

PhD Online Test Information Brochure (July 2020)

Test Dates: April 5 and April 12, 2020

1. All India level PhD online test (Computer based test) will be conducted by Manipal Academy of Higher Education.
2. The performance in the test will account to 70% and interview/presentation will account to the remaining 30%. Highest performers will be selected to attend the interview at Manipal.
3. Students who register for the online test can take the tests at the centres mentioned in the online application form.
4. The test design is as follows:
Duration of the paper: 2 hours

Question paper design: MCQs (single best response) each correct answer carries 04 marks and a wrong answer has 01 negative marks

Total maximum marks: 400 (Paper 1: 200, Paper 2: 200)

Part 1: General paper (total questions: 50)

- a. Research Aptitude: 15
- b. Logic and Reasoning: 10
- c. Basic Math and Statistics: 15
- d. English Language: 10

Part 2: Subject specific paper (total questions: 50)

Student can take any of the streams mentioned below that is relevant to the Master's program.

Category 1	
Broad area	Biological sciences/Health sciences/Life sciences
Specific areas	• Life Sciences
	• Health Sciences
	• Regenerative Medicine and Stem Cell Biology
	• Public Health
	• Virology
	• Stream 1: Pharmaceuticals, Quality Assurance, Regulatory Affairs And Pharmaceutical Management
	• Stream 2: Pharmaceutical Biotechnology, Pharmacology And Pharmacy Practice
	• Stream 3: Pharmaceutical Chemistry, Pharmaceutical Analysis And Pharmacognosy
• Nursing	

	• Dentistry
	• Speech and Hearing
	• Physiotherapy
	• Nuclear Medicine
	• Occupational Therapy
	• Optometry
	• Health Information Management

Category 2	
Broad area	Science/Technology/ management (RA)
Specific areas	• Chemistry
	• Physics
	• Mathematics
	• Biostatistics/Data Science
	• Applied Physics (Photonics/Nanoscience)
	• Biomedical engineering
	• Biotechnology
	• Chemical engineering
	• Civil engineering & Geology
	• Computers
	• Power and energy systems
	• Electronics and communication
	• Instrumentation and Control
	• Mechanical
	• Management
• Commerce	
• Architecture	

Category 3	
Broad areas	Humanities and Social Sciences (RA)
Specific area	Gandhian and Cultural Studies
	Geopolitics and International Relations
	Humanities

5. For details of the PhD program at MAHE, please follow this link:
<https://manipal.edu/mu/academics/phd.html>

Syllabus Outline

Life Sciences/Health & Biological Sciences/Stem cell and Regenerative medicine

BIOMOLECULES

Metabolism of carbohydrates

Glycolysis: Importance, reactions, regulation and energy yield. Gluconeogenesis: from Lactate, Fatty acids, Glycerol. Glucogenic amino acids, Cori cycle, Glucose-alanine cycle, Regulation of glycolysis and gluconeogenesis. Rapoport-Leubering Pathway; Glycogen metabolism and regulation, Hexose monophosphate shunt pathway (Pentose phosphate pathway): Importance, reactions. Tricarboxylic acid cycle: Importance, reactions, energy yield, regulatory mechanism, amphibolic role, Anaplerotic and cataplerotic reactions

Metabolism of lipids

Lipids: Importance of classification, Fatty acid synthesis: Tricarboxylate transport system, Fatty acid synthase complex, reactions and its regulation. β -oxidation of fatty acids: Activation, transport and reactions, energy yield. Ketone bodies: synthesis, regulation and utilization.

Metabolism of amino acids & integration of metabolism

Sources and uses of amino acids, Transamination, Deamination, Transdeamination, Ammonia metabolism, role of glutamine, ammonia toxicity. Urea cycle: reactions, regulation and metabolic disorders. Metabolism of amino acids: Metabolic classification, metabolism and synthesis of specialized products from: Glycine, Glutamic acid, Phenylalanine and Sulfur containing amino acids. Inborn errors of metabolism associated with these amino acids

Biological oxidation

High and low energy compounds, Redox potential and redox pair, Mitochondrial organization. The mitochondrial respiratory chain, order and organization of carriers, sequence of electron carriers, sites of ATP production, and ATP synthase complex. Oxidative phosphorylation: mechanism and hypothesis and Inhibitors. Uncouplers and Ionophores

Vitamins and minerals

Definition and classification. RDA, sources, activation, absorption, transport, storage, biochemical function, their coenzyme activity and deficiency manifestation of fat soluble and water-soluble vitamins, deficiency manifestations.

Acid-base balance

Acids and bases, production of acids and bases in the body. Maintenance of blood pH: chemical and physiological buffer systems. Renal and respiratory regulation of pH. Hemoglobin as buffer, Chloride shift, Disturbance in acid-base balance, Anion gap

Plasma proteins

Components of blood, components of plasma, Major proteins of plasma and their functions, Bence Jones protein

HUMAN GENETICS

Introduction to genetics

Timeline of major discoveries in genetics. Theories in genetics- pangenesis, spontaneous generation, preformation, epigenesis, inheritance of acquired characters, germplasm theory, Contributions of Mendel, Morgan and McKusick

Inheritance and genetics

Mendelism and its extensions: Law of segregation; Law of independent assortment; Chromosomal basis of segregation and independent assortment; Linkage; Crossing over; Multiple allelism; Pleiotropy; Cytoplasmic inheritance

Chromosome and its Chemistry

1) Chromatin structure: Histones, DNA, nucleosome morphology and higher-level organization; Functional states of chromatin and alterations in chromatin organization. 2) Chromosome organization: Metaphase chromosomes: centromere and kinetochore, telomere and its maintenance; Holocentric chromosomes; Heterochromatin and euchromatin, position effect variegation; chromosomal domains (matrix, loop domains) and their functional significance. 3) Giant chromosomes: Polytene and lampbrush chromosomes. 4) Cytogenetic aspects of cell division: Chromosome labeling and cell cycle analysis, Overview of mitosis and meiosis, sister chromatid cohesion remodeling, regulation of exit from metaphase, chromosome movement at anaphase. Genetic control of meiosis with examples from yeast. 5) Techniques in the study of chromosomes and their applications:

Gene(s) and chromosomal mutations

Concept of gene: Fine structure of gene, split genes, pseudogenes, non-coding genes, overlapping genes and multi-gene families. Genome mapping: Physical maps - an overview and approaches. Chromosomal abnormalities, induced chromosomal aberrations. ISCN guidelines. Gene mutations: Nonsense, Missense, Point mutations; Intragenic and Intergenic suppression; Frameshift mutations; Physical, chemical, and biological mutagens; Transposition- Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation

Genetics and Epigenetic variations

X and Y chromosomes evolution, X chromosome Inactivation, Chromosome fragile sites and disorders; Genomic imprinting and uniparental disomy, Trinucleotide repeat expansion and disorders. Molecular basis of epigenetics: Histone modifications, DNA methylation and. Genetic and epigenetic changes in human genome: Organization of nuclear and organellar genomes; C-value paradox, Repetitive DNA, satellite DNAs and interspersed repeated, DNAs, Transposable elements, LINES, SINES, Alu family and their application in genome mapping

Pharmacogenetics and pharmacogenomics

Introduction, origin, status, and the hope for personalized medicine, challenges of pharmacogenetics and genomics

Human genetics and applications

Genetic predisposition to common diseases; Diagnosis of genetic diseases, Pre-symptomatic diagnosis & Carrier detection, PCR based molecular techniques, principles and applications; Population screening and risk calculation.

CELL BIOLOGY

General Introduction

- a) Molecular interactions, Organic molecules, and Biochemical energetics
- b) Evolution of life: time scale, spontaneous evolution of organic molecules, self-replicating RNA, evolution of metabolism
- c) Evolution of genomes: origin of introns, acquisition of exons, multigene families, chromosome reorganization, exon shuffling, transposons

Cell Architecture and Dynamics

- a) **Cell membrane:** Fluid mosaic model, asymmetry of lipid bilayer, membrane proteins and association with lipid bilayer, lipid rafts, Transport across membrane

- b) **Cytoskeleton:** The self-assembly and Dynamic structure of cytoskeletal filaments - Microfilaments, Intermediate filaments, Microtubules, Molecular motors
- c) **Cell junctions:** occluding junctions and communicating junctions; classification of junction proteins and functions; tight junctions; Actin filament attachment sites, Intermediate filament attachment sites, communicating junctions with specific examples
- d) **Extracellular matrix and functions:** components of ECM, synthesis of ECM, Integrins, MMP, TIMP

Cell communication & signaling

- a) Spatial and temporal specificity, ligands and receptor interactions,
- b) Post-translational modifications in signaling,
- c) Classification of receptors and functions; G protein coupled, Ion channel linked and Enzyme linked receptors;
- d) Secondary messengers, amplification of signals;
- e) Regulation of cell signaling, negative feedback;
- f) Specific examples a) growth factor signaling, b) lipid signaling
- g) Proteolysis

Cellular responses

- a) **Cell proliferation:** Cell cycle: components and control system in eukaryotes, mitosis and cytokinesis, signaling mechanisms
- b) **Cell migration:** cell polarity, chemotaxis, actin cytoskeleton rearrangement, lamellipodia, Filopodia, Membrane Ruffles, and Stress Fibers, myosin proteins, small GTPases, Rho kinases, Rac kinase and Cdc42
- c) **Apoptosis:** extrinsic and intrinsic pathways, signaling mechanisms. Oxidative and ER stress proteins in inducing apoptosis
- d) **Autophagy:** signaling mechanisms and functions
- e) **Cell differentiation:** differentiating proteins/growth factors and transcription factors, Yamanaka factors, classical examples such as macrophage differentiation, neuronal differentiation

MOLECULAR BIOLOGY & RECOMBINANT DNA TECHNOLOGY

DNA Replication Mechanisms

DNA as genetic material; Basis for DNA replication and repair; Mechanisms of DNA replication in Bacteria and Eukaryotes; Different DNA Polymerases; Cell cycle control of DNA replication

DNA Repair Mechanisms

Agents that damage DNA; Types of DNA damage; DNA repair mechanisms: Photoreactivation, BER, NER, SSB repair, DSB repair

Transcription

Different RNAs in cells - their structure and functions; RNA polymerases in prokaryotes and eukaryotes; Transcription in prokaryotes - stages, significance; Transcription in eukaryotes - stages, mRNA processing; Gene promoters, enhancers, and other regulators

Translation

Translation - Structure of Ribosomes, Genetic code, steps in translation, polypeptide folding and modifications, secretions

Control of Gene expression

An overview of gene control; DNA binding motifs in gene regulatory proteins; role of genetic switches; The molecular genetic mechanisms that create specialized cell types; Posttranscriptional and Posttranslational controls; genome replication and evolution

Genomes

Introduction to Human genome, Genome Anatomies, Transcriptome and Proteomes, Mapping genome, Sequencing of genome

Regulation of Genomes

Accessing the genome, Regulation of Genome activity

Transposons and rearrangement of DNA

Transposition mechanisms, controlling elements, retroviruses and retrotransposons, Ty elements, rearrangement of DNA - yeast mating types, Ti plasmids

Enzymes in laboratory applications

Restriction enzymes, Phosphatases, DNA polymerases and DNA ligases

Manipulating proteins, DNA and RNA

Isolating cells and growing them in culture, Fractionation of cells, Isolating, cloning and sequencing DNA, Analysing protein structure and function, Studying gene expression and function

Introduction to Recombinant DNA technology

Historical aspects, applications, containment systems and importance

Applications of recombinant DNA technology

Agricultural (plant and animal), Medical (Production of insulin, growth hormones, vaccines), Environmental and industrial applications

Protein engineering and design

Approaches to Study Protein Functions and Regulation in Budding Yeast, Regulation of expression of Proteins, Directed and random mutagenesis and Protein Engineering, Methods for Studying Protein-Protein and Protein-DNA Interactions

IMMUNOLOGY & IMMUNOGENETICS

Overview of immune system

a) Innate & adaptive immune system, b) Cardinal features of immune system and kinetics
c) Evolution of immune system

Cells, Tissues and Organs of immune system

a) Central and peripheral organ system: Structure and functions of Bone marrow, Thymus, anatomy of lymphatic system, Lymph nodes, tonsils, spleen. b) Cells of immune system: Origin and differentiation of Progenitor cells in lymphoid, myeloid and erythroid lineages. c) Granulocytes: Functions of Neutrophils, eosinophils, and basophils. Oxygen dependent and independent mechanisms for eliminating pathogens. d) Monocyte differentiation. Structure and function of sub populations of macrophages: M1 and M2 macrophages; resident and differentiated macrophages. e) Dendritic cells, Mast cells, T cells, B cells, Natural killer cells. f) Specialized barriers: MALT, GALT & SALT; immune privileged sites

Innate Immunity

a) Constitutive and inducible innate defense mechanisms. b) Recognition of microbes; pattern recognition receptors. c) Classification, evolution, and function of PRR. d) Microbial associated patterns e) TLR/Myd signaling. f) Antiviral response g) Inflammatory response and inflammation:

Acquired Immunity

a) Antibody synthesis and B cell activation b) Immunoglobulin: Structure, classification, genetics, and diversity. c) Antigens, Immunogenicity, Adjuvants and haptens c) T cell: Types, Development, and Journey d) BCR vs. TCR, Immunoglobulin super family

Antigen presentation

a) Antigen presenting cells - professional and nonprofessional cells. b) Antigen processing and presentation, vesicular and cytoplasm mediated mechanisms. c) Dendritic cell maturity, d) Activation of T cells and B cells by APCs, e) T cell dependent and

independent B cell activation f) decline of T cell responses. g) Regulation of humoral to Fc receptors

Signaling in the immune system

a) Cytokines and cytokine receptors. Families of cytokine receptors. b) Pro and anti-inflammatory cytokines. c) Biological activities of interleukins. d) Functions of cytokine in biological processes such as hematopoiesis, immune response, cell survival and death, differentiation.

Complement

Complement components, complement activation, regulation of complement activation, complement and inflammation, complement deficiency

Tolerance and autoimmunity

Tolerance, mechanism of self-tolerance, termination of tolerance and autoimmunity

PHARMACY: SYLLABUS OUTLINE

Stream 1: PHARMACEUTICS, QUALITY ASSURANCE, REGULATORY AFFAIRS AND PHARMACEUTICAL MANAGEMENT

Pharmaceutics

- Powders, Capsules, Tablets, Parenterals, Liquid Orals, Suspensions and emulsions, Semisolids, Prolonged Action Pharmaceuticals, Novel drug Delivery systems and Cosmetics
- Preformulation, Stability of formulated products, Dosage Form Additives and Packaging Materials
- Pharmacokinetics and Biopharmaceutics

Pharmacy Management

- Basic aspects of Pharmaceutical Marketing
- Principles of Pharmaceutical Management
- Basics of Pharmaceutical Jurisprudence like Drugs and Cosmetics Act 1945. Pharmacy Act 1948.

Quality Assurance

- Good Manufacturing Practices (c GMP) as per Schedule M and 21 CFR.
- Calibration and performance qualifications of analytical, laboratory and manufacturing instruments.
- Analytical method validation as per ICH Q2R1.
- Bioanalytical method validation as per USFDA Guidance.
- 3. Bioequivalence regulations of USFDA and CDSCO.
- CTD and e-CTD format for regulatory submissions.
- ICH Guidelines.
- Good Laboratory Practices.
- Statistical Quality/process Control.
- Product recalls as per CDSCO.

Regulatory Affairs

- Regulatory requirements for US FDA submissions (Prescription drugs, Medical Devices, and Biologics).
- Regulatory requirements for CDSCO submissions (Prescription drugs, Medical Devices, and Biologics).
- Bioequivalence regulations of USFDA and CDSCO.
- CTD and e-CTD format for regulatory submissions.
- ICH Guidelines.
- Good Laboratory Practices.

STREAM 2: PHARMACEUTICAL BIOTECHNOLOGY, PHARMACOLOGY AND PHARMACY PRACTICE

Pharmaceutical Biotechnology:

Biological macromolecules and their structures. Ultra-structure and morphology of bacteria, fungi and virus. Microbial antibiotic resistance, factors and mechanisms involved. Principles of disinfection and sterilization. Recombinant DNA technology and basic molecular biology techniques

Pharmacology:

Mechanism of action, uses and adverse reactions of drugs

Pharmacy Practice:

Pathophysiology and Pharmacotherapy of:

Gastrointestinal disorders

Cardiovascular disorders

Neurological and psychological disorders

Endocrine disorders

Urologic disorders

Infections

Haematopoietic disorders

Stream 3: PHARMACEUTICAL CHEMISTRY, PHARMACEUTICAL ANALYSIS AND PHARMACOGNOSY

Pharmaceutical chemistry

Structure and properties: Acidity & Basicity, Solubility, Polarity. Important reactions and reagents used in organic chemistry, Stereochemistry, Medicinal chemistry of Therapeutic agents, Drug design and developments aspects of Medicinal chemistry.

Pharmaceutical Analysis

Principle, theory and applications of Spectroscopy and chromatography based advanced analytical instrumentation techniques for identification, characterization, separation and quantification of pharmaceuticals.

Pharmacognosy

Evaluation: Identification, authentication and adulteration and detection of crude drugs
Phytochemistry: General method of extraction, isolation, identification and characterization of compounds

Plant Secondary Metabolites: Definition, chemistry, isolation, Separation and identification tests including their biogenesis of drugs containing: a) Alkaloids b) Glycosides c) Flavonoids d) Volatile oils d) Resins

Virology

Human Anatomy and Physiology

Basic Virology

Biosafety and Biosecurity

Basic Epidemiology

Basic Biostatistics including Data collection and management

Basic Immunology and Host Virus interactions

Tissue/Cell culture

Cellular and Molecular Biology

Systematic Virology

Surveillance

Virological Techniques

Molecular Virology and advanced Molecular Biology

Applied Epidemiology - Outbreak investigation and management

Applied Biostatistics

Clinical Virology

Insect vectors of viral diseases

Analytical methods

Bioinformatics

Advanced Immunology and immunology of Viral diseases

Emerging Viral Diseases and Public health response
Viral Vaccines
Anti-viral Pharmacotherapy
GIS and its application in viral disease epidemiology
Veterinary and Plant Virology
Virology Laboratory design and management

Nursing

Advanced Nursing Practice

- Health Care Delivery system
- Bio psychosocial Pathology: Pathophysiology and psychodynamics of disease causation, Life process, homeostatic mechanism, biological and psychosocial dynamics in causation of disease, Common problems, Treatment, pre and post-operative care, Cardiopulmonary resuscitation, infection prevention, standard safety measures, biomedical waste management.
- Philosophy and theories of Nursing: Nursing theories and health belief models.
- Psychological aspects and human relations: Human behavior, Life processes, growth and development, Personality development, defense mechanism, communication, interpersonal relationships, individual and group dynamics, organizational behavior, basic human needs across the life span, stress and adaptation, crisis and its intervention, end of life care, coping with loss, death and grieving

Nursing Education

- Teaching Learning Process: teaching, learning, instructional design, competency based education and outcome based education
- Measurement and Evaluation; process, principles, types, standardized and non-standardized test
- Continuing Education in Nursing
- Curriculum development: process, model, framework, types, steps, curriculum change
- Quality Assurance: accreditation, state and national council, professional associations

Nursing Research Methodology

- Research approaches and design
- Developing theoretical/ conceptual framework
- Sampling
- Tools and methods of data collection
- Data analysis

Nursing Management

- Organization and functions of nursing services and education at national, state, district and institution
- Elements of administration
- Legal and ethical issues
- Nursing informatics

Allied Health

Occupational Therapy

Speech and Hearing

1. Basics and application of Electrophysiology
2. Adult language disorders
3. Speech Sciences
4. Diagnostic Audiology
5. Child language disorders/SLI

Physiotherapy

1. Orthopedic physiotherapy
2. Neurological physiotherapy
3. Cardiopulmonary physiotherapy
4. Community Physiotherapy
5. Pediatric Physiotherapy
6. Women's health physiotherapy
7. Geriatric Physiotherapy

Nuclear Medicine

1. Radiation Physics in Nuclear Medicine
 - a) Atoms and atomic models
 - b) Nuclear radiations and their properties
 - c) Radioactivity, decay equations, Units of radioactivity and half-life
 - d) Production of radionuclides: Nuclear reactor produced and accelerator produced
 - e) Interaction of different ionizing radiations with matter
2. Radiochemistry and Radiopharmaceuticals
 - a) Radionuclide generators: principle and types
 - b) Radiopharmaceuticals their ideal characteristics
 - c) Tc-99m labelled radiopharmaceuticals
 - d) PET radiopharmaceuticals
 - e) Quality control methods of radiopharmaceuticals: paper chromatography, thin layer chromatography, gel chromatography, HPLC etc.
3. Radiobiology
 - a) Effect of radiation at cellular level
 - b) Effect of radiation at molecular level
 - c) Effect of radiation at genetic level
 - d) Effect of radiation at organ level
 - e) Radiomodifiers, radiosensitizers, radioprotectors and radiation hormesis
4. Radiation detection and measurement
 - a) Gas filled detectors principle and working (ionization chamber, proportional counter and GM counter)
 - b) Scintillation detectors principle and working (organic and inorganic scintillation detectors, liquid scintillation detectors)
 - c) Semiconductor radiation detectors principle and working
5. Radiation safety
 - a) Principles of radiation safety
 - b) Safe handling of radioactive materials
 - c) Transport and storage of radioactive materials

- d) Management and disposal of radioactive waste in medical and research institutions
- e) Radiation emergency and preparedness
- 6. Cell Biology
 - a) Structure and functions of cell and cellular organelles
 - b) Cell cycle, mitosis, meiosis
 - c) Cell signalling and cell death
 - d) Basics of immunology
 - e) Cancer biology
- 7. Molecular Biology
 - a) Gene expression and gene regulation
 - b) Protein structure and function
 - c) Nucleic acids and nucleoproteins
 - d) DNA and RNA metabolism
 - e) Protein synthesis
- 8. Human Anatomy and physiology
 - a) Cardiovascular system
 - b) Excretory and reproductive system
 - c) Respiratory system
 - d) Endocrine and Nervous system
 - e) Digestive system
 - f) Musculoskeletal system
- 9. Biochemistry
 - a) Interaction of macromolecules with water
 - b) Enzymes
 - c) Carbohydrates and glycobiology
 - d) Bioenergetics and different biochemical pathways
 - e) Biosynthesis of carbohydrates, lipids, amino acids, nucleotides etc.
- 10. Research tools and techniques in biological research
 - a) Isotopic and non-isotopic assays, fluorimetry, FISH and GISH
 - b) Spectroscopic techniques NMR and ESR spectroscopy, Mass spectroscopy, FT-IR spectroscopy, UV-Vis spectroscopy, X- ray diffraction etc.
 - c) Microscopic techniques: Light microscopy, electron microscopy
 - d) Physiological measurement tools: Electrocardiogram, single neuron recording, patch clamp recording, lesion and stimulation of brain, recording of brain activity, SPECT, PET, MRI, fMRI in research
 - e) Basics of cell culture techniques

Optometry

- a) Perimetry and Glaucoma
- b) Posterior eye diseases
- c) Visual Neuroscience and Psychophysics
- d) Technology innovations in eye care

Health Information Management

1. Health Information Management
 - a. Privacy laws Indian context
 - b. Electronic health records-Indian context
2. Health Management information system
 - a. Implementation issues in Indian context
3. Digitization of health care documentation-Indian context
 - a. Application of mhealth in health care
 - b. Recent developments in terms of the national digital health mission
4. Health Insurance and Universal health coverage
 - a. Health Insurance information systems in south east Asia
 - b. Social and community health insurance
 - c. Challenges of implementing UHC in India
5. Health Policy and standards
 - a. EHR /EMR standards in India
 - b. Health insurance regulations
6. Quality assurance in health care
 - a. Clinical and medical audit
 - b. NABH accreditation process

Public Health

1. Drug Regulatory Affairs
2. Demography
3. Digital Health
4. Health Economics
5. Health Systems Research
6. Public Health Genomics
7. Health Technology Assessment
8. Social Protection
9. One-Health
10. Health Informatics
11. Anthropology and Behavioural Science
12. Health Workforce Management
13. Maternal and Child Welfare
14. Epidemiology
15. Environmental and Occupational Health
16. Inquiry into Health Research Methodologies
17. Communicable and Non-Communicable Diseases

Chemistry

Chemical periodicity; Structure & bonding; Main elements, transition elements, inner transition elements; their compounds & industrial applications; Organometallic compounds; Bioinorganic chemistry; Analytical chemistry; Data analysis.

Quantum chemistry; chemical and statistical thermodynamics; Electrochemistry; Chemical kinetics and photochemical reactions; Colloids and surfaces; Solid state Chemistry; Polymer chemistry and Nuclear chemistry; Phase rule.

Nomenclature of organic molecules; Principles of stereochemistry: Aromaticity: Organic reactive intermediates & reaction mechanisms Common named reactions and rearrangements; Organic transformations and reagents; Concepts in organic synthesis; Asymmetric synthesis; Pericyclic reactions - Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S). Chemistry of natural products.

Molecular spectroscopy: Rotational and vibrational spectra of diatomic molecules; Electronic spectra; IR and Raman activities - selection rules; basic principles of magnetic resonance. IR, Raman, NMR, EPR, Mössbauer, UV-vis, NQR, MS, electron spectroscopy and microscopic techniques.

Chemistry in nanoscience and technology; Catalysis and green chemistry; Medicinal chemistry; Supramolecular chemistry. Environmental chemistry.

Mathematics

Real Analysis: Countability, Metric spaces, Numerical sequences and series, Continuity, Riemann- *Stieltjes* Integration, Sequence and Series of Functions, Uniform Convergence.

Linear Algebra: Linear transformations, characteristic roots, canonical forms, trace, transpose and the determinants, dual spaces, inner product spaces, orthogonal sets, Hermitian, Unitary and normal transformations, bilinear, quadratic and Hermitian forms.

Topology: Bases and sub-bases, Continuity and homeomorphism, Subspaces, product and quotient spaces, metric spaces, continuity, convergence, compactness.

Measure Theory: Measurable and non-measurable sets, Littlewoods three principles, Riemann integral, Lebesgue integral, Differentiation of monotone functions, Functions of bounded variation, Measurable functions, convergence, Radon - Nikodym Theorem, Product measure, Inner measure, Invariant measures.

Functional Analysis: Linear mappings. Reflexive spaces. Convergence of weak, strong type, Banach spaces and Hilbert spaces, linear operators, Spectral theorem, Asymptotic centres. Fixed point theorems. Convex spaces, Convexity and extreme points.

Complex Analysis: Analytic functions, conformal mappings, complex integrations, Laurent series expansions, singularities, residues, residue integration

Differential equations: Linear differential equations of first and nth order with constant and variable coefficients. Partial differential equations of first and second order. Classification and solution methods.

Number Theory: Divisibility, Congruence, Gaussian Integers, Euler phi function, Primes and pseudo-primes, factorization, Modular Arithmetic, Computations over finite fields, irreducible polynomials.

Algebra: Groups, Subgroups, Quotient Groups, Normal Subgroups, Homomorphism, Direct Sums and products, Group acting on a set, Permutation Groups, Symmetric Groups, Sylow's Theorem and Applications, Permutation Groups, Rings, Ideals, Maximal Ideals, Factorization of Polynomials, Irreducibility, Finite fields, Field Extensions.

Graph Theory: Eulerian and Hamiltonian graphs, connectivity, Eccentricity, radius and diameter of a graph, Bipartite graphs, complement of a graph, self-complementary graphs. Trees, Traveling salesman problem, seating problem, Königsberg bridge problem, Colouring, independence and domination, chromatic polynomials, Planar graphs.

Numerical Methods: Interpolation, Differentiation, Integration, System of equations, Eigen values and Eigen Vectors, Initial and Boundary value problems.

Statistics

PART - A(16)

Basis Mathematics and Statistics (8 + 8 = 16 Marks)

Set theory, Linear algebra, Integration and differentiation, Measures of central tendency, Measures of dispersion

PART - B (34)

Probability and Probability Distribution: (11 marks)

Basics of probability theory including definitions and theorems of probability, Random variables,

Expectation, Inequalities, Limit theorems, Discrete Distribution: Bernoulli, Binomial, Poisson, Uniform,

Negative binomial, Hypergeometric, Geometric distribution and Multinomial, Continuous Distribution:

Uniform, Cauchy, Exponential, Weibull, Gamma, Beta, Normal, Lognormal, Pareto, Laplace, Logistic, Chi-square,

Student t, F and Multivariate normal distribution.

Statistical Inference (11 marks)

Point Estimation - Characteristics of the estimators, Maximum likelihood estimators

Sampling distributions - Standard Errors, Central limit theorem

Interval Estimation

Hypothesis testing - Parametric inferences, Non-Parametric inferences, Power of a test

Sample size determination

Multiple linear regression (4)

concept, assumptions, least squares estimation, maximum likelihood estimation, R^2 and adjusted R^2 ,

testing the significance of independent variables using t test, ANOVA F test for overall significance, enter

method, stepwise method, forward and backward methods, transformation of variables. Model building

strategies - Multi-collinearity, how to deal with multi-collinearity, residual analysis, detection of outliers.

Introduction to Generalized linear models-Exponential family of distributions, link functions, Logistic

regression-model specification and inference

Designs of experiment (5)

Concept, Randomisation, replication and local control. Standard designs: RBD, CRD, LSD and factorial:

model specification, testing hypothesis using variance component approach and post hoc test

used. (Bonferroni, LSD and Tukeys HSD)

Multivariate analysis (3)

MANOVA, Linear Discriminant analysis, Principal component analysis, Factor analysis and Cluster analysis

Physics

Mathematical Methods Of Physics: Functions of complex variable, General Curvilinear coordinates, Matrices, Tensors, Group Theory, Special Functions, Integral transform.

Classical Mechanics: Mechanics of a system of particles, Central forces, Mechanics of rigid bodies, Lagrangian Equations, Hamilton's equations, Continuum mechanics of solid media and Fluid mechanics.

Quantum Mechanics: Mathematical Formalism, Mathematical Formalism, Schrodinger Equation, Quantum mechanics in three dimensions, Identical particles, Angular momentum, , Approximation methods, degenerate perturbation theory, Scattering theory, Relativistic quantum mechanics.

Fundamentals Of Electronics: Network analysis, Semiconductor devices and circuits, Operational amplifiers and circuits, Digital electronics.

Introduction To Condensed Matter Physics: Crystal structure and bonding in solids, Elastic properties and lattice dynamics, Thermal and electrical properties of solids, Band theory of solids, Dielectric and Magnetic properties of solids.

Numerical Methods And Computational Physics: Input-Output Functions, Pre-processor Directives, Operators and Expressions, Loop Control and Decision Control Statements, Functions, Arrays, File Handling, Solution of Algebraic Equations, Matrices and Linear Systems of Equation, Least Square curve fitting, Numerical differentiation and integration, Ordinary differential equations, Partial differential equations, Monte Carlo methods.

Nuclear And Particle Physics: General properties of the nucleus and nuclear decay, Interaction of radiation with matter, radiation detectors and particle accelerators, Nuclear models, Nuclear reactions, Nuclear forces, Elementary particle interactions and families.

Atomic And Molecular Physics: Interaction of EM-radiation with atoms and molecules, X-ray Spectra and Resonance spectroscopy, Microwave spectra, infrared spectra and Raman spectroscopy, Electronic spectroscopy.

Electromagnetism: Electrostatics and Magneto statics, Electrodynamics, Electromagnetic theory, Radiation.

Experimental Methods In Physics: Data interpretation and analysis, Instrumentation, Experimental Methods.

Thermodynamics And Statistical Physics: Statistical basis of thermodynamics, Classical Statistics, Quantum statistics, First and second order phase transitions, Fluctuations in canonical, grand canonical and micro canonical ensembles.

Geology

Earth and Planetary system, Geomorphology, Structural geology, Crystallography and Mineralogy, Geochemistry and Petrology, Geological time scale Stratigraphic principles, Geology of India, Indian mineral resources. Ore genesis and ore exploration, Ground water geology. Paleontology and Micropaleontology, Oceanography and Climatology, Engineering geology, Natural hazards, Remote sensing & GIS and its application.

Photonics and Nanoscience

Photonics

Atomic and molecular spectroscopy, Optics and electrodynamics, Electronics, circuits and devices, Solid-state physics, Crystal structure and X-ray diffraction, Band Theory of solids, Fundamentals of photonics, Fiber optics and communication, Fundamentals of lasers and Advanced laser technology, Different types of lasers, Photonics devices and sensors, Optical imaging techniques, Non-linear optics.

Nanoscience

Atomic and molecular spectroscopy, optics and electrodynamics; Electronics, circuits and devices, Solid-state physics, Crystal structure and X-ray diffraction, Band Theory of solids, Fundamental of nanoscience and technology, Nano-materials and characterization, Advanced nanotechnology, Metal nanoparticles, quantum dots, nano-composites, Nano-structured materials.

Architecture

1. Theory of Design, Graphics and History,
Types of Design Thinking; Phases of Design Thinking; Significance of Design Thinking; Design Thinking Methods; Design Process; Design Concept Visualization; Design Movements; Design Evaluation Process; Technology and Design Thinking; Basic concepts of design, form space, aesthetics, Principles of landscape design and site planning, landscape elements and material
Architecture and Design Visual composition in 2D and 3D; Principles of Art and Architecture; Organization of space; Anthropometrics; Planning and design considerations for different building types; Site planning; Circulation- horizontal and vertical; Barrier free design; Space Standards; Building Codes; National Building Code. Elements, construction, architectural styles and examples of different periods of Indian and Western History of Architecture; Oriental, Vernacular and Traditional architecture; Architectural developments since Industrial Revolution; Influence of modern art on architecture; Art nouveau, Eclecticism, International styles, Post Modernism, Deconstruction in architecture; Recent trends in Contemporary Architecture; Works of renowned national and international architects. Architectural Graphics; Computer Graphics- concepts of CAD, BIM, 3D modeling and Architectural rendition
2. Technology and Services
Building Materials, Construction and Management Behavioral characteristics and applications of different building materials viz. mud, timber, bamboo, brick, concrete,

steel, glass, FRP, AAC, different polymers, composites. Building construction techniques, methods and details; Building systems and prefabrication of building elements; Principles of Modular Coordination; Estimation, specification, valuation, professional practice; Construction planning and equipment; Project management techniques e.g. PERT, CPM etc. Building and Structures Principles of strength of materials; Design of structural elements in wood, steel and RCC; Elastic and Limit State design; Structural systems in RCC and Steel; Form and Structure; Principles of Pre-stressing; High Rise and Long Span structures, gravity and lateral load resisting systems; Principles and design of disaster resistant structures, tall buildings, precast elements. Services, Infrastructure and Transportation Building Services: Water supply; Sewerage and drainage systems; Sanitary fittings and fixtures; Plumbing systems; Principles of internal and external drainage system; Principles of electrification of buildings; Intelligent Buildings; Elevators and Escalators - standards and uses; Air-Conditioning systems; Firefighting Systems; Building Safety and Security systems. Urban Infrastructure - Transportation, Water Supply, Sewerage, Drainage, Solid Waste Management, Electricity and Communications.

3. Sustainable design and environment

Environmental Planning and Design Ecosystem- natural and man-made ecosystem; Ecological principles; Concepts of Environmental Impact Analysis; Environmental considerations in planning and design; Resource depletion, pollution, resource management, urban ecology, global warming, climate change, Urban environmental issues, solid waste management, water conservation. Climatic considerations, building climatology, indoor environmental quality, Environmental Impact Assessment - Social, economic and ecological. Techniques and tools like building energy simulation, renewable energy, HVAC optimization, materials with recycled content. Thermal comfort, ventilation and air movement; Principles of lighting and illumination; Climate responsive design; Solar architecture; Principles of architectural acoustics; Energy efficiency and Green Building Technology - Norms, standards, rating and evaluation. Disaster risk management, planning and design responses. Contemporary and Traditional examples of sustainable / energy efficient architecture / settlement planning in India and other parts of the world.

4. Urban Design and Planning

Urban Design Concepts and theories of urban design; Public Perception; Townscape; Public Realm; Urban design interventions for sustainable development and transportation; Historical and modern examples of urban design; Public spaces, character, spatial qualities and Sense of Place; Elements of urban built environment - urban form, spaces, structure, pattern, fabric, texture, grain etc.; Principles, tools and techniques of urban design; Urban renewal and conservation; Site planning; Landscape design; Development controls - FAR, densities and building byelaws. Urban Planning and Housing Planning process; Types of plans - Master Plan, City Development Plan, Structure Plan, Zonal Plan, Action Area Plan, Town Planning Scheme, Regional Plan; Salient concepts, theories and principles of urban planning; Sustainable urban development; Emerging concepts of cities - Eco-City, Smart City, Transit Oriented Development (TOD), SEZ, SRZ etc. Housing; Concepts, principles and examples of neighborhood; Housing typologies; Slums; Affordable Housing; Housing for special areas and needs; Residential densities; Standards for housing and community facilities; National Housing Policies, Programs and Schemes.

Biomedical engineering

Diode, BJT and MOSFET - Characteristics and circuits, feedback amplifiers, power amplifiers, Linear ICs; Combinational circuit design, sequential circuit design, PLD, Pipelining, Memory; Network Theorems, RL and RC circuits, Two port network parameters, poles and zeros; Basic signals, operations, Fourier Analysis, Sampling, LTI systems, Laplace Transform, Z-transform, DTFT, DFT and FFT; Spectral analysis, filters, noise, modulation techniques, wave propagation, basic optical communication; Architecture of 8051, Input/Output pins, ports and circuits, Instruction sets, Addressing modes, Programming of 8051, counter and timers, Serial Data Input/Output, Interrupts;

Metals, semiconductors, and insulators. Optical properties of materials. Magnetic materials. Superconductivity. Basics of nanoscience and nanotechnology, Material characterization methods, Biomaterials, Structural and organization of tissues, Sterilization process, Tissue homeostasis, Cell signaling, Stem cells, Bio-fluid mechanics, Soft & Hard tissue mechanics, Human movement mechanics, Recorders, transducers, data acquisition system & monitoring instruments, Imaging modalities; X-rays for imaging: generation and detection; Computed tomography (CT): the Radon transform & the central slice theorem; Image reconstruction from projections: the Direct Fourier Method, convolution-back projection algorithm (parallel & fan-beam projections); 5 generations of X-ray CT systems; Emission CT: principles, Positron emission tomography; Magnetic resonance imaging: Principles of data-generation, exploiting “ T_1 ” & “ T_2 ” to resolve tissues; resolving the spatial locations.

Biotechnology

Biochemistry: Biomolecules-structure and functions; Biological membranes, structure, action potential and transport processes; Enzymes- classification, kinetics and mechanism of action; Basic concepts and designs of metabolism (carbohydrates, lipids, amino acids and nucleic acids) photosynthesis, respiration and electron transport chain; Bioenergetics

Microbiology: Viruses- structure and classification; Microbial classification and diversity (bacterial, algal and fungal); Methods in microbiology; Microbial growth and nutrition; Aerobic and anaerobic respiration; Nitrogen fixation; Microbial diseases and host-pathogen interaction

Cell Biology: Prokaryotic and eukaryotic cell structure; Cell cycle and cell growth control; Cell-Cell communication, Cell signalling and signal transduction

Molecular Biology and Genetics: Molecular structure of genes and chromosomes; Mutations and mutagenesis; Nucleic acid replication, transcription, translation and their regulatory mechanisms in prokaryotes and eukaryotes; Mendelian inheritance; Gene interaction; Complementation; Linkage, recombination and chromosome mapping; Extra chromosomal inheritance; Microbial genetics (plasmids, transformation, transduction, conjugation); Horizontal gene transfer and Transposable elements; RNA interference; DNA damage and repair; Chromosomal variation; Molecular basis of genetic diseases

Immunology: History of Immunology; Innate, humoral and cell mediated immunity; Antigen; Antibody structure and function; Molecular basis of antibody diversity; Synthesis of antibody and secretion; Antigen-antibody reaction; Complement; Primary and secondary lymphoid organ; B and T cells and macrophages; Major histocompatibility complex (MHC); Antigen processing and presentation; Polyclonal and monoclonal antibody; Regulation of immune response; Immune tolerance; Hypersensitivity; Autoimmunity; Graft versus host reaction.

Bioinformatics: Major bioinformatic resources and search tools; Sequence and structure databases; Sequence analysis (biomolecular sequence file formats, scoring matrices, sequence alignment, phylogeny); Data mining and analytical tools for genomic and proteomic studies; Molecular dynamics and simulations (basic concepts including force fields, protein-protein, protein-nucleic acid, protein-ligand interaction)

Bioprocess Calculations, Thermodynamics: Steady and unsteady state mass and energy balances including multiphase, multicomponent, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis. First and Second laws of thermodynamics. Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium.

Unit Operations:

Newtonian and non-Newtonian fluids, shell-balances including differential form of Bernoulli equation and energy balance, macroscopic friction factors, dimensional analysis, flow through pipeline systems, flow meters, elementary boundary layer theory, flow past immersed bodies including packed and fluidized beds, Turbulent flow: fluctuating velocity, universal velocity profile and pressure drop. Steady and unsteady heat conduction, convection and radiation, thermal boundary layer and heat transfer coefficients, boiling, condensation and evaporation; types of heat exchangers and evaporators and their process calculations. Design of double pipe, shell and tube heat exchangers, and single and multiple effect evaporators. Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stage-wise and continuous contacting and stage efficiencies; HTU & NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying and adsorption

Bioprocess Engineering and Process Biotechnology:

Chemical engineering principles applied to biological system, Principle of reactor design, ideal and non-ideal multiphase bioreactors, mass and heat transfer; Rheology of fermentation fluids, Aeration and agitation; Media formulation and optimization; Kinetics of microbial growth, substrate utilization and product formation; Sterilization of air and media; Batch, fed-batch and continuous processes; Various types of microbial and enzyme reactors. Engineering principle of bioprocessing- Upstream production and downstream; Bioprocess design and development from lab to industrial scale; Microbial, animal and plant cell culture platforms; Production of biomass and primary/secondary metabolites; industrial enzymes, antibiotics; Large scale production and purification of recombinant proteins; Industrial application of chromatographic and membrane based bio-separation methods; Immobilization of biocatalysts (enzymes and cells) for bioconversion processes; Bioremediation-Aerobic and anaerobic processes for stabilization of solid / liquid wastes.

Chemical engineering

Process Calculations: Steady and unsteady state mass and energy balances including multiphase, multicomponent, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis.

Momentum Transfer: Fluid statics, Newtonian and non-Newtonian fluids, shell-balances including differential form of Bernoulli equation and energy balance, Macroscopic friction factors, dimensional analysis and similitude, flow through pipeline systems, flow meters, pumps and compressors, elementary boundary layer theory, flow past immersed bodies including packed and fluidized beds, Turbulent flow: fluctuating velocity, universal velocity profile and pressure drop.

Mechanical operations: Particle size and shape, particle size distribution, size reduction and classification of solid particles; free and hindered settling; centrifuge and cyclones; thickening and classification, filtration, agitation and mixing; conveying of solids.

Chemical Engineering Thermodynamics: First and Second laws of thermodynamics. Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium.

Mass Transfer: Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stage-wise and continuous contacting and stage efficiencies; HTU & NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption.

Heat Transfer: Steady and unsteady heat conduction, convection and radiation, thermal boundary layer and heat transfer coefficients, boiling, condensation and evaporation; types of heat exchangers and evaporators and their process calculations. Design of double pipe, shell and tube heat exchangers, and single and multiple effect evaporators.

Chemical Reaction Engineering: Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, non-ideal reactors; residence time distribution, single parameter model; non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis.

Chemical Technology: Inorganic chemical industries (sulphuric acid, phosphoric acid, chlor-alkali industry), fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); petroleum refining and petrochemicals; polymerization industries (polyethylene, polypropylene, PVC and polyester synthetic fibres).

Process Instrumentation and Process Control: Measurement of process variables; sensors, transducers and their dynamics, process modelling and linearization, transfer functions and dynamic responses of various systems, systems with inverse response, process reaction curve, controller modes (P, PI, and PID); control valves; analysis of closed loop systems including stability, frequency response, controller tuning, cascade and feed forward control.

Process Modelling and Simulation: Models and model building, principles of model formulation, precautions in model building, fundamental laws- continuity equation, energy equation, equation of motion, transport equations equation of state, equilibrium kinetics; classification of models; numerical solutions of mathematical equations -algebraic equation in one and two variables; simultaneous linear equations; ordinary differential equation in one variables and more than one variable, stiff differential equations, lumped parameter models, distributed parameter models

Materials Science: Selection of process materials, economic considerations, mechanical properties and strength of materials, properties and uses of ferrous metals cast iron, plain carbon steels, thermal and electrical insulating properties. nonferrous metals and alloys-plastics as materials of construction, types of plastics, properties and application of non-metals, wood, stoneware, glass, silica, carbon, rubber Glass, rubber lining and metal lining of process vessels, biomaterials and nanomaterials. Phase diagrams and phase transformation, corrosion prevention, different forms of corrosion.

Pollution Control and Safety- Nutrient and hydrologic cycles, types of pollution, legislation to environmental pollution, aspects of pollution control evaluation and characterization of wastewater, treatment methods, advanced wastewater treatment, Sludge treatment and disposal, solid waste management, noise pollution and control. Principles of air pollution, plume behaviour, equipment for control and abatement of air pollution. Pollution control of effluent in chemical industries.

Biochemical Engineering: Biomolecules-structure and functions; Biological membranes, structure, action potential and transport processes; enzymes-classification, kinetics and mechanism of action. chemical engineering principles applied to biological system, principle of reactor design, ideal and non-ideal multiphase bioreactors, mass and heat transfer; rheology of fermentation fluids, aeration and agitation; Media formulation and optimization; kinetics of microbial growth, substrate utilization and product formation; sterilization of air and media; Batch, fed-batch and continuous processes; various types of microbial and enzyme reactors.

Civil engineering & Geology

Structural Engineering: Analysis of determinate and indeterminate structures-matrix methods, slope deflection method, strain energy method, finite element method, design of concrete and steel structures, materials for concrete and mix design, design of pre stressed concrete beams, structural dynamics, analysis of free and forced vibration.

Geotechnical Engineering: Engineering properties of soil, stresses in soil, flow through soil, shear strength, compaction and consolidation, soil exploration, passive and active earth pressure, earth retaining structures, slope stability analysis, load carrying capacity of shallow and deep foundations, soil dynamics, ground improvement techniques

Water resources Engineering: fluid properties and classification, fluid pressure and its measurements, kinematics of fluid motion, fluid dynamics, ideal fluid flow, laminar and turbulent flow through pipes, flow in open channels, hydrology, hydrological cycle and its components, flood studies and estimation, hydrograph, unit hydrograph, S curve, flood routing, capacity and planning, hydraulic structures, duty, delta, crop water requirement, bliss creep theory,

Environmental Engineering: population forecasting, characteristics of water and waster water, IS standards, water and waste water treatment process, distribution of water, disposal of sewage, self purification of streams, air pollution and control, sources, air quality standards, plume rise and stack height, characteristics, composition and properties of municipal solid waste, collection and transportation, disposal, land fills, types, leachate generation, monitoring of landfills.

Construction Technology and management: construction techniques, properties of special concrete, construction safety practices, quality control principles and practices in construction, construction materials management, project planning and management: PERT and CPM, construction economics and management, application of

mathematical modeling in construction, construction equipment management, construction contract administration and dispute resolution

Transportation Engineering: highway classification, design of highway alignments, design of pavements and drainage, traffic flow theory, railways, tractive resistance, design of permanent way, points and crossings, track junction, classification of airports, geometric design of run way, visual aids and air traffic control systems.

Geology: Earth and Planetary system, Geomorphology, Structural geology, Crystallography and Mineralogy, Geochemistry and Petrology, Geological time scale Stratigraphic principles, Geology of India, Indian mineral resources. Ore genesis and ore exploration, Ground water geology. Paleontology and Micropaleontology, Oceanography and Climatology, Engineering geology, Natural hazards, Remote sensing & GIS and its application.

Computers

Artificial Intelligence: Basics, Agents, Environments, Search techniques, First Order Logic, Syntax, Semantics, Deduction, Reasoning, Game Playing, Heuristics, Problem-Solving, State-Space, Problem Characteristics.

Computer Networks: Overview of computer networks, OSI model, TCP/IP computer network model, Network types, Physical Layer, Signaling System, Throughput, MAC Layer, Error Detection, Network Layer & Transport Layer; IP addressing, Routing algorithms, Protocols, Sliding Window, Congestion.

Data Structures: Sorting, Searching, Performance Analysis of Algorithms, Stack, Queue, Circular Queue, Linked List, Creation, Insertion, Deletion Operations, Applications, Trees, Tree Traversal, Graphs.

Database Systems: Overview of Structured Query Language (SQL), Basic structure of SQL queries, Join Expressions, Triggers, Normal Forms, Procedures and Functions, Integrity Constraints, Authorization.

Data Warehousing & Data Mining: Basic Concepts, Data Warehousing, OLAP, Correlation Tests, Data Pre-processing, Data Integration and Transformation, Knowledge Discovery, Data Mining Techniques; Association Rule Mining, Classification and Prediction Algorithms, Clustering Techniques.

Design & Analysis of Algorithms: Fundamentals of Algorithms, Analysis of Algorithm Efficiency, Asymptotic Notations, Arrays, Binary Trees, B+ trees, Binary Search Trees, Heaps, Graphs, Hashing, Dynamic Programming.

Digital Image Processing: Digital image, Components of an Image Processing System, Spatial domain, Frequency domain, Sampling, Quantization, Enhancement, Segmentation, Edge Detection, Histogram, Filtering Techniques, Morphological Operations, Representation and Description, Image Compression.

Information Security: Basic Concepts, Security Attacks, Services, Mechanisms, Number Theory, Symmetric Key Cryptography, Asymmetric Key Cryptography, Encryption and Decryption Algorithms, Digital Signatures, Key Generation, Key Exchange and Key Management Techniques, Authentication Protocols.

Machine Learning: Types, Inductive Classification, Decision Tree Learning, Computational Learning, Bayesian Learning, Instance-based Learning, Principal Component Analysis (PCA), Ensemble Methods, Artificial Neural Networks, Training, Testing, Classification, Clustering, Support Vector Machines, Deep Learning.

Programming Languages: General features, Data types, Abstract Data Types (ADT), Structuring, Syntax, Semantics, Object based languages: Concepts of Objects, Class vs ADT, Control Structures, Methods, General Features-inheritance, polymorphism, derived classes & information hiding, Exception Handling.

Power and energy systems

Diode, BJT and MOSFET - Characteristics and circuits, feedback amplifiers, power amplifiers, Linear ICs; Combinational circuit design, sequential circuit design, PLD, Pipelining, Memory; Network Theorems, RL and RC circuits, Two port network parameters, poles and zeros; Basic signals, operations, Fourier Analysis, Sampling, LTI systems, Laplace Transform, Z-transform, DTFT, DFT and FFT; Spectral analysis, filters, noise, modulation techniques, wave propagation, basic optical communication; Architecture of 8051, Input/Output pins, ports and circuits, Instruction sets, Addressing modes, Programming of 8051, counter and timers, Serial Data Input/Output, Interrupts;

Electric machines, power system analysis, operation and control of power system, renewable energy resources, control theory, power quality issues, switchgear and protection, power electronics systems and control, lighting science and devices.

Electronics and communication

Diode, BJT and MOSFET - Characteristics and circuits, feedback amplifiers, power amplifiers, Linear ICs; Combinational circuit design, sequential circuit design, PLD, Pipelining, Memory; Network Theorems, RL and RC circuits, Two port network parameters, poles and zeros; Basic signals, operations, Fourier Analysis, Sampling, LTI systems, Laplace Transform, Z-transform, DTFT, DFT and FFT; Spectral analysis, filters, noise, modulation techniques, wave propagation, basic optical communication; Architecture of 8051, Input/Output pins, ports and circuits, Instruction sets, Addressing modes, Programming of 8051, counter and timers, Serial Data Input/Output, Interrupts;

MOSFET operations, pass transistor logic, Verilog HDL, Timing analysis (STA), VLSI testing, pseudo NMOS logic, Electrical and Mechanical Concepts, micromachining, MEMS transduction and actuation techniques, Micro sensing for MEMS, Basic Bio-MEMS fabrication technologies, LIGA, RF MEMS and Microfluidic devices and components for Bio-MEMS, Dimensionality and size dependent phenomena-Miller indices, Effective mass. Top-down and Bottom-up techniques for nanomaterial synthesis, Characterization Techniques, Applications.

Instrumentation and control

Diode, BJT and MOSFET - Characteristics and circuits, feedback amplifiers, power amplifiers, Linear ICs; Combinational circuit design, sequential circuit design, PLD, Pipelining, Memory; Network Theorems, RL and RC circuits, Two port network parameters, poles and zeros; Basic signals, operations, Fourier Analysis, Sampling, LTI systems, Laplace Transform, Z-transform, DTFT, DFT and FFT; Spectral analysis, filters, noise, modulation techniques, wave propagation, basic optical communication; Architecture of 8051, Input/Output pins, ports and circuits, Instruction sets, Addressing modes, Programming of 8051, counter and timers, Serial Data Input/Output, Interrupts;

Measurement errors, Measuring instruments, Sensors, transducers and signal conditioning circuits for industrial instrumentation, Biomedical instrumentation, Feedback principles, signal flow graphs, Stability Analysis-Time and frequency domain, design of compensators, state-space representation of systems, P, PI, PID, cascade, feed-forward, and ratio controllers.

Mechanical

Design Engineering:

Kinematics and Dynamics of Machinery, Analysis of Stress & Strain, Stress-strain relationship, Fatigue of Materials, Design of machine elements - shafts, weldments,

springs and gears, Power trains, Friction, Wear & Lubrication, Bearings, Vibrations. Automotive chassis and frames, Braking systems, Suspension systems, hybrid and electric vehicles

Thermal Engineering & Fluidics:

Laws of thermodynamics, Power Cycles, Fluid Mechanics - Kinematics and Dynamics of fluid flow, Viscous Flow, Flow past immersed bodies, Flow of compressible fluids, Flow through nozzle and diffusers, Turbomachines, Heat Transfer - Conduction, Convection and Radiation, Heat Exchangers, I C Engines, Alternate fuels, Solar Thermal Power Systems, Wind Energy, Refrigeration & Air conditioning, Aircraft Propulsion system, combustion

Manufacturing Engineering:

Production Techniques - Welding, Forging, Casting, Extrusion, Sheet Metal forming, Machining - Mechanics of machining, Cutting tool geometry and materials, Tool wear & mechanisms, Tool life, Machinability of materials, Jigs & fixtures, Press Tools, Non-conventional machining - Chemical machining, ECM, EDM, Ultrasonic machining, Abrasive water jet machining, powder metallurgy, rapid prototyping

Materials Science & Metallurgy:

Crystal Structure, Crystal defects, Iron-Carbon Phase diagrams, Solid state Reactions, Heat Treatment of alloys, Ferrous and non-ferrous materials, Composite materials.

Management

Human Resource Management

Unit 1: Changing environment and role of human resource management

Work force diversity, Technological changes, Globalization, Organizational restructuring, changing nature of work.

Unit 2: Strategic human resource management

Models and dimensions, Manpower planning: Need, Objectives and methods,

Unit 3: Job analysis

Meaning, Techniques and purpose,

Unit 4: Talent management

Practices and processes, developing and retaining talent.

Unit 5: Training and development

Meaning and methods

Unit 6: Managing employee performance

Definition, need and methods

Unit 7; Industrial relations

Approaches, Grievance handling laws related to IR

Unit 8: Labour Welfare & Social Security Measures

Concept, law related to welfare and social security.

Marketing Management

Unit 1: Defining Market Environment and Developing Marketing Strategies

Evolution of marketing, Holistic marketing, Micro and Macro environment, SWOT analysis, Porters 5 force model, Growth strategies.

Unit 2: Analyzing Market Opportunities

Consumer decision making process, Types of buyer behavior, Factors influencing consumer buying behavior, Segmentation approaches, Targeting, Positioning strategies

Unit 3: Product decisions

Types of consumer products, Product life cycle, Stages of new product development,

Unit 4: Pricing decisions

Pricing objectives, Determinants of pricing, and Pricing strategies

Unit 5: Channel Design Decisions

Channel intermediaries, Key process of supply chain management, Types of retail operations

Unit 6: Promotion Decisions

Tools of promotion, Tools of sales promotion, and Promotion budgeting

Commerce**Banking and Finance**

Unit-1: Accounting and Financial analysis: Basic accounting concepts and conventions. Capital and Revenue recognition. Financial Statements. Ratio Analysis.

Unit-2: Financial Management: Calculating cost of specific funds, Calculating weighted average cost of capital, Capital structure theories and leverage, Capital budgeting. Computation of net present value, Internal rate of return, Pay back and accounting rate of return. Working capital management, inventory management, receivables management, cash management, need and factors affecting dividend policies.

Unit-3: Banking and Insurance: Commercial banking in India. Types and functions of banks. Types of banks in India, Basics of asset liability management, Non-performing assets, performance analysis of banking companies., Basics of life and general insurance, need of insurance to individual investors, types of insurance products.

Unit-4: Money and Capital Market: Indian financial markets and their functioning. Sources of capital, Long term and short term sources of finances, Regulatory authorities (RBI, SEBI) in India for money market and capital market.

Unit-5: Cost and Management Accounting: Elements of costs, Types of costs, Cost sheet, Marginal and absorption cost.

General Management

Unit-1: Organisation Behaviour: Planning and decision making in an organisation. Theories of organisational structure, organisational design, Introduction to personality, Basic concepts relating to individual behaviour such as perception, attitude.

Unit-2: Organization Change and Development: Meaning and need for organisational change, Strategies to overcome resistance, Process of organisational change and development, Meaning and definition of organisational development.

Unit-3: Business Ethics: Meaning and need of business ethics in organisation, Organization climate, Structure and ethics, Code of ethics, Ethics committee, Ethics training, Integrity Pact, Meaning and need of corporate governance, Rights of shareholders, Rights of other stakeholder such as employees, Customers, Lenders, Vendors, Government, and Society.

Unit-4: Micro and Macro Economics: Demand and supply theories, Elasticity of demand and supply theories, theories of cost and production. National income,

Unit-5: Business Law: Law of contracts, Doctrine of ultravires, Corporate veil, Indoor management, Memorandum and articles of association, Kinds of share capital, Basics of negotiable instruments such as notes, Bills and cheques-promissory notes, Bills of exchange and cheques.

Geopolitics and International Relations

Approaches to the study of International relations: Idealism, Realism, Neo-realism, Marxism, Neo-liberalism, Social Constructivism.

Concepts: State, Power, Sovereignty, Security (traditional and non- traditional), Balance of Power, Hegemony, National Interest, Geopolitics, Cold War, Collective Security, Detente, Foreign Policy and Diplomacy
 India's Foreign Policy: India's Foreign Policy, Non Aligned Movement, India's Nuclear Policy, India's relations with major powers: USA, Russia, People's Republic of China
 Regional Organisations: BIMSTEC, SAARC, ASEAN, SCO, African Union, GCC
 New International Economic Order (NIEO)
 Conflict and Peace: Changing Nature of Warfare, Weapons of Mass Destruction, Deterrence, conflict resolution.
 Nuclear Weapons, Arms Control and Nuclear Disarmament
 Contemporary Security Challenges: Global Terrorism, Climate Change and Environmental Concerns, Migration and Refugees

Cultural Studies:

Cultural Studies, Cultural History, Art History, Visual Culture, Advertising and Design Theory, Media Theory, Gandhian Studies, Tagore Studies
 Literature, music, film, folklore, fine arts-art history, visual culture, visual design, advertising and management, and related field of studies.
 Gandhian ideas and theories, Tagore ideas and theories, media and visual culture, Society and Culture, Classical arts and folklore, arts and aesthetics, arts and religious studies, arts and management, arts and science, arts and philosophy, arts and environment.

Cultural studies, ecosophical aesthetics, cultural history, art history, visual culture, advertising and design theory, media studies, Gandhian studies, Tagore studies.

- Sub areas: Literature, music, film, folklore, fine arts, art history, media, visual culture, visual design, advertising and management, and related field of studies.
- Interdisciplinary areas: Gandhian ideas and theories, Tagore ideas and theories, media and visual culture, society and culture, classical arts and folklore, arts and aesthetics, arts and religious studies, arts and management, arts and science, arts and philosophy, arts and environment.

Candidates may answer the open ended questions with reference to their own specialisation and area of interest. Background knowledge on at least one of the following areas is desirable: cultural studies, arts, history, communication and media, critical theory, arts and aesthetics, literature and philosophy, visual culture, advertising and management theory, folklore, fine arts, film studies, environment and literature, Gandhian studies, Tagore studies, globalisation studies. The questions would be broadly based on basic knowledge on arts, communication and cultural studies of India with an emphasis on the area of individual specialisation. The purpose of the entrance exam is to identify and understand the calibre of the candidate in terms of academic strength: analytical skills, comprehensive writing and ability to debate on specific areas of interest.

Suggested reading:

Cultural History of India, Oxford India Paperbacks, A.L. Basham
 What is cultural history, Polity, P. Burke
 Ways of Seeing by John Berger
 The transformation of Nature in Art, Ananda Coomaraswamy
 Indian Philosophy, OUP, S. Radhakrishnan
 Ecosophical aesthetics: Art, Ethics and Ecology with Guattari, P. Gardner MacCormack
 Aesthetics and philosophy of Art, Lanham: Rowman & Littlefield publishers, R. Stecker
 Comparative Indian Literature, Sone Perspective, Sterling Publication, I. Choudhuri

Media and communication research methods, SAGE, A.A. Berger
Mass Media research, an introduction, Michael Rosenberg.
Handbook of qualitative methodologies for Mass communication research, Jensen, K B., Jankowski, N.W., Routledge
A Handbook of Media and Communication research, Jensen, K.B., Routledge
Story of Philosophy, Will Durant
What is Art, Leo Tolstoy
Eco socialism or Eco capitalism? Oriental Longman, S. Sarkar.
The Argumentative Indian, Amartya Sen.
Orientalism, Edward Said
Location of Culture, Homi K. Bhabha
Academic publications and theories of Noam Chomsky, Michel Foucault, Jacques Derrida, Gayatri Spivak, UR Ananthamurthy, Ashish Nandy, Amarthya Sen, Arjun Appadurai, Partha Mitter, Chistrophe Pinney, Patricia Oberoi and other contemporary thinkers are also recommended.

Humanities and Social Sciences

I. Cultural Studies

Keywords: hegemony, popular culture, power, resistance, aspiration

Suggested readings:

Rayford Guins and Omayra Zaragoza Cruz (eds.) Popular Culture: A Reader, London, Thousand Oaks, and New Delhi: Sage Publications, 2005.

Simon During (ed.) The Cultural Studies Reader, London and New York: Routledge, 1993.

Tony Crowley and Alan Girvin (eds.) The Routledge Language and Cultural Theory Reader, London and New York: Routledge, 2000.

II. Visual Culture

Keywords: gaze, apparatus, darshan

Suggested readings:

Christopher Pinney. Camera Indica: The Social Life of Indian Photographs, Chicago and London: The University of Chicago Press, 1997.

Gerald Mast, Marshall Cohen and Leo Braudy (eds.) Film Theory and Criticism: Introductory Readings, Oxford University Press, 1992.

M. Madhava Prasad. Ideology of the Hindi Film: A Historical Construction, New Delhi: Oxford University Press, 1998.

Ravi S. Vasudevan. Making Meaning in Indian Cinema, New Delhi: Oxford University Press, 2000.

Humanities and Social Sciences

Sociological Theory

Emile Durkheim

Max Weber

Karl Marx

Talcott Parsons

M.N. Srinivas

Sociological Methods

Ethnography

Comparative Method

Focus Groups and Interpretation

Main Concepts

Gender and Sexuality

Marriage Patterns

Family norms

Morality and Science

Sociology of Health, Illness and Medicine

Youth cultures

Transnationalism

Suggested Readings

Uberoi, P., ed. (1993). Family, kinship and marriage in India. New Delhi: Oxford University Press.

Suicide

Rules of Sociological Methods

Communist Manifesto

Protestant Ethics and the spirit of capitalism

The fieldworker and the field

Shah, A. M. (2014). The Writings of A.M. Shah: The Household and Family in India. New Delhi: Orient Blackswan.

Parsons, Talcott. 1944. "The Social Structure of the Family." Pp. 173–201. In R. N. Anshen (Ed.), The Family: Its Function and Destiny. New York: Harper.

Beteille, A. (2002). Sociology Essays on Approach and Method. New Delhi: Oxford University Press.