation (Basic)

- Sources, acquisition and interpretation of data
- Quantitative and qualitative data
- Graphical representation and mapping of data

Information and Communication Technology (ICT)

- ICT: meaning, advantages, disadvantages and uses
- General abbreviations and terminology
- Basics of internet and e-mailing

People and Environment (General)

- People and environment interaction
- Sources of pollution
- Pollutants and their impact on human life, exploitation of natural and energy resources
- Natural Hazards and mitigation.

Department of Mathematics
Jamia Millia Islamia, New Delhi
Syllabus for Ph.D. Entrance Test

Real Analysis

Outer and inner Lebesgue measure, Lebesgue measurable sets, Properties of measurable sets, Borel sets and their measurability, Non-measurable sets, Cantor's ternary sets and their properties. Measurable function, Characteristic function, Step function, Continuous function, Set of measure zero, Borel measurable function, the structure of measurable function. Riemann integral and its deficiency, Lebesgue integral of bounded function, Comparison of Riemann and Lebesgue integrals, Properties of Lebesgue integral for bounded measurable function, The Lebesgue integral for unbounded functions, Integral of non-negative measurable functions, General Lebesgue integral, Improper integral.Point wise convergence, Convergence almost everywhere, Uniform convergence almost everywhere, Convergence in measure, F. Reisz's theorem on convergence a.e., D.F. Egoroff's theorem, Lebesgue bounded convergence theorem, Lebesgue dominated convergence theorem, Fatou's lemma, Monotone convergence theorem. L^P-space, Properties of L^P-space, Holder's inequality, Minkowski's inequality and Schwartz's inequality, Convergence in the mean, Riesz-Fischer theorem.

Abstract Algebra

Groups, order of an element of a group, Subgroups, Cyclic groups, Cosets, Normal subgroups, Quotient groups, Homomorphisms, Isomorphisms Permutation groups. Cayley's Theorem, Automorphisms, Normalizer and centre, Conjugate classes, Class equation and its applications, Direct products, Sylow's theorems, Finite abelian groups, Normal Series and Solvable Groups. Rings, Subrings, Ideals, Integral Domain and their properties, Quotient Rings, Ring Homomorphisms, Isomorphisms, Ring of Polynomials and their properties. Principal Ideal Domain, Euclidean Domain, Unique Factorization Domain, Primitive Polynomials, Gauss' lemma, Eisenstein's criterion for Irreducibility.

Linear Algebra

Vector Space, Subspaces and properties, Basis and Dimensions, Sum and direct sum of Subspaces, Independent Subspaces, Quotient Space, Linear transformations, Rank and Nullity of a linear transformation, Sylvester's law of nullity. Algebra of linear transformations, $\mathrm{Hom}(U,V)$, Singular and Non-singular linear transformations, Invertible linear transformations, Dual spaces, Principle of duality, Bidual, Annihilators. Matrix of a linear transformation, Change of Basis, Equivalent and Similar matrices, Relationship between $\mathrm{Hom}(U,V)$ and $M_{m,n}(F)$, Minimal polynomials of a linear transformation and its properties, Cyclic Space. Eigen values and Eigen vectors, Inner product spaces, Orthogonality and Orthonormality, Schwarz inequality, Gram-Schmidt orthogonalization process, Adjoint, Hermitian, Unitary and Normal linear operators.

Topology

Definition and examples of topological spaces, Neighbourhood of a point, Open and Closed sets, Closure, Interior, Exterior and boundary, Limit points, Derived sets, Bases and subbases, I and II countable space, Lindelof space, Separable space, Continuity, Homeomorphism, Subspaces, product spaces and quotient spaces. Compactness, Continuous functions and compact sets. Finite intersection property, Heine Borel theorem, Locally compact spaces,

Bolzano Weierstrass property. Separation Axioms, T_i(i = 0,1,2,3,4) spaces, Regular and completely regular spaces, Normal and completely normal spaces, Urysohn's lemma, Tietze extension theorem. Connected and Disconnected space, Examples, Components, Locally connected spaces, Closure of a connected space, totally disconnected spaces.

Functional Analysis

Definition and examples, subspaces, some concrete examples of Banach spaces, bounded linear operators, spaces of bounded linear operators, equivalent norms, open mapping and closed graph theorems and their consequences, uniform boundedness principle. Examples and basic properties, Forms of dual spaces, Hahm-Banach theorem and its consequences, embedding and reflexivity, adjoint of bounded linear operators, weak convergence. Definitions and examples, orthogonality of vectors, orthogonal complements and projection theorem, orthonormal sets, complete orthonormal sets. Bounded linear functionals, Riesz-Frechet theorem, Hilbert-adjoint operators, self-adjoint operators, normal operators and unitary operators.

Complex Analysis

Complex integration, Cauchy-Goursat Theorem, Cauchy's integral formula. Higher order derivatives, Morera's theorem, Cauchy inequality and Liouville's theorem, The fundamental theorem of algebra. Taylor's theorem, Maximum modulus principle, Schwarz lemma, Laurent's series, Isolated singularities, Residues, Cauchy's residue theorem, Evaluation of integrals, Branches of many valued functions with arg z, log z, and za . Meromorphic functions, The argument principle, Rouche's theorem, Inverse function theorem. Bilinear transformations and their properties and classification, Definition and examples of conformal mappings.

Wavelet Analysis

Fourier transform in $L^1(R)$, properties of Fourier transforms Fourier transform in $L^2(R)$, Parseval Identities, Change of roof, Inversion formula, Plancherel Theorem, Duality Theorem, Poission summation formula, Sampling theorem, Heisenberg's uncertainty principle, Heisenberg's inequality, Discrete Fourier transform, Fast Fourier transform. Wavelet Transform: Gabor transform, Parseval formula, Inversion formula, Continuous wavelet transform, Maxican hat wavelet, Properties of wavelet transforms, Discrete wavelet transform. Multiresolution Analysis and Construction of Wavelets: Multiresolution Analysis, Mother wavelet, Haar wavelet, Shannon wavelet, Meyer wavelet, Franklin wavelet, Orthonormal spline wavelets, Compactly supported wavelets. Wavelets and Applications: Biorthogonal wavelets, Wavelets in several variables, Wavelet packets, Multiwavelets, Wavelet frames, Applications in Neural Networks, Turbulance and Medicine

Mechanics

Kinematics of a rigid body motion, Moments and Products of inertia, Perpendicular and Parallel axis theorem, Momental ellipsoid, Kinetic energy, Theorem of Konig, Angular momentum, Euler's dynamical equations. Generalized coordinates, Constraints, Basic problem of Mechanics, degree of freedom, Ideal constraints, D' Alembert's principle, necessary and sufficient condition for a holonomic system to be in equilibrium, generalized forces for a holonomic system. Lagrange's equations of motion. Lagrange function, techniques of calculus of variations, Hamilton's equation of motion. Hamilton's principles.Canonical transformation, Lagrange's and Poison brackets Integral in variances, Hamilton-Jacobi Poisson equations.

Differential Equations

Existence & uniqueness theorem, General theory of Homogenous and nonhomogeneousequations with constant coefficients, Theory of equations with variable coefficients, Method of variation parameter and the formula for particular integral in terms of Wronskian. Series Solution of second order linear differential equations near ordinary point,Singularity and the solution in the neighborhood of regular singular point, Euler equation and Frobenious method, Solution of Legendre, Bessel, Hermite and Lagurre differential equations. Formulation of heat conduction equation and its solution by the method of separation of variables,Steady state condition and the solution of heat conduction problem with non-zero end conditions, Formation of wave equation and its solution by the method of separation of variables. Linear homogeneous boundary value problems, Eigen values and Eigen functions, SturmLiouville boundary value problems, Non-homogeneous boundary value problems, Green's functions and the solution of boundary value problems in terms of Green's functions.

Numerical Analysis

Newton-Raphson method for Complex roots, Solution of system of nonlinear equations by Seidal Iteration method, Newton-Raphson method. Lagrange's form of interpolating polynomial, Existence and uniqueness of interpolating polynomial, Hermite, Piecewise and Cubic spline interpolation. Approximation: Weighted least squares approximation, Method of least squares for continuous functions, Gram-Schmidt orthogonalization process, Approximation of functions using Chebyshev polynomials. Numerical integration: Romberg's method, Guass Quadrature formula and error estimation. Numerical solution of Initial Value Problems: Runge-Kutta method of order four for system of equations, second and higher order differential equations, Boundary Value problems by Shooting method, Finite difference method, Convergence of finite difference scheme, Stability Analysis. Numerical solution of partial differential equations: Parabolic equations- explicit methods and Crank-Nicolson method with stability analysis. Elliptic equations- Standard five point formula, Jacobi's iteration method and Leibmann's method, Hyperbolic equations: Explicit finite difference method.

Differential Geometry

Tensors: co-ordinate transformation, contravariant, covariant vectors and tensors of higher rank, contraction, quotient law of tensor, metric tensor and 3-index christofell symbols and their properties, transformation law for christofell symbols, covariant derivative of a vector and tensor, Riemannian curvature tensor and its properties, Ricci tensors and scalar curvature. Curves in R^3: Representation of curves, unit and arbitrary speed curves, Frenet-frame, curvature and torsion, Serret - Frenet formula, Helix, Minkowski 3-space E_1^3, Slant helix, Minkowski space time E_1^4, k-type slant helix, directional derivative and covariant derivative, Frame field, altitude matrix and connection Forms, Curve frame rotation matrix, offset curves. Surface in R^3: Definition and examples of a smooth surface, differentiable functions on surfaces, tangent plane and unit surface normal, Surface of revolution, first fundamental form and its properties, second fundamental form, tangential intersection of two surfaces, normal curvature, principal curvature. Meusnier's theorem, Euler's theorem, Umbilical surface, Helicoidal surface, Shape operator and its properties, Gaussian and mean curvature, minimal surface, ruled surface, line of curvature, Rodriguez formula, geodesic of a surface

and geodesic equation, Gauss and Weingarten equations, Mainardi-Codazzi equations, geodesic curvature, Liouville's formula, Gauss-Bonnet theorem.

Fluid Dynamics

Kinematics: Definition, Lagrangian and Eulerian Specifications, Stramline, Path line and Streak line, Linear strain rate, Shear strain rate, Vorticity and Circulation, Material derivative, Acceleration of fluid particle, Numerical problems on Lagrangian/Eulerian specifications, Stramline/pathe line/Streak line and Material derivative. Conservation laws: Conservation of mass in integral and differential forms, Origin of forces in fluid, Stress at a point, Conservation of Momentum, Constitutive equation for Newtonian fluid, Navier-Stokes equation, Euler equation, Bernoulli's equation and its applications, Boussinesq approximation. Laminar Flows: Steady flow between parallel plates, Volume flow rate, Average velocity, Plane Couette flow, Magnitude of shear stress, Plane Poiseuille flow, Magnitude of shear stress, Steady flow in a pipe, Shear stress at any point, Volume flow rate, Impulsively started plate: Similarity solutions. Dynamic Similarity: Dimensional analysis, Rayleigh's technique, Backinghamπ –theorem, Significance of Reynolds number, Definition of Reynold's number, Froude number, Euler number, Mach number, Prandtl number. Boundary Boundarylaer and boundary equation, Boundary layer thickness, Displacement thickness, Drag and lift, Blassius equation and its solution.

Operations Research

Convex sets and their properties, Graphical method, Integer Programming, Branch and Bound Technique, Theory of Simplex method, Two-Phase Simplex Method, Big-M method. Duality in LP, Conversion of primal to dual, Dual Simplex method, Sensitivity analysis, Discrete change in price vector, requirement vector and coefficient matrix, adding a new variable and new constraints. Queuing Theory, Distribution of arrival and departure pattern, (M/M/1):(∞/FCFS), (M/M/1):(N/FCFS) and (M/M/S):(∞/FCFS) queuing models, Network analysis, Critical Path Method (CPM), Project Evaluation and Review Technique (PERT), Project management with CPM/PERT. Dynamic programming, Bellman's Principle of Optimality, Nonlinear Programming (NLP), Graphical method for NLP, Kuhn-Tucker Conditions for Constrained Optimization, Quadratic Programming, Wolfe's modified Simplex method, Separable Programming.

Centre for Theoretical Physics

Ph.D. Entrance Examination

Syllabus

I. Classical Mechanics

Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force motions. Two body Collisions - scattering in laboratory and Centre of mass frames. Rigid body dynamics-moment of inertia tensor. Non-inertial frames and pseudoforces. Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Poisson brackets and canonical transformations. Symmetry, invariance and Noether's theorem. Hamilton-Jacobi theory. Periodic motion: small oscillations, normal modes. Special theory of relativity-Lorentz transformations, relativistic kinematics and mass–energy equivalence.

II. Quantum Mechanics

Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator, etc.). Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment. Time-independent perturbation theory and applications. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle, spin-statistics connection. Relativistic Quantum mechanics: Klein-Gordon and Dirac Equations

III. Electromagnetic Theory

Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance. Electromagnetic waves in free space. Dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. Dynamics of charged particles in static and uniform electromagnetic fields.

IV. Thermodynamic and Statistical Physics

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential. Phase space, micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases. Blackbody radiation and Planck's distribution law.

V. Mathematical Methods of Physics

Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, Cayley-Hamilton Theorem. Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order, Special functions (Hermite, Bessel, Laguerre and Legendre functions). Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions; Taylor & Laurent series; poles, residues and evaluation of integrals. Elementary probability theory, random variables, binomial, Poisson and normal distributions.