Ph.D. Winter Semester (Dec) Admissions 2026-27

Syllabus – National level Ph.D. Entrance Examination

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Dept. of Architecture and Planning

1. ARCHITECTURE

Architecture, Planning, and Design:

Architectural Graphics; Visual composition in 2D and 3D; Computer application in Architecture and Planning; Anthropometrics; Organization of space; Circulation- horizontal and vertical; Space Standards; Universal design; Building bye-laws; Codes and standards

Construction and Management:

Project management techniques e.g. PERT, CPM, etc.; Estimation and Specification; Professional practice and ethics; Form and Structure; Principles and design of disaster-resistant structures; Temporary structures for rehabilitation

Urban Design, Landscape and Conservation:

Historical and modern examples of urban design; Elements of the urban built environment – urban form, spaces, structure, pattern, fabric, texture, grain, etc.; Concepts and theories of urban design; Principles, tools and techniques of urban design; Public spaces, character, spatial qualities and Sense of Place; Urban design interventions for sustainable development and transportation; Development controls – FAR, densities and building bye-laws.; Urban renewal and conservation; heritage conservation; historical public spaces and gardens; Landscape design; Site planning

Services and Infrastructure:

Firefighting Systems; Building Safety and Security systems; Building Management Systems; Water treatment; Water supply and distribution system; Water harvesting systems; Principles, Planning and Design of storm water drainage system; Sewage disposal methods; Methods of solid waste management - collection, transportation, and disposal; Recycling and Reuse of solid waste; Land-use – transportation - urban form inter-relationships; Design of roads, intersections, grade separators, and parking areas; Hierarchy of roads and level of service; Para-transits and other modes of transportation, Pedestrian and slow moving traffic planning.

History and Contemporary Architecture:

Principles of Art and Architecture; World History of Architecture: Egyptian, Greco-Roman period, Byzantine, Gothic, Renaissance, Baroque-Rococo, etc.; Recent trends in Contemporary Architecture: Art nouveau, Art Deco, Eclecticism, International styles, Post Modernism, Deconstruction in architecture, etc.; Influence of Modern art and Design in Architecture; Indian vernacular and traditional Architecture, Oriental Architecture; Works of renowned national and international architects

Building Construction and Structural systems:

Building construction techniques, methods and details; Building systems and prefabrication of building elements; Principles of Modular Coordination; Construction planning and equipment; Building material characteristics and applications; Principles of strength of materials; Alternative building materials; Foundations; Design of structural elements with different materials; Elastic and

Limit State design; Structural systems; Principles of Pre-stressing; High Rise and Long Span structures, gravity and lateral load resisting systems.

Building Services and Sustainability:

Solar architecture; Thermal, visual, and acoustic comfort in built environments; Natural and Mechanical ventilation in buildings; Air-Conditioning systems; Sustainable building strategies; Building Performance Simulation and Evaluation; Intelligent Buildings; Water supply; Sewerage and drainage systems; Sanitary fittings and fixtures; Plumbing systems; Principles of internal and external drainage system; Principles of electrification of buildings; Elevators and Escalators - standards and uses

2. PLANNING

Regional and Settlement Planning:

Regional delineation; settlement hierarchy; Types and hierarchy of plans; Various schemes and programs of central government; Transit Oriented Development (TOD), SEZ, SRZ, etc.; Public Perception and user behaviour; National Housing Policies, Programs, and Schemes.; Slums, Squatters, and informal housing; Standards for housing and community facilities; Housing for special areas and needs

Planning Techniques and Management:

Application of G.I.S and Remote Sensing techniques in urban and regional planning; Tools and techniques of Surveys – Physical, Topographical, Land use and Socio-economic Surveys; Urban Economics, Law of demand and supply of land and its use in planning; Graphic presentation of spatial data; Local self-governance, Panchayatiraj institutions; Planning Legislation and implementation – Land Acquisition Act, PPP etc.; Decision support system and Land Information System; Urban geography and econometrics; Management of Infrastructure Projects; Demography and equity in planning.

Infrastructure Planning:

Process and Principles of Transportation Planning and Traffic Engineering; Road capacity and Travel demand forecasting; Traffic survey methods, Traffic flow Analysis; Traffic analyses and design considerations; Traffic and transport management and control in urban areas; Mass transportation planning; Intelligent Transportation Systems; Urban and Rural Infrastructure System Network.

Planning Process:

Salient concepts, theories, and principles of urban planning; concepts of cities - Eco-City, Smart City; Concepts and theories by trendsetting planners and designers; Ekistics; Urban sociology; Social, Economic, and environmental cost-benefit analysis; Methods of non-spatial and spatial data analysis; Development guidelines such as URDPFI.

Environmental Planning and Design:

Natural and man-made ecosystem; Ecological principles; Environmental considerations in Planning and design; Environmental pollution- types, causes, controls, and abatement strategies; Sustainable development, goals, and strategies; Climate change and built environment; Climate responsive design.

Housing:
Housing typologies; Concepts, principles, and examples of neighborhood; Residential densities; Affordable Housing; Real estate valuation.

3. CIVIL ENGINEERING

Engineering Mechanics:
System of forces, free-body diagrams, equilibrium equations; Internal forces in structures; Friction and its applications; Centre of mass; Free Vibrations of un-damped SDOF system.

Strength of Materials:
Bending moment and shear force in statically determinate beams; Simple stress and strain relationships; Simple bending theory, flexural and shear stresses, shear centre; Uniform torsion, Transformation of stress; buckling of column, combined and direct bending stresses

Structural Analysis:
Statically determinate and indeterminate structures by force/energy methods; Method of superposition; Analysis of trusses, arches, beams, cables, and frames; Displacement methods: Slope deflection and moment distribution methods; Influence lines; Stiffness and flexibility methods of structural analysis.

Concrete Technology:
Concrete - Constituents, mix design, short-term and long-term properties.

Reinforced Concrete Structures:
Working stress and Limit state design concepts; Design of beams, slabs, columns; Bond and development length; Pre-stressed concrete beams.

Steel Structures:
Working stress and Limit state design concepts; Design of tension and compression members, beams and beam-columns, column bases; Connections - simple and eccentric, beam-column connections, plate girders, and trusses; Concept of plastic analysis - beams and frames.

4. GEOGRAPHY

Population and Development – Population as resource; Population and development: a debate; Population and ecosystem; Demographic transition. Problems and Policies: Optimum population; Family welfare and planning; Population policies in developed and developing countries (case study of India). Population-Development Conflict: Concepts of rich and poor worlds and their global perspectives; Neo-Malthusian theory; Future perspectives: Growth scenario and relationship with development.

Climatology
Nature and Scope of Climatology, Climatic elements – atmospheric temperature, pressure, moisture: forms of condensation and precipitation, general atmospheric circulations and

processes, jet stream. Global climate system – Approaches to climatic classification; Classification of Koppen, and Thornthwaite, Major climates of the world – tropical, Temperate and polar. Climatic changes – evidences, causes, global warming, Impact of Global Warming.

Urban Systems: Concept of National Urban System, Central Place Theory of Christaller and Losch; the rank-size distribution of cities; Primate City distribution, Diffusion theories Organization of urban space: urban morphology and land use structure, city-region relations, urban sprawl, umland and periphery; rural-urban fringe, Theories of city structure (Burgess, Hoyt, Harris and Ullman, Mann, White)

Contemporary urban issues: urban poverty; urban renewal; slums; transportation; housing; urban infrastructure; urban finance; environmental pollution; urban crime. Urban policy and planning: Concept and History of urban planning, urban land use planning, Urban Policy and programmes in India.

Urban Geography

Urban Geography - Definition, nature and scope; different approaches and recent trends in urban geography; Origin and growth of urban places; classification of urban settlements, Aspects of urban places: Location, site and situation; Major processes of urban growth and change; Urban economic base: Basic and non-basic functions

Fundamentals of Remote Sensing and GIS

Fundamentals: Remote sensing: definition and scope; Electro-magnetic radiation, Remote sensing regions and bands; Spectral signature; Types of remote sensing. Aerial Photographs and Satellite Imagery.: Aerial photos: types, scale, resolution; Geometric properties of aerial photos; GIS: Definition, and Components, Geographical data: types and characteristics; Spherical and plane coordinate systems in GIS; geo-referencing, Digital representation of geographic data: Data structure, spatial data model, raster and vector models; GIS data standards: concepts and components; Integration of Remote sensing and GIS; GIS project design and planning methodologies; GIS data base management systems; Applications of GIS Recommended Reading

Urban Land Use and Settlements Organization Geographic Concern And Development

Geographical, sociological and economic aspects of rural and urban Development - Government, non-government and community participation in the local and regional area planning and development. Role of socio-cultural aspects on growth patterns of city and neighbourhood communities; Social planning and policy, and community participation; Land use determinants - Location dynamics of urban Land use - Spatial organization of urban settlement - Social and economic Impacts of urban growth and expansion. Economic growth and development, quality of life; Human development index; Economic principles in land use planning; Policies and strategies in economic planning, balanced versus unbalanced growth, public sector dominance; changing economic policies, implications on land.

5. ENVIRONMENTAL SCIENCES

Fundamentals of Environmental Sciences

Definition, Principles and Scope of Environmental Science, Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere.

Laws of thermodynamics, heat transfer processes, mass and energy transfer across various interfaces, material balance.

Meteorological parameters - pressure, temperature, precipitation, humidity, mixing ratio,

saturation mixing ratio, radiation and wind velocity, adiabatic lapse rate, environmental lapse rate. Wind roses.

Interaction between Earth, Man and Environment. Biogeographic provinces of the world and agro-climatic zones of India. Concept of sustainable development.

Natural resources and their assessment. Remote Sensing and GIS: Principles of remote sensing and GIS. Digital image processing and ground truthing. Application of remote sensing and GIS in land cover/land use planning and management (urban sprawling, vegetation study, forestry, natural resource), waste management and climate change.

Environmental education and awareness. Environmental ethics.

Environmental Biology

Ecology as an inter-disciplinary science. Origin of life and speciation. Human Ecology and Settlement.

Ecosystem Structure and functions: Structures - Biotic and Abiotic components. Functions - Energy flow in ecosystems, energy flow models, food chains and food webs. Biogeochemical cycles, Ecological succession. Species diversity, Concept of ecotone, edge effects, ecological habitats and niche. Ecosystem stability and factors affecting stability. Ecosystem services.

Basis of Ecosystem classification. Types of Ecosystem: Desert (hot and cold), forest, rangeland, wetlands, lotic, lentic, estuarine (mangrove), Oceanic.

Biomes: Concept, classification and distribution. Characteristics of different biomes: Tundra, Taiga, Grassland, Deciduous forest biome, Highland Icy Alpine Biome, Chapparal, Savanna, Tropical Rain forest.

Population ecology: Characteristics of population, concept of carrying capacity, population growth and regulations. Population fluctuations, dispersion and metapopulation. Concept of 'r' and 'k' species. Keystone species.

Community ecology: Definition, community concept, types and interaction - predation, herbivory, parasitism and allelopathy. Biological invasions.

Biodiversity and its conservation: Definition, types, importance of biodiversity and threats to biodiversity. Concept and basis of identification of 'Hotspots'; hotspots in India. Measures of biodiversity. Strategies for biodiversity conservation: in situ, ex situ and in vitro conservation. National parks, Sanctuaries, Protected areas and Sacred groves in India. Concepts of gene pool, biopiracy and bio-prospecting. Concept of restoration ecology. Extinct, Rare, Endangered and Threatened flora and fauna of India.

Concept of Industrial Ecology.

Toxicology and Microbiology: Absorption, distribution and excretion of toxic agents, acute and chronic toxicity, concept of bioassay, threshold limit value, margin of safety, therapeutic index, biotransformation. Major water borne diseases and air borne microbes.

Environmental Biotechnology: Bioremediation – definition, types and role of plants and microbes for in situ and ex situ remediation. Bioindicators, Biofertilizers, Biofuels and Biosensors.

Environmental Assessment, Management and Legislation

Aims and objectives of Environmental Impact Assessment (EIA). Environmental Impact Statement (EIS) and Environmental Management Plan (EMP). Overview of Environmental Laws in India, Coastal Regulation Zones (CRZ) 1991 amended from time to time. National Forest Policy, 1988, National Water Policy, 2002, National Environmental Policy, 2006.

Statistical Approaches and Modelling in Environmental Sciences

Attributes and Variables: types of variables, scales of measurement, measurement of Central tendency and Dispersion, Standard error, Moments – measure of Skewness and Kurtosis, Basic concept of probability theory, Sampling theory, Distributions - Normal, log-normal, Binomial, Poisson, t, 2 and F-distribution. Correlation, Regression, tests of hypothesis (t-test, 2test ANOVA: one-way and two-way); significance and confidence limits.

Approaches to development of environmental models; linear, simple and multiple regression models, validation and forecasting. Models of population growth and interactions: Lotka-Voltera model, Leslie's matrix model.

Contemporary Environmental Issues

Global Environmental Issues – Biodiversity loss, Climate change, Ozone layer depletion. Sea level rise. International efforts for environmental protection.

National Action Plan on Climate Change (Eight National missions – National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a 'Green India', National Mission for Sustainable Agriculture, National Mission on Strategic Knowledge for Climate Change).

Current Environmental Issues in India: Environmental issues related to water resource projects - Narmada dam, Tehri dam, Almatti dam, Cauvery and Mahanadi, Hydro-power projects in Jammu & Kashmir, Himachal and North-Eastern States.

Water conservation-development of watersheds, Rain water harvesting and ground water recharge. National river conservation plan – Namami Gange and Yamuna Action Plan. Eutrophication and restoration of lakes. Conservation of wetlands, Ramsar sites in India. Soil erosion, reclamation of degraded land, desertification and its control. Climate change - adaptability, energy security, food security and sustainability. Forest Conservation – Chipko movement, Appiko movement, Silent Valley movement and Gandhamardhan movement. People Biodiversity register.

Biochemistry: Structure and function of biomolecules; Basic concepts and regulation of metabolism of carbohydrates, lipids, amino acids and nucleic acids; Photosynthesis, respiration and electron transport chain. Enzymes - Classification, catalytic and regulatory strategies; Enzyme kinetics - Michaelis-Menten equation; Enzyme inhibition - competitive, non-competitive and uncompetitive inhibition. Vitamins and Hormones. Laws of thermodynamics; Solution thermodynamics; Phase equilibria, reaction equilibria; Energetics of metabolic pathways, oxidation and reduction reactions. Ionic equilibria, Dissociation equilibria of acids and bases.

Microbiology: Bacterial and fungal classification and diversity; Microbial interactions; Viruses - structure and classification; Methods in microbiology; Microbial growth and nutrition; Nitrogen fixation; Microbial diseases and host-pathogen interactions; Antibiotics and antimicrobial resistance.

Immunology: Innate and adaptive immunity, humoral and cell-mediated immunity, Antibody structure and function, Molecular basis of antibody diversity, Antigen-antibody reaction, Complement system, Major histocompatibility complex (MHC), Polyclonal and monoclonal antibody, Hypersensitivity, Autoimmunity.

Genetics, Cellular and Molecular Biology:
Mendelian inheritance; Gene interaction; Extrachromosomal inheritance; Microbial genetics – transformation, transduction and conjugation. Molecular structure of genes and chromosomes; Mutations and mutagenesis. Regulation of gene expression; Nucleic acid - replication, transcription, splicing, translation and their regulatory mechanisms; Non-coding and micro RNA; RNA interference; DNA damage and repair. Restriction and modification enzymes; Vectors - plasmids, bacteriophage and other viral vectors, cosmids, Ti plasmid, bacterial and yeast artificial chromosomes; Expression vectors; cDNA and genomic DNA library; Gene isolation and cloning, strategies for production of recombinant proteins; Transposons and gene targeting.

Prokaryotic and eukaryotic cell structure; Cell cycle and cell growth control; Cell-cell communication; Cell signaling and signal transduction; Protein trafficking; Cell death and autophagy; Extra-cellular matrix. Biological membranes - structure, membrane channels and pumps, molecular motors, action potential and transport processes;

Bioprocess engineering
Newtonian and non-Newtonian fluids, fluid flow - laminar and turbulent; Equations of fluid flow - Continuity equation. Units and dimensions, dimensional analysis. Rate law, zero and first order kinetics; Enzyme immobilization, Kinetics of cell growth, substrate utilization and product formation; Batch, fed-batch and continuous processes; Microbial and enzyme reactors; Molecular diffusion and film theory; Oxygen transfer and uptake in bioreactor, kLa and its measurement. Biostatistics: Mean, Median, Mode, standard deviation.

Types of microorganisms used for food processing and their resources, Nutritional values of food, Use of enzymes in food industry, Factors affecting growth and survival of microorganisms in food, Single cell protein, genetically modified food, Fermented food products, Dairy Products- Fermented milk, Cheese, Butter, Fermented Meat, Fermented fish.

Plant Biotechnology: Totipotency; Regeneration of plants; Plant growth regulators and elicitors; Tissue culture and cell suspension culture system - methodology, kinetics of growth and nutrient optimization; Production of secondary metabolites; Hairy root culture; Plant products of industrial importance; Artificial seeds; Somaclonal variation; Protoplast, protoplast fusion - somatic hybrid and cybrid; Transgenic plants - direct and indirect methods of gene transfer techniques; Selection marker and reporter gene; Plastid transformation.

Animal Biotechnology: Culture media composition and growth conditions; Animal cell and tissue preservation; Anchorage and non-anchorage dependent cell culture; Kinetics of cell growth; Micro & macro-carrier culture; Hybridoma technology; Stem cell technology; Animal cloning; Transgenic animals; Knockout and knock-in animals.

Molecular and analytical tools: Polymerase chain reaction; DNA/RNA labelling and sequencing; Southern and northern blotting; In-situ hybridization; DNA fingerprinting, RAPD, RFLP; Site-directed mutagenesis; Gene transfer technologies; CRISPR-Cas; Biosensing and biosensors. Principles of microscopy - light, electron, fluorescent and confocal; Principles of spectroscopy - UV, visible, CD, IR, fluorescence, FT-IR, MS, NMR; Electrophoresis; Micro-arrays; Enzymatic assays; Immunoassays - ELISA, RIA, immunohistochemistry; immunoblotting; Flow cytometry; Whole genome and ChIP sequencing.

Computational tools: Bioinformatics resources and search tools; Sequence and structure databases; Sequence analysis - sequence file formats, scoring matrices, alignment, phylogeny; Genomics, proteomics, metabolomics; Gene prediction; Functional annotation; Secondary structure and 3D structure prediction; Knowledge discovery in biochemical databases; Metagenomics; Metabolic engineering and systems biology.

Advanced bioengineering: Biomaterials, tissue engineering, 3D & 4D bioprinting, organoids, organ on a chip, nanobiotechnology, drug delivery and translational research, pharmaceutical nanotechnology.

Determinants & matrices, differential calculus, Taylor's theorem, Ordinary differential equations of first order, linear differential equations, partial differential equations: linear and nonlinear equation of first order. Stoichiometry: material balance calculations, equation of state: ideal and van der Waals equation, laws of thermodynamics (zeroth, first, second and third), energy calculations for ideal gas (open and closed systems).

Newtonian and non-Newtonian fluids, Bernoulli equation, pressure drop calculations and transportation of fluids, particle size reduction, settling and filtration. Modes of heat transfer: conduction, convection and radiation, heat exchangers and evaporators. Molecular diffusion in fluids and convective mass transfer, distillation and absorption. Kinetics of homogeneous reactions, ideal reactors (CSTR, PFR), enzymatic reactions and catalysts.

Transfer functions and dynamic responses of various systems (first, second and higher order), controller modes (P, PI, and PID). Process instrumentation (pressure, temperature, flow, pH and composition). Treatment of solid, liquid and gaseous pollutants.

Section 1: Physical Chemistry

Structure: Postulates of quantum mechanics. Operators. Time dependent and time independent Schrödinger equations. Born interpretation. Dirac bra-ket notation. Particle in a box: infinite and finite square wells; concept of tunnelling; particle in 1D, 2D and 3D-box; applications. Harmonic oscillator: harmonic and anharmonic potentials; hermite polynomials. Rotational motion: Angular momentum operators, Rigid rotor. Hydrogen and hydrogen-like atoms: atomic orbitals; radial distribution function. Multi-electron atoms: orbital approximation; electron spin; Pauli Exclusion Principle; slater determinants. Approximation Methods: Variation method and secular determinants; first order perturbation techniques. Atomic units. Molecular structure and Chemical bonding: Born Oppenheimer approximation; Valence bond theory and linear combination of atomic orbitals – molecular orbital (LCAO-MO) theory. Hybrid orbitals. Applications of LCAO-MO theory to H2 +, H2; orbital theory (MOT) of homo- and heteronuclear diatomic molecules. Hückel approximation and its application to annular π – electron systems. Group Theory: Symmetry elements and operations; Point groups and character tables; Internal coordinates and vibrational modes; symmetry adapted linear combination of atomic orbitals (LCAO-MO); construction of hybrid orbitals using symmetry aspects.

Spectroscopy: Atomic spectroscopy; Russell-Saunders coupling; Term symbols and spectral details; origin of selection rules. Rotational, vibrational, electronic and Raman spectroscopy of diatomic and polyatomic molecules. Line broadening. Einstein's coefficients. Relationship of transition moment integral with molar extinction coefficient and oscillator strength. Basic principles of nuclear magnetic resonance: gyromagnetic ratio; chemical shift, nuclear coupling. Equilibrium: Laws of thermodynamics. Standard states. Thermochemistry. Thermodynamic functions and their relationships: Gibbs-Helmholtz and Maxwell relations, Gibbs-Duhem equation, van't Hoff equation. Criteria of spontaneity and equilibrium. Absolute entropy. Partial molar quantities. Thermodynamics of mixing. Chemical potential. Fugacity, activity and activity coefficients. Ideal and Non-ideal solutions, Raoult's Law and Henry's Law, Chemical equilibria. Dependence of equilibrium constant on temperature and pressure. Ionic mobility and conductivity. Debye-Hückel limiting law. Debye-Hückel-Onsager equation. Standard electrode potentials and electrochemical cells. Nernst Equation and its application, relationship between Electrode potential and thermodynamic quantities, Potentiometric and conduct metric titrations. Phase rule. Clausius- Clapeyron equation. Phase diagram of one component systems: CO2, H2O, S; two component systems: liquid- vapour, liquid-liquid and solid-liquid systems. Fractional distillation. Azeotropes and eutectics. Statistical thermodynamics: micro canonical, canonical and grand canonical ensembles, Boltzmann distribution, partition functions and thermodynamic properties.

Kinetics: Elementary, parallel, opposing and consecutive reactions. Steady state approximation. Mechanisms of complex reactions. Unimolecular reactions. Potential energy surfaces and classical trajectories, Concept of Saddle points, Transition state theory: Eyring equation, thermodynamic aspects. Kinetics of polymerization. Catalysis concepts and enzyme catalysis. Kinetic isotope effects. Fast reaction kinetics: relaxation and flow methods. Diffusion controlled reactions. Kinetics of photochemical and photo physical processes.

Surfaces and Interfaces: Physisorption and chemisorption. Langmuir, Freundlich andBrunauer Emmett–Teller (BET) isotherms. Surface catalysis: Langmuir-Hinshelwood mechanism. Surface tension, viscosity. Self-assembly. Physical chemistry of colloids, micelles and macromolecules.

Section 2: Inorganic Chemistry

Main Group Elements: Hydrides, halides, oxides, oxoacids, nitrides, sulfides – shapes and reactivity. Structure and bonding of boranes, carboranes, silicones, silicates, boron nitride, borazines and phosphazenes. Allotropes of carbon, phosphorous and sulphur. Industrial synthesis of compounds of main group elements. Chemistry of noble gases, pseudohalogens, and interhalogen compounds. Acid-base concepts and principles (Lewis, Brønsted, HSAB and acid base catalysis).

Transition Elements: Coordination chemistry – structure and isomerism, theories of bonding (VBT, CFT, and MOT). Energy level diagrams in various crystal fields, CFSE, applications of CFT, Jahn Teller distortion. Electronic spectra of transition metal complexes: spectroscopic term symbols, selection rules, Orgel and Tanabe-Sugano diagrams, nephelauxetic effect and Racah parameter, charge-transfer spectra. Magnetic properties of transition metal complexes. Ray-Dutt and Bailar twists, Reaction mechanisms: kinetic and thermodynamic stability, substitution and redox reactions. Metal-metal multiple bond.

Lanthanides and Actinides: Recovery. Periodic properties, spectra and magnetic properties.

Organometallics: 18-Electron rule; metal-alkyl, metal-carbonyl, metal-olefin and metal-carbene complexes and metallocenes. Fluxionality in organometallic complexes. Types of organometallic reactions. Homogeneous catalysis - Hydrogenation, hydroformylation, acetic acid synthesis, metathesis and olefin oxidation. Heterogeneous catalysis - Fischer- Tropsch reaction, Ziegler- Natta polymerization.

Radioactivity: Detection of radioactivity, Decay processes, half-life of radioactive elements, fission and fusion processes.

Bioinorganic Chemistry: Ion (Na+ and K+) transport, oxygen binding, transport and utilization, electron transfer reactions, nitrogen fixation, metalloenzymes containing magnesium, molybdenum, iron, cobalt, copper and zinc.

Solids: Crystal systems and lattices, Miller planes, crystal packing, crystal defects, Bragg's law, ionic crystals, structures of AX, AX2, ABX3 type compounds, spinels, band theory, metals and semiconductors.

Instrumental Methods of Analysis: UV-visible, fluorescence and FTIR spectrophotometry, NMR and ESR spectroscopy, mass spectrometry, atomic absorption spectroscopy, Mössbauer spectroscopy (Fe and Sn) and X-ray crystallography. Chromatography including GC and HPLC. Electroanalytical methods- polarography, cyclic voltammetry, ion-selective electrodes. Thermoanalytical methods.

Section 3: Organic Chemistry

Stereochemistry: Chirality and symmetry of organic molecules with or without chiral centres and determination of their absolute configurations. Relative stereochemistry in compounds having more than one stereogenic centre. Homotopic, enantiotopic and diastereotopic atoms, groups and faces. Stereoselective and stereospecific synthesis. Conformational analysis of acyclic and cyclic compounds. Geometrical isomerism and optical isomerism. Configurational and

conformational effects, atropisomerism, and neighbouring group participation on reactivity and selectivity/specificity.

Reaction Mechanisms: Basic mechanistic concepts – kinetic versus thermodynamic control, Hammond's postulate and Curtin-Hammett principle. Methods of determining reaction mechanisms through kinetics, identification of products, intermediates and isotopic labelling. Linear free-energy relationship – Hammett and Taft equations. Nucleophilic and electrophilic substitution reactions (both aromatic and aliphatic). Addition reactions to carbon-carbon and carbon-heteroatom (N and O) multiple bonds. Elimination reactions. Reactive intermediates – carbocations, carbanions, carbenes, nitrenes, arynes and free radicals. Molecular rearrangements.

Organic Synthesis: Synthesis, reactions, mechanisms and selectivity involving the following classes of compounds – alkenes, alkynes, arenes, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, nitriles, halides, nitro compounds, amines and amides. Uses of Mg, Li, Cu, B, Zn, P, S, Sn and Si based reagents in organic synthesis. Carbon-carbon bond formation through coupling reactions - Heck, Suzuki, Stille, Sonogoshira, Negishi, Kumada, Hiyama, Tsuji-Trost, olefin metathesis and McMurry. Concepts of multistep synthesis - retrosynthetic analysis, strategic disconnections, synthons and synthetic equivalents. Atom economy and Green Chemistry, Umpolung reactivity – formyl and acyl anion equivalents. Selectivity in organic synthesis – chemo-, regio- and stereoselectivity. Protection and deprotection of functional groups. Concepts of asymmetric synthesis – resolution (including enzymatic), desymmetrization and use of chiral auxiliaries, organocatalysis. Carbon-carbon and carbon-heteroatom bond forming reactions through enolates (including boron enolates), enamines and silyl enol ethers. Stereoselective addition to C=O groups (Cram, Prelog and Felkin-Anh models).

Pericyclic Reactions and Photochemistry: Electrocyclic, cycloaddition and sigmatropic reactions. Orbital correlations - FMO and PMO treatments, Woodward-Hoffmann rule. Photochemistry of alkenes, arenes and carbonyl compounds. Photooxidation and photoreduction. Di-π-methane rearrangement, Barton-McCombie reaction, Norrish type-I and II cleavage reaction.

Heterocyclic Compounds: Structure, preparation, properties and reactions of furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline.

Biomolecules: Structure, properties and reactions of mono- and di-saccharides, physicochemical properties of amino acids, chemical synthesis of peptides, chemical structure determination of peptides and proteins, structural features of proteins, nucleic acids, lipids, steroids, terpenoids, carotenoids, and alkaloids.

Experimental Techniques in Organic Chemistry: Optical rotation (polarimetry). Applications of various chromatographic techniques such as thin-layer, column, HPLC and GC. Applications of UV-visible, IR, NMR and Mass spectrometry in the structural determination of organic molecules.

1. CIVIL ENGINEERING

Mechanics and Strength of Materials: System of forces, free-body diagrams, equilibrium equations, centre of gravity, bending moment and shear force in statically determinate beams, simple stress and strain relationships, simple bending theory, flexural and shear stresses, torsion and buckling of columns

Structural Analysis: Statically determinate and indeterminate structures by force/ energy methods and displacement methods

Concrete Structures: Limit state design concepts, design of beams, slabs, and columns

Steel Structures: Limit state design concepts, design of tension and compression members

Construction Materials and Management: Construction materials: Structural steel – composition, material properties and behaviour; Concrete - constituents, mix design, short-term and long-term properties. Construction Management: Types of construction projects; Project planning and network analysis - PERT and CPM. Cost estimation

Soil Mechanics: Three-phase system and phase relationships, index properties; Unified and Indian standard soil classification system; Permeability - one dimensional flow, Seepage through soils – two dimensional flow, flow nets, uplift pressure, piping, capillarity, seepage force; Principle of effective stress and quicksand condition; Compaction of soils; One- dimensional consolidation, time rate of consolidation; Shear Strength, Mohr's circle, effective and total shear strength parameters

Foundation Engineering: Sub-surface investigations - Drilling bore holes, sampling, plate load test, standard penetration and cone penetration tests; Earth pressure theories - Rankine and Coulomb; Stability of slopes – Finite and infinite slopes, Bishop's method; Shallow foundations – Terzaghi's and Meyerhoff's bearing capacity theories, effect of water table; Combined footing and raft foundation; Deep foundations – dynamic and static formulae, Axial load capacity of piles in sands and clays, pile load test, pile under lateral loading, pile group efficiency, negative skin friction

Fluid Mechanics: Properties of fluids, fluid statics; Continuity, momentum and energy equations and their applications; Potential flow, Laminar and turbulent flow; Flow in pipes, pipe networks; Concept of boundary layer and its growth; Concept of lift and drag

Hydraulics: Forces on immersed bodies; Flow measurement in channels and pipes; Dimensional analysis and hydraulic similitude; Channel Hydraulics - Energy-depth relationships, specific energy, critical flow, hydraulic jump, uniform flow, gradually varied flow and water surface profiles

Hydrology: Hydrologic cycle, precipitation, evaporation, evapo-transpiration, watershed, infiltration, unit hydrographs, hydrograph analysis, reservoir capacity, flood estimation and routing, surface runoff models, ground water hydrology - steady state well hydraulics and aquifers; Application of Darcy's Law

Irrigation: Types of irrigation systems and methods; Crop water requirements - Duty, delta, evapotranspiration; Gravity Dams and Spillways; Lined and unlined canals, Design of weirs on permeable foundation; cross drainage structures

Transportation Infrastructure: Geometric design of highways - cross-sectional elements, sight distances, horizontal and vertical alignments

Highway Pavements: Highway materials - desirable properties and tests; Desirable properties of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible and rigid pavement using IRC codes

Water and Waste Water Quality and Treatment: Basics of water quality standards – physical, chemical and biological parameters; Unit processes and operations; Water requirement; Water distribution system; Drinking water treatment. Sewerage system design, quantity of domestic wastewater, primary and secondary treatment. Effluent discharge standards

Air Pollution: Types of pollutants, their sources and impacts, air pollution control, air quality, standards

Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal)

2.APPLIED GEOLOGY

Geomorphology: Geomorphic processes and agents; development and evolution of landforms in continental and oceanic settings; tectonic geomorphology.

Structural Geology: Forces and mechanism of rock deformation; primary and secondary structures; geometry and genesis of planar and linear structures (bedding, cleavage, schistosity, lineation); folds, faults, joints and unconformities; Stereographic projection; shear zones, thrusts and superposed folding; basement-cover relationship. Interpretation of geological maps.

Crystallography and Mineralogy: Elements of crystal symmetry, form and twinning; crystallographic projection; crystal chemistry; classification of minerals, physical and optical properties of rock- forming minerals.

Geochemistry: Cosmic abundance of elements; meteorites; geochemical evolution of the earth; geochemical cycles; distribution of major, minor and trace elements in crust and mantle;

elements of high temperature and low temperature geochemical thermodynamics; isotopic evolution of the crust and the mantle, mantle reservoirs; geochemistry of water and water-rock interaction.

Igneous Petrology: Classification, forms, textures and genesis of common igneous rocks; magmatic differentiation; binary and ternary phase diagrams; major and trace elements as monitors of partial melting and magma evolutionary processes. Mantle plumes, hotspots and large igneous provinces.

Sedimentology: Texture, structure and sedimentary processes; petrology of common sedimentary rocks; Sedimentary facies and environments, cyclicities in sedimentary succession; provencance and basin analysis. Important sedimentary basins of India.

Metamorphic Petrology: Structures and textures of metamorphic rocks. Physico-chemical conditions of metamorphism and concept of metamorphic facies, grade and baric types; chemographic projections; metamorphism of pelitic, mafic and impure carbonate rocks; role of bulk composition including fluids in metamorphism; thermobarometry and metamorphic P-T-t paths, and their tectonic significance.

Stratigraphy: Principles of stratigraphy and concepts of correlation; Lithostratigraphy, biostratigraphy and chronostratigraphy. Principles of sequence stratigraphy and applications. Stratigraphy of peninsular and extra-peninsular India. Boundary problems in Indian stratigraphy.

Resource Geology: Ore-mineralogy; ore forming processes - ore-rock association (magmatic, hydrothermal, sedimentary, supergene and metamorphogenic ores); fluid inclusions as ore genetic tools. Coal and petroleum geology; marine mineral resources. Prospecting and exploration of economic mineral deposits - sampling, ore reserve estimation, geostatistics, mining methods. Ore dressing and mineral economics. Distribution of mineral, fossil and nuclear fuel deposits in India.

Global Tectonics: Plate motions, driving mechanisms, plate boundaries, supercontinent cycles.

Applied Geology: Physico-mechanical properties of rocks and soils; rock index tests; Rock failure criteria (Mohr-Coulomb, Griffith and Hoek-Brown criteria); shear strength of rock discontinuities; rock mass classifications (RMR and Q Systems); in-situ stresses; rocks as construction materials; geological factors in the construction of engineering structures including dams, tunnels and excavation sites. Analysis of slope stability.
Natural hazards (landslide, volcanic, seismogenic, coastal) and mitigation. Principles of climate change.

Hydrogeology: Groundwater flow and exploration, well hydraulics and water quality.
Basic Principles of Remote Sensing: energy sources and radiation principles, atmospheric absorption, interaction of energy with earth's surface, aerial-photo interpretation, multispectral remote sensing in visible, infrared, thermal IR and microwave regions, digital processing of satellite images. GIS – basic concepts, raster and vector mode operations.

DISCRETE MATHEMATICS:

Combinatorics: Basic counting arguments, Permutations and Combinations, Recurrence relations.

Graph Theory: Elementary properties of graphs, Paths, Cycles, Trees, Euler tours in a graph.

Discrete Probability: Discrete probability spaces, Events, Conditional probability, Bayes Theorem, Independent events, Random Variables, Expected value.

Logic and Set Theory: Boolean logic, Basic set theory.

Linear Algebra: Vector space, basis, matrices, rank, inner products, orthogonality, system of linear equations, eigenvalues and eigenvectors

Calculus: Limits, continuity and differentiability, Maxima and minima, Mean value theorem, Integration

DATA STRUCTURES AND ALGORITHMS:

Time and space complexity analysis of algorithms - Asymptotic Analysis Searching and sorting algorithms, pointers and dynamic memory allocation, recursion, linked lists, stacks and queues, Heaps and Priority queues, Binary search trees, hashing, Binary Trees, Graph search, Minimum Spanning Tree and shortest path algorithms.

COMPUTER PROGRAMMING:

Data Types, Operators and Expressions: Variables and constants, declarations, arithmetic and logical operators, Assignment operator, Input/output. Control Flow: Statements and blocks - if-else, switch, while, for and do-while statements, break and continue, goto and labels. Functions and Program structure: Basics of functions, Parameter passing, scope rules, recursion. Aggregate data types: Single and multidimensional arrays, structures and unions, Pointers to arrays and structures, passing arrays and pointers as arguments to functions.

Section 1: Engineering Mathematics

Linear Algebra: Matrix Algebra, Systems of linear equations, Eigen values, Eigen vectors.

Calculus: Mean value theorems, Theorems of integral calculus, Evaluation of definite and improper integrals, Partial Derivatives, Maxima and minima, Multiple integrals, Fourier series, Vector identities, Directional derivatives, Line integral, Surface integral, Volume integral, Stokes's theorem, Gauss's theorem, Divergence theorem, Green's theorem.

Differential equations: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Method of variation of parameters, Cauchy's equation, Euler's equation, Initial and boundary value problems, Partial Differential Equations, Method of separation of variables.

Complex variables: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula, Taylor series, Laurent series, Residue theorem, Solution integrals.

Probability and Statistics: Sampling theorems, Conditional probability, Mean, Median, Mode, Standard Deviation, Random variables, Discrete and Continuous distributions, Poisson distribution, Normal distribution, Binomial distribution, Correlation analysis, Regression analysis.

Section 2: Electrical and Electronic Measurements and Electromagnetic Fields

Bridges and Potentiometers, Measurement of voltage, current, power, energy and power factor; Instrument transformers, Digital voltmeters and multi-meters, Phase, Time and Frequency measurement; Oscilloscopes, Error analysis.

Coulomb's Law, Electric Field Intensity, Electric Flux Density, Gauss's Law, Divergence, Electric field and potential due to point, line, plane and spherical charge distributions, Effect of dielectric medium, Capacitance of simple configurations, Biot-Savart's law, Ampere's law, Curl, Faraday's law, Lorentz force, Inductance, Magnetomotive force, Reluctance, Magnetic circuits, Self and Mutual inductance of simple configurations.

Section 3: Analog and Digital Electronics

Simple diode circuits: clipping, clamping, rectifiers; Amplifiers: biasing, equivalent circuit and frequency response; oscillators and feedback amplifiers; operational amplifiers: characteristics and applications; single stage active filters, Active Filters: Sallen Key, Butterwoth, VCOs and timers, combinatorial and sequential logic circuits, multiplexers, demultiplexers, Schmitt triggers, sample and hold circuits, A/D and D/A converters.

Section 4: Electric circuits

Network elements: ideal voltage and current sources, dependent sources, R, L, C, M elements; Network solution methods: KCL, KVL, Node and Mesh analysis; Network Theorems: Thevenin's, Norton's, Superposition and Maximum Power Transfer theorem; Transient response of dc and ac networks, sinusoidal steady-state analysis, resonance, two port networks, balanced three phase circuits, star-delta transformation, complex power and power factor in ac circuits.

Section 5: Control Systems

Mathematical modelling and representation of systems, Feedback principle, transfer function, Block diagrams and Signal flow graphs, Transient and Steady- state analysis of linear time invariant systems, Stability analysis using Routh Hurwitz and Nyquist criteria, Bode plots, Root loci, Lag, Lead and Lead-Lag compensators; P, PI and PID controllers;

Section 6: Electrical Machines, Power Systems and Power Electronics

Single phase transformer: equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three-phase transformers: connections, vector groups, parallel operation; Auto-transformer, DC machines: separately excited, series and shunt, motoring and generating mode of operation and their characteristics, speed control of dc motors; Three-phase induction machines: principle of operation, types, performance, torque-speed characteristics, no-load and blocked-rotor tests, equivalent circuit, starting and speed control; Operating principle of single-phase induction motors; Synchronous machines: cylindrical and salient pole machines, performance and characteristics, regulation and parallel operation of generators, starting of synchronous motors;

Basic concepts of electrical power generation, ac and dc transmission concepts, Models and performance of transmission lines and cables, Economic Load Dispatch (with and without considering transmission losses), Series and shunt compensation, Electric field distribution and insulators, Distribution systems, Per- unit quantities, Bus admittance matrix, Gauss- Seidel and Newton-Raphson load flow methods, Voltage and Frequency control, Power factor correction, Symmetrical components, Symmetrical and unsymmetrical fault analysis, Principles of over-current, differential, directional and distance protection; Circuit breakers, System stability concepts, Equal area criterion.

Static V-I characteristics and firing/gating circuits for Thyristor, MOSFET, IGBT; DC to DC conversion: Buck, Boost and Buck-Boost Converters; Single and three phase configuration of uncontrolled rectifiers; Voltage and Current commutated Thyristor based converters; Bidirectional ac to dc voltage source converters; Magnitude and Phase of line current harmonics for uncontrolled and thyristor based converters; Power factor and Distortion Factor of ac to dc converters; Single-phase and three-phase voltage and current source inverters, sinusoidal pulse width modulation

Section 7: Instrumentation

Resistive-, capacitive-, inductive-, piezoelectric-, Hall effect sensors and associated signal conditioning circuits; transducers for industrial instrumentation: displacement (linear and angular), velocity, acceleration, force, torque, vibration, shock, pressure (including low pressure), flow (variable head, variable area, electromagnetic, ultrasonic, turbine and open channel flow meters) temperature (thermocouple, bolometer, thermistor, pyrometer and semiconductor); liquid level, pH, conductivity and viscosity measurement.

Engineering Mathematics:

Linear Algebra: Vector space, basis, linear dependence and independence, matrix algebra, Eigen values and Eigen vectors, rank, solution of linear equations- existence and uniqueness.

Vector Analysis: Vectors in plane and space, vector operations, gradient, divergence and curl, Gauss's, Green's and Stokes' theorems.

Probability and Statistics: Mean, median, mode, standard deviation, combinatorial probability, probability distributions, binomial distribution, Poisson distribution, exponential distribution, normal distribution, joint and conditional probability.

Networks, Signals and Systems:

Circuit analysis: Node and mesh analysis, superposition, Thevenin's theorem, Norton's theorem, reciprocity. Sinusoidal steady state analysis: phasors, complex power, maximum power transfer. Time and frequency domain analysis of linear circuits: RL, RC and RLC circuits, solution of network equations using Laplace transform.

Continuous-time signals: Fourier series and Fourier transform, sampling theorem and applications.

Discrete-time signals: DTFT, DFT, z-transform, discrete-time processing of continuous-time signals. LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeroes, frequency response, group delay, phase delay.

Electronic Devices and Circuits:

P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode and solar cell.

Diode circuits: clipping, clamping and rectifiers; BJT and MOSFET amplifiers: biasing, ac coupling, small signal analysis, frequency response. Current mirrors and differential amplifiers; Op-amp circuits: Amplifiers, summers, differentiators, integrators, active filters, Schmitt triggers and oscillators.

Number representations: binary, integer and floating-point- numbers. Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates and their static CMOS implementations, arithmetic circuits, code converters, multiplexers, decoders; Sequential circuits: latches and flip-flops, counters, shift-registers, finite state machines, propagation delay, setup and hold time, critical path delay; Data converters: sample and hold circuits, ADCs and DACs. Semiconductor memories: ROM, SRAM, DRAM.

Communications:

Random processes: auto correlation and power spectral density, properties of white noise, filtering of random signals through LTI systems; Information theory: entropy, mutual information and channel capacity theorem; Digital communications: PCM, DPCM, digital modulation schemes (ASK, PSK, FSK, QAM), bandwidth, inter-symbol interference, MAP, ML detection, matched filter receiver; Fundamentals of error correction, Block codes and Cyclic codes.

Electromagnetics:

Maxwell's Equations: Differential and integral forms and their interpretation, boundary conditions, wave equation; Transmission Lines: equations, characteristic impedance, impedance matching, impedance transformation, S-parameters; Antennas: Dipole and monopole Antennas, Linear antenna arrays.

(a) PhD Economics:

Micro Economics

Basic concepts in economics- Scarcity and optimal allocation of resources; production possibility frontier, theory of demand and supply, price, income and Cross elasticity of demand, indifference curve analysis, revealed preference theorem, Theory of Consumer Behaviour; Theory of Production and Costs; Market Structures, competitive and non-competitive equilibria and their efficiency properties; perfect competition, monopoly, monopolistic competition, oligopoly, Price discrimination and pricing strategies, Decision making under uncertainty Attitude towards Risk; Game Theory – Non Cooperative games; Factor Pricing; General Equilibrium Analysis; Efficiency Criteria: Pareto-Optimality, Kaldor – Hicks and Wealth Maximization; Welfare Economics: Fundamental Theorems , Social Welfare Function; Asymmetric Information: Adverse Selection and Moral Hazard

Macro Economics

Consumption Function: Absolute Income Hypothesis, Relative Income Hypothesis, Permanent Income and Life Cycle Hypotheses, Consumption under Uncertainty – Modern approach; Investment Function: Keynesian Approach, Accelerator Theory and Neo-Classical Theory of Investment and Tobin's Q Theory of Investment; Demand for Money : Quantity Theory of Money, Keynesian Approach, Baumol and Tobin's Contribution, Friedman's Restatement of Quantity Theory of Money; Supply of Money: Definition of Money and its importance in Macroeconomics. Money Multiplier and Credit Creation by Commercial Banks. Derivation, Properties and Shifts of IS and LM Curves and Simultaneous Equilibrium in Money and Product Markets. Effects of Monetary and Fiscal Policies under Different Cases in the IS-LM Framework; Inflation: Its effects, Kaldorian Theory of Distribution. Quantity Theory View, Keynes' view. Phillips Curve Analysis, Long Run Phillips Curve, Monetarist and Structuralist Views of Inflation; Balance of Payments: Current and Capital Accounts, Mundell-Flemming Open Economy Model, Disequilibrium in Balance of Payments and Its Consequences, Balance of Payments Adjustment Policies under Fixed and Flexible Exchange Rates; Monetary and Fiscal Policies: Objectives, Conflicts Among Objectives, Mundell Model, Swan Model; Recent Developments: Monetarism; New-Classical Macroeconomics: Rational Expectation Revolution and Real Business Cycle Theory; New-Keynesian Macroeconomics.

Statistics and Econometrics

Probability Theory: Concepts of probability, Distributions, Moments, Central Limit theorem; Descriptive Statistics – Measures of Central tendency & dispersions, Correlation, Index Numbers; Sampling methods & Sampling Distribution; Statistical Inferences, Hypothesis testing; Linear Regression Models and their properties – BLUE; Identification Problem; Simultaneous Equation Models – recursive and non-recursive; Discrete choice models; Time Series Analysis

Growth and Development Economics

Economic Growth and Economic Development; Theories of Economic Development: Adam Smith, Ricardo, Marx, Schumpeter, Rostow, Balanced & Unbalanced growth, Big Push approach; Models of Economic Growth: Harrod-Domar, Solow, Robinson, Kaldor; Technical progress –

Disembodied & embodied; endogenous growth; Indicators of Economic Development: PQLI, HDI, SDGs; Poverty and Inequalities – Concepts and Measurement; Social Sector Development: Health, Education, Gender

International Economics

Theories of International Trade, International Trade under Imperfect Competition, Gains from Trade, Terms of Trade, Trade Multiplier, Tariff and Non- Tariff barriers to trade; Dumping and Anti-Dumping Policies, GATT, WTO and Regional Trade Blocks; Trade Policy Issues, Balance of Payments: Composition, Equilibrium and Disequilibrium and Adjustment Mechanisms, Foreign Exchange Market and Arbitrage, Exchange rate determination, IMF & World Bank.

Public Economics

Market Failure and Remedial Measures: Asymmetric Information, Public Goods, Externality, Regulation of Market – Collusion and Consumers' Welfare, Public Revenue: Tax & Non-Tax Revenue, Direct & Indirect Taxes, Progressive and non-Progressive Taxation, Incidence and Effects of Taxation, Public expenditure, Public Debt and its management, Public Budget and Budget Multiplier, Tax Incidence, Fiscal Policy and its implications, Environment as a Public Good, Market Failure and Coase Theorem, Cost-Benefit Analysis.

Indian Economy

Economic Growth in India: Pattern and Structure, Agriculture, Industry & Services Sector: Pattern & Structure of Growth, Major Challenges, Policy Responses, Rural & Urban Development – Issues, Challenges & Policy Responses, Flow of Foreign Capital, Trade Policies, Infrastructure Development: Physical and Social; PublicPrivate Partnerships, Reforms in Land, Labour and Capital Markets, Poverty, Inequality & Unemployment, Functioning of Monetary Policy in India, Fiscal Policy in the Indian context: Structure of Receipts and Expenditure, Tax reforms-Goods and Services Tax, Issues of Growth and Equity, Fiscal Federalism, Centre-State Financial Relations and Finance Commissions of India; Sustainability of Deficits and Debt, The Fiscal Responsibility and Budget Management Act 2003, Demonetization and aftermath. India's balance of payments, Composition of India's Trade, Competitiveness of India's exports, India's exchange rate policy.

(b) PhD English:

Multi-genre literatures in English

Poetry, the novel and other forms of fiction including the short story, drama, creative non-fiction, and non-fiction prose—with emphasis on the long 19th and 20th centuries.

Indian English Literatures

Especially in a comparative context, anglophone and in English translation, literatures from India and, extending to some degree, the larger Indian subcontinent.

Literary criticism and theory

Critical and cultural intellectual-traditions and approaches widely referred to and used in the discipline of English.

History of English literature and English literary studies

Research approaches and methodologies
Including interpretive techniques responsive to literary forms, devices, concepts, and genres.

Film & Media Studies

Childhood studies

Environmental Humanities

Research Methodology

Research Problem - Research Process - Literature Review - Hypothesis formulation - Research Design - Sampling - Data Collection - Descriptive Statistics - Hypothesis testing - Correlation and Regression - Publishing research - Indexation of journals - Impact Factor - Ethics in research

Data Sciences & Analytics

Probability-Independence-Bayes Theorem-Confidence Intervals-Hypothesis Testing - Central Tendency, Proportion and Variance-Parametric and Non-Parametric Estimation-Model Building - Supervised Methods: Regression, Decision Tree and Neural Networks-Unsupervised Methods - KNN-Dimensionality Reduction - PCA, SVD

Organisational Behaviour & Human Resource Management

OB-Significance and Theories-Personality-Perception-Attitude-Group Behaviour-Conflict and Negotiation-Human Resource Management: Functions- HR Planning-Recruitment and Selection- Job Analysis-Training and Development-Performance Management-Compensation and Benefits- Workforce Diversity-Employee Engagement-Industrial Relations-Organisational Development.

Operations & Decision Sciences

Decision Making: Concept, Process, Techniques- Operations Management: Role and Scope-Production control-Forecasting techniques – causal and time series models, moving average, exponential smoothing, trend and seasonality-Aggregate production planning-Master production scheduling; MRP, Capacity Planning-Operation Research: Linear programming – problem formulation, simplex method, duality, and sensitivity analysis-Transportation and assignment Problems: Queuing models: M/M/1 and M/M/c; Simulation – Manufacturing and Service systems applications-Inventory: Functions, costs, classifications, deterministic inventory models, quantity discount-Perpetual and periodic inventory control systems-Project management: CPM, PERT, Crashing-Logistics and Supply Chain Management: Drivers and Supply Chain Network Design- Facility Location and Plant Layout: Site Selection and Analysis, Plant Layout Types-Principles of Material Handling-Unit-Load Concept-Quality Management and Statistical Quality Control- Process Capability- Quality Circles- Total Quality Management – KAIZEN, Benchmarking, Six Sigma; ISO 9000 Series Standards- Selective inventory control techniques.

Finance

Accounting Principles and Standards-Preparation of Financial Statements-Financial Statement Analysis – Ratio Analysis, Funds Flow and Cash Flow Analysis, DuPont Analysis-Preparation of Cost Sheet, Marginal Costing, Cost Volume Profit Analysis-Standard Costing & Variance Analysis- Financial Management, Concept & Functions-Capital Structure – Theories, Cost of Capital-Sources and Finance-Budgeting and Budgetary Control, Types and Process, Zero base Budgeting- Leverages – Operating, Financial and Combined Leverages, EBIT–EPS
Analysis-Financial Breakeven Point & Indifference Level-Time Preference for Money-Capital Budgeting-Dividend – Theories and Determination-Mergers and Acquisition-Portfolio Management.

Marketing

Marketing- Concepts, Orientations- Market Segmentation, Targeting & Positioning- Product & Pricing- Product Mix, Product Life Cycle, New Product Development, Pricing Strategies- Marketing Channels, Advertising & Sales Promotion- Consumer and Industrial Buying Behaviour: Theories and Models of Consumer Behaviour- Brand Management: Role of Brands, Brand Equity, Equity Models-Developing a Branding Strategy-Brand Name Decisions, Brand Extensions and Loyalty- Service Marketing – Managing Service Quality and Brands- Marketing Strategies of Service Firms- Retail Marketing-Customer Relationship Marketing-Emerging Trends in Marketing-International Marketing.

Strategy

Strategic Management - Strategy formulation -External Analysis - Porters Forces - Internal Analysis - Resource Based View- Competition - Mergers and Acquisition - Business and Public Policy- Corporate Governance.

Economics

Demand and Supply- Elasticity - Production-Marginal and Average concepts - Opportunity and Sunk Costs- Long Run and Short Run- Market Structures - competitive markets - monopoly - monopolistic competition - oligopoly- game theory - market failures- externalities, public goods, asymmetric information.

All candidates are required to attempt Module 1, while they have the flexibility to choose any one section from Module 2. The exam will last for one hour and will consist of 15 questions from Module 1 and 15 questions from Module 2. Each question carries one mark, with a total of 30 marks available.

Module 1 (Mandatory for all candidates)

Basic materials science: Classification of materials: metals, ceramics, polymers, and composites. Nature of bonding, fundamentals of crystallography, symmetry operations, crystal systems, Bravais lattices, unit cells, primitive cells, crystallographic planes, and directions; Structures of metals, ceramics, polymers, amorphous materials, and glasses.

Suggested Text books / Reference books:

1. Callister, W. D. Jr., & Rethwisch, D. G. (2018). Materials Science and Engineering: An Introduction (10th ed.). Wiley.
2. Raghavan, V. (2015). Materials Science and Engineering: A First Course (6th ed.). PHI Learning.
3. Shackelford, J. F. (2021). Introduction to Materials Science for Engineers (9th ed.). Pearson Education.

Quantitative and logical reasoning: Arithmetic, Number Systems, Time, Speed, and Distance, Time and Work, Algebra, Basic Algebraic Identities, Linear Equations, Quadratic Equations, Polynomials, Trigonometric Ratios, Trigonometric Identities, Heights and Distances, Data Interpretation, Probability, Permutation and Combination

English language comprehension: Reading Comprehension, Passage Selection, Drawing Inferences, Vocabulary, Synonyms and Antonyms, Word Meanings,Contextual Usage, Analogies, Grammar, Parts of Speech, Sentence Structure, Tenses, Subject-Verb Agreement, Verbal Reasoning, Logical Deductions, Statement and Conclusion. Statement and Assumption, Statement and Inference, Passage Conclusion, Understanding Context, Filling in the Blanks, Error Spotting, Grammar Errors, Spelling Mistakes, Sentence Completion, Sentence Improvement, Sentence Reconstruction

Module 2 (Choose any one section)

Section 1: Physical and Mechanical Metallurgy

Defects in crystalline materials. Alloying, Phase diagrams, Phase transformation, TTT diagrams, Non equilibrium cooling, precipitation hardening, Diffusion in solids, Heat treatment. Concept of stress and strain, mechanical properties of materials, concept of dislocations, dislocation theory, Plastic deformation, slip, twinning, creep, fatigue, fracture, strengthening mechanisms, elements of theory of plasticity, metal forming processes.

Section 2: Physics of Materials

Physical, Mechanical, Chemical, Electrical, Thermal, Optical, Magnetic properties of materials, Postulates of quantum mechanics; Uncertainty principle; Schrodinger equation, Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors,

Charge Carriers, Semiconductor devices and device structures (diodes, junctions, transistors, field effect devices, homo- and heterojunction devices), Device characteristics, Hall effect, Optoelectronic devices (solar cells, photo-detectors, LEDs, LASERS), Phonons, Free electron theory, Thermoelectric power, Superconductivity: type-I and type-II superconductors, Josephson junctions and tunnelling, Plasmons, Excitons.

Section 3: Chemistry of Materials

Classes of materials- inorganic and organic materials, surfaces, interfaces, Nanomaterials, thin films, and multilayers, porous materials, Covalent organic frameworks, porous organic polymers and related organic porous materials, soft materials- effects of synthesis on the structure and properties of various materials. Chemical and catalytic aspects of materials, catalytic action, electrocatalysts, and photocatalytic materials.

Section 4: Fluid mechanics and heat transfer

Fluid mechanics: : Properties of fluids: density, pressure, viscosity, surface tension, capillarity, vapour pressure; Buoyancy, Bernoulli's equation; laminar and turbulent flows, entry length, Hagen-Poiseuille equation; Darcy-Weisbach equation; energy losses in pipes; Fluid pressure and velocity measurement

Heat Transfer: *Conduction*: Generalized differential energy equations of heat conduction; types of boundary conditions; lumped heat capacity systems; Thermal conductivity, Thermal contact resistance. Convection: Newtons law of cooling; forced, mixed and natural convection heat transfer; hydraulic and thermal boundary layer, heat exchangers, parallel and counter flow heat exchangers, effectiveness, boiling and condensation

Section 5: Materials Characterization

X-ray diffraction, bragg's law, structure factor, lattice strain, quantitative analysis using XRD; spectroscopic techniques such as UV-Vis, IR and Raman; optical microscopy: resolution and limit of resolution, different types of optical microscopes and operation modes. Electron microscopy,basic construction and working principle of SEM, beam specimen interaction, imaging modes, sample preparation for SEM. TEM : Basic construction and working principle of TEM. Imagine and diffraction modes in TEM, basics of electron diffraction, Energy dispersive spectroscopy in SEM and TEM, sample preparation for TEM. Tensile test, hardness measurement. Electrical conductivity, carrier mobility and concentrations. Thermal analysis techniques TGA, DSC etc.

Section 6: Biomaterials

Different class of materials used in medicine – polymers, metals, ceramics, Biomaterials- Bioinert, Bioactive and Bioresorbable materials; Implants, dental materials, stents, shape memory alloys, drug releasing hydrogels and biomimetic system. Testing of biomaterials: In vitro and In vivo studies, Simulated body fluids, MTT Assay, Time kill Assay, Cell culture studies, Drug delivery systems, Anti-bacterial and Anti-Fungal systems. Tests for biocompatibility. Bone fillers and Dental cements: zinc phosphate, zinc polycarboxylate, glass ionomer, resin-modified glass ionomers (RMGIs), and resin cements, etc. Testing of cement and fillers. Grafts: Autograft, Isograft, Allograft, Xenograft etc. Working principles of major diagnostic instruments: X-ray, MRI, CT scans, USG etc, Biofouling, Biological environment and host response – Inflammation, wound healing, and foreign body response, Degradation of implanted materials: polymers, metals, ceramics, biocompatibility- methods for improvement, Biosensors.

Section 7: Computational Methods in Materials Science

Computer simulations as a tool for materials science: Need and Prospects, Length and time scales of multiscale modeling. Basics of statistical mechanics: Probability, Entropy and temperature, Boltzmann distribution, Thermodynamic ensembles, ergodicity.

Ab initio methods: Schrodinger equation, Electronic states of many particle systems. Introduction to first principles energy methods: The Hartree-Fock approximation, Density functional theory Atomistic Simulation Techniques: Molecular Dynamics (MD) - Introduction, inter-atomic potential functions, Lennard-Jones potential, equilibration and property evaluation

Calculus: Functions of two or more variables, continuity, directional derivatives, partial derivatives, total derivative, maxima and minima, saddle point, method of Lagrange's multipliers; Double and Triple integrals and their applications to area, volume and surface area; Vector Calculus: gradient, divergence and curl, Line integrals and Surface integrals, Green's theorem, Stokes' theorem, and Gauss divergence theorem.

Linear Algebra: Finite dimensional vector spaces over real or complex fields; Linear transformations and their matrix representations, rank and nullity; systems of linear equations, characteristic polynomial, eigenvalues and eigenvectors, diagonalization, minimal polynomial, Cayley-Hamilton Theorem, Finite dimensional inner product spaces, Gram- Schmidt orthonormalization process, symmetric, skew-symmetric, Hermitian, skew-Hermitian, normal, orthogonal and unitary matrices; diagonalization by a unitary matrix, Jordan canonical form; bilinear and quadratic forms.

Real Analysis: Metric spaces, connectedness, compactness, completeness; Sequences and series of functions, uniform convergence, Ascoli-Arzela theorem; Weierstrass approximation theorem; contraction mapping principle, Power series; Differentiation of functions of several variables, Inverse and Implicit function theorems; Lebesgue measure on the real line, measurable functions; Lebesgue integral, Fatou's lemma, monotone convergence theorem, dominated convergence theorem.

Complex Analysis: Functions of a complex variable: continuity, differentiability, analytic functions, harmonic functions; Complex integration: Cauchy's integral theorem and formula; Liouville's theorem, maximum modulus principle, Morera's theorem; zeros and singularities; Power series, radius of convergence, Taylor's series and Laurent's series; Residue theorem and applications for evaluating real integrals; Rouche's theorem, Argument principle, Schwarz lemma; Conformal mappings, Mobius transformations.

Ordinary Differential equations: First order ordinary differential equations, existence and uniqueness theorems for initial value problems, linear ordinary differential equations of higher order with constant coefficients; Second order linear ordinary differential equations with variable coefficients; Cauchy-Euler equation, series solutions (power series, Frobenius method); Legendre and Bessel functions and their orthogonal properties; Systems of linear first order ordinary differential equations, Sturm's oscillation and separation theorems, Sturm-Liouville eigenvalue problems, Systems of ordinary differential equations: Linearized stability, Lyapunov functions.

Algebra: Groups, subgroups, normal subgroups, quotient groups, homomorphisms, automorphisms; cyclic groups, permutation groups, Group action, Sylow's theorems and their applications; Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domains, Principle ideal domains, Euclidean domains, polynomial rings, Eisenstein's irreducibility criterion; Fields, finite fields, field extensions, algebraic extensions, algebraically closed fields.

Functional Analysis: Normed linear spaces, Banach spaces, Hahn-Banach theorem, open mapping and closed graph theorems, principle of uniform boundedness; Inner-product spaces, Hilbert spaces, orthonormal bases, projection theorem, Riesz representation theorem, spectral theorem for compact self-adjoint operators.

Numerical Analysis: Systems of linear equations: Direct methods (Gaussian elimination, LU

decomposition, Cholesky factorization), Iterative methods (Gauss-Seidel and Jacobi) and their convergence for diagonally dominant coefficient matrices; Numerical solutions of nonlinear equations: bisection method, secant method, Newton-Raphson method, fixed point iteration; Interpolation: Lagrange and Newton forms of interpolating polynomial, Error in polynomial interpolation of a function; Numerical differentiation and error, Numerical integration: Trapezoidal and Simpson rules, Newton-Cotes integration formulas, composite rules, mathematical errors involved in numerical integration formulae; Numerical solution of initial value problems for ordinary differential equations: Methods of Euler, Runge-Kutta method of order 2.

Partial Differential Equations: Method of characteristics for first order linear and quasilinear partial differential equations; Second order partial differential equations in two independent variables: classification and canonical forms, method of separation of variables for Laplace equation in Cartesian and polar coordinates, heat and wave equations in one space variable; Laplace and Fourier transform methods.

Topology: Basic concepts of topology, bases, subbases, subspace topology, order topology, product topology, quotient topology, metric topology, connectedness, compactness, countability and separation axioms, Urysohn's Lemma.

Linear Programming: Linear programming models, convex sets, extreme points; Basic feasible solution, graphical method, simplex method, two phase methods, revised simplex method ; Infeasible and unbounded linear programming models, alternate optima; Duality theory, weak duality and strong duality; Balanced and unbalanced transportation problems, Initial basic feasible solution of balanced transportation problems (least cost method, north- west corner rule, Vogel's approximation method); Optimal solution, modified distribution method; Solving assignment problems, Hungarian method.

Engineering Mathematics: Limit, continuity, differentiability, mean value theorems, higher order and partial derivatives, sequences and series, convergence, multiple integrals, vector field: divergence and curl, integral theorems, Linear algebra: solution of a system of linear equations, vector spaces, rank and determinant, eigenvalue problems, Ordinary Differential Equations (ODE): solution of first order ODE, solution of second order non-homogeneous ODE with constant coefficients, Probability distributions and random variables, statistics: population and sampling, tests of hypothesis, analysis of variance, curve fitting.

Engineering Mechanics: Force and moment, resultant of a force system, equations of equilibrium, free-body diagram, friction forces: laws of Coulomb friction, properties of surfaces: first moment and second moments of area, transfer theorems, polar moment of area, particle kinematics: velocity and acceleration calculations in rectangular and polar coordinates, particle dynamics: Newton's laws, energy and momentum methods.

Fluid Mechanics: Fluid properties, fluid statics, forces on submerged bodies, stability of floating bodies; Bernoulli's equation, velocity and discharge measuring devices, Prandtl's boundary layer equations, dynamic action of fluid on flat and curved surfaces, force, work done and efficiency, classification and performance analysis of hydraulic turbines and pumps.

Thermodynamics: First law of thermodynamics applied to non-flow and flow processes, pure substances, second law of thermodynamics applied to cycles, entropy change of pure substances, entropy principle.

Solid Mechanics: Definition of stress, deformation and strain, Hooke's Law, various elastic constants, shear force and bending moment diagrams, stress and deformation analysis of structural elements like rods, beams, shafts, buckling analysis of columns, plane stress and plane strain problems, principal stresses and planes, Mohr's circle, strain-displacement relations.

Heat Transfer: Generalized heat conduction equation, heat transfer in fins, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, heat exchanger performance; thermal radiation: radiant energy exchange between black surfaces.

Machining Science: Mechanics of metal cutting, cutting tool geometries, tool materials, tool wear.
Mechanical behavior of materials: Slip systems, dislocations, grain size. Fracture: Brittle and ductile fracture, Fatigue and creep. Tension tests, hardness tests.

Cast irons: types, effect of elements, defects.

Steel and non-ferrous metallurgy: Iron carbon diagrams, heat treatment.

Metal casting and joining: Solidification, casting processes, inspection. Joining processes - Arc welding, laser beam, ultrasonic, Heat affected Zone.

Metrology: Geometric Dimensioning and Tolerancing, Coordinate Measuring Machines, Surface Finish Measurement.

Operations Management: Manufacturing planning and control: Demand forecasting, aggregate production planning, master production scheduling, material requirements planning, Inventory control: Single period inventory models, periodic review and continuous review policies, Supply chain management: Supply chain drivers, performance measures.

Operations Research: Formulation and solution of linear programming problems, primal-dual relationships, sensitivity analysis**,** transportation and assignment problems, network flow models, queuing models, PERT and CPM.

Mechanics of Machinery and Vibrations: Mechanisms and machines, kinematics of mechanisms, degrees of freedom, position, displacement, velocity and acceleration analysis, cams and gears: law of gearing, types of cams and gears, gear trains, static and dynamic force analysis of machines, balancing, vibration analysis of single DoF systems: free and forced vibration, undamped and damped systems.

Machine Design: The design process, design factors, selection of materials, statistical considerations in design, stress concentration, theories of failure, design for impact and fatigue loads, design of various types of joints like threaded joints, welded joints, and joints with keys and pins, design of machine elements like springs and power shafting, design of clutches, brakes, design of gears, lubrication and journal bearing design, rolling contact bearings and their selection.

Modern machining processes: Abrasive Jet machining, Ultrasonic machining, Chemical and electrochemical machining, electro-discharge machining, wire EDM.

CNC Machine tools: Mechatronic elements, CNC programming.
Work systems design: Method study, time study, productivity measurement.
Statistical quality control: Control charts for variables and attributes, process capability, acceptance sampling.

Thermal Engineering: Analysis of gas power cycles: Otto cycle, Diesel cycle, analysis of actual cycles. four stroke and two stroke engines, valve timing and port timing diagrams: Engine systems: fuel systems, cooling system, lubrication system, ignition system. Combustion in IC engines: stages of combustion, normal and abnormal combustion, fuel rating. IC Engine performance; Brayton cycle: Regeneration, reheat and inter-cooled cycles. properties of steam and atmospheric air, psychrometry, Carnot vapour cycle, Rankine cycle, inter- cooling, reheat and regeneration, co- generation; vapour compression refrigeration cycle, refrigeration system components; coal and other fossil fuels, combustion calculations; steam generators, steam nozzles, steam turbines, impulse and reaction turbines, velocity diagram calculations, turbine performance, compounding of steam turbines; condensers, cooling towers.

Mathematical Physics
Vector Calculus: Linear vector space: basis, orthogonality and completeness; matrices; similarity transformations, diagonalization, eigenvalues and eigenvectors; linear differential equations: second order linear differential equations and solutions involving special functions; complex analysis: Cauchy-Riemann conditions, Cauchy's theorem, singularities, residue theorem and applications; Laplace transform, Fourier analysis; elementary ideas about tensors: covariant and contravariant tensors .

Classical Mechanics
Lagrangian Formulation: D'Alembert's principle, Euler-Lagrange equation, Hamilton's principle, calculus of variations; symmetry and conservation laws; central force motion: Kepler problem and Rutherford scattering; small oscillations: coupled oscillations and normal modes; rigid body dynamics: inertia tensor, orthogonal transformations, Euler angles, Torque free motion of a symmetric top; Hamiltonian and Hamilton's equations of motion; Liouville's theorem; canonical transformations: action-angle variables, Poisson brackets, Hamilton-Jacobi equation. Special Theory of Relativity: Lorentz transformations, relativistic kinematics, mass-energy equivalence.

Electromagnetic Theory
Solutions of electrostatic and magnetostatic problems including boundary value problems; method of images; separation of variables; dielectrics and conductors; magnetic materials; multipole expansion; Maxwell's equations; scalar and vector potentials; Coulomb and Lorentz gauges; electromagnetic waves in free space, non-conducting and conducting media; reflection and transmission at normal and oblique incidences; polarization of electromagnetic waves; Poynting vector, Poynting theorem, energy and momentum of electromagnetic waves; radiation from a moving charge.

Quantum Mechanics
Postulates of quantum mechanics; uncertainty principle; Schrodinger equation; Dirac Bra-Ket notation, linear vectors and operators in Hilbert space; one dimensional potentials: step potential, finite rectangular well, tunneling from a potential barrier, particle in a box, harmonic oscillator; two and three dimensional systems: concept of degeneracy; hydrogen atom; angular momentum and spin; addition of angular momenta; variational method and WKB approximation, time independent perturbation theory; elementary scattering theory, Born approximation; symmetries in quantum mechanical systems .

Thermodynamics and Statistical Physics
Laws of thermodynamics; macrostates and microstates; phase space; ensembles; partition function, free energy, calculation of thermodynamic quantities; classical and quantum statistics; degenerate Fermi gas; black body radiation and Planck's distribution law; Bose-Einstein condensation; first and second order phase transitions, phase equilibria, critical point.

Atomic and Molecular Physics
Spectra of one-and many-electron atoms; spin-orbit interaction: LS and jj couplings; fine and hyperfine structures; Zeeman and Stark effects; electric dipole transitions and selection rules; rotational and vibrational spectra of diatomic molecules; electronic transitions in diatomic

molecules, Franck-Condon principle; Raman effect; EPR, NMR, ESR, X-ray spectra; lasers: Einstein coefficients, population inversion, two and three level systems.

Solid State Physics

Elements of crystallography; diffraction methods for structure determination; bonding in solids; lattice vibrations and thermal properties of solids; free electron theory; band theory of solids: nearly free electron and tight binding models; metals, semiconductors and insulators; conductivity, mobility and effective mass; Optical properties of solids; Kramer's-Kronig relation, intra-and inter-band transitions; dielectric properties of solid; dielectric function, polarizability, ferroelectricity; magnetic properties of solids; dia, para, ferro, antiferro and ferri-magnetism, domains and magnetic anisotropy; superconductivity: Type-I and Type II superconductors, Meissner effect, London equation, BCS Theory, flux quantization.

Electronics

Semiconductors in Equilibrium: Electron and hole statistics in intrinsic and extrinsic semiconductors; metal-semiconductor junctions; Ohmic and rectifying contacts; PN diodes, bipolar junction transistors, field effect transistors; negative and positive feedback circuits; oscillators, operational amplifiers, active filters; basics of digital logic circuits, combinational and sequential circuits, flip-flops, timers, counters, registers, A/D and D/A conversion.

Nuclear and Particle Physics

Nuclear radii and charge distributions, nuclear binding energy, electric and magnetic moments; semi empirical mass formula; nuclear models; liquid drop model, nuclear shell model; nuclear force and two nucleon problem; alpha decay, beta-decay, electromagnetic transitions in nuclei; Rutherford scattering, nuclear reactions, conservation laws; fission and fusion; particle accelerators and detectors; elementary particles; photons, baryons, mesons and leptons; quark model; conservation laws, isospin symmetry, charge conjugation, parity and time-reversal invariance.

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