

SCHEME and SYLLABII OF EXAMINATION

FOR

RESEARCH APTITUDE TEST

FOR

Ph.D Programme

Offered by



Indira Gandhi Delhi Technical University for Women

(Established by Govt. of Delhi vide Act 09 of 2012)

(Formerly Indira Gandhi Institute of Technology)

Kashmere Gate Delhi-110006

SCHEME OF RAT EXAM

1. RAT examination would comprise of 60 Multiple Choice Questions (MCQ) divided into two parts:

PART A: This part shall carry 30 MCQ questions pertaining to research aptitude, logical reasoning, analytical and numerical ability, graphical analysis, quantitative comparison, data interpretation and reading comprehension. .

PART B: This part shall carry 30 MCQ questions pertaining to the subject.

2. The RAT exam would be of 60 marks where each question would carry 01 mark. The RAT shall be qualifying exam with qualifying marks as 50%.

3. The duration of the RAT exam would be 02 hrs.

4. The RAT exam is conducted in the following disciplines:

ENGINEERING STREAMS

- Electronics and Communication Engineering, Electrical Engineering (under Dept. of ECE)
- Computer Science Engineering / Information Technology.
- Mechanical Engineering.

APPLIED SCIENCES AND HUMANITIES

- Mathematics
- Physics
- Chemistry
- English

ARCHITECTURE & PLANNING

SYLLABUS FOR PART A
(COMMON TO ALL)

- (i) Research Aptitude
- (ii) Logical reasoning
- (iii) Analytical reasoning
- (iv) Numerical ability
- (v) Graphical representation and analysis
- (vi) Quantitative comparison
- (vii) Data interpretation : Qualitative and quantitative data
- (viii) Reading comprehension

SYLLABUS FOR PART B

ARCHITECTURE & PLANNING

1. Architecture & Design

Principles of Art and architecture, Visual composition in 2D & 3D Organization of space, Computer Graphics, Architectural Graphics, Programming languages and automation. Planning and design considerations for different building types, anthropometrics, site planning, Barrier-free design, Circulation- horizontal and vertical, space Standards, National Building Code and Building Codes. Elements, architectural styles, construction and examples of different periods different periods of Indian & Western History

2. Building Materials, Construction & Management

Behavioural applications and characteristics of various building materials viz. Mud, bamboo, timber, brick, concrete, glass, steel, FRP, different polymers, AAC and composites. Building systems and prefabrication of building elements, Building construction techniques, methods and details, Principles of Modular Coordination, Estimation, valuation, specification, professional practice, Project management techniques, Construction planning and equipment e.g. CPM, PERT etc.

3. Building & Structures

Elastic and Limit State design, Principles of the strength of materials, Design of structural elements in steel, wood and RCC, Structural systems in RCC and Steel, Principles and design of disaster resistant structures, Form and Structure, Principles of Prestressing, gravity & lateral load resisting systems, High Rise & Long Span structures.

4. Environmental Planning & Design

Ecological principles, Concepts of Environmental Impact Analysis, Ecosystem natural and manmade ecosystem, Environmental considerations in planning and design, Principles of architectural acoustics; Green Building Concepts & Rating, ECBC, Principles of lighting and illumination, Climate responsive design, Thermal comfort, ventilation & air movement Solar architecture, Environmental pollution- types, causes, controls and abatement strategies, Building Performance Simulation and Evaluation, Ecosystem natural and man

5. Urban Design

Public Perception, Concepts and theories of urban design, Townscape, Urban design interventions for sustainable development and transportation, Public Realm, Historical and modern examples of urban design, Elements of urban built environment - urban form, structure, spaces, pattern, texture, fabric, grain etc, Site planning; Landscape design; Development controls – FAR, densities and building byelaws, Public spaces, spatial qualities, character and Sense of Place, Principles, tools & techniques of 6. Urban Planning & Housing, principles, concepts and examples of the neighbourhood, Affordable Housing, Housing for special areas and needs, Housing typologies, Slums, Residential densities, National Housing Policies, Standards for housing and community facilities, Programs & Schemes.

6. Urban Planning & Housing

Types of plans - City Development Plan, Master Plan, Structure Plan, Action Area Plan, Zonal Plan, Town Planning Scheme, Planning process, Regional Plan, Salient concepts, principles of urban planning Decision support system and Land Information System., Graphic presentation of spatial data, Tools and techniques of Surveys - Topographical, Physical, Land use and Socioeconomic Surveys, Methods of nonspatial & spatial data analysis, Application of G.I.S & Remote Sensing techniques in urban and regional planning;

7. Planning Techniques & Management

Social, environmental cost-benefit analysis and Economical, Urban Economics, Law of demand and supply of land and its use in planning, Management of Infrastructure Urban Infrastructure – Water Supply, Transportation, Sewerage, Solid Waste Management, Drainage, Electricity & Communications. Building Services: Sewerage and drainage systems, Water supply, Sanitary fittings and fixtures, Principles of internal and external drainage system, Plumbing systems, Principles of electrification of buildings, Elevators and Escalators - standards and uses, Intelligent Buildings, Air-Conditioning systems, Building Safety & Security systems and Firefighting Systems.

COMPUTER SCIENCE & ENGINEERING (CSE) / INFORMATION TECHNOLOGY (IT) COMPUTER APPLICATIONS (CA)

Digital Logic: Logic functions, Minimization, Design and synthesis of combinational and sequential circuits; Number representation and computer arithmetic (fixed and floating point).

Computer Organization and Architecture: Machine instructions and addressing modes, ALU and data-path, CPU control design, Memory interface, I/O interface (Interrupt and DMA mode), Instruction pipelining, Cache and main memory, Secondary storage.

Programming and Data Structures: Programming in C; Functions, Recursion, Parameter passing, Scope, Binding; Abstract data types, Arrays, Stacks, Queues, Linked Lists, Trees, Binary search trees, Binary heaps.

Algorithms: Analysis, Asymptotic notation, Notions of space and time complexity, Worst and average case analysis; Design: Greedy approach, Dynamic programming, Divide-and-conquer; Tree and graph traversals, Connected components, Spanning trees, Shortest paths; Hashing, Sorting, Searching. Asymptotic analysis (best, worst, average cases) of time and space, upper and lower bounds, Basic concepts of complexity classes – P, NP, NP-hard, NP-complete.

Theory of Computation: Regular languages and finite automata, Context free languages and Push-down automata, Recursively enumerable sets and Turing machines, Undecidability.

Compiler Design: Lexical analysis, Parsing, Syntax directed translation, Runtime environments, Intermediate and target code generation, Basics of code optimization.

Operating System: Processes, Threads, Inter-process communication, Concurrency, Synchronization, Deadlock, CPU scheduling, Memory management and virtual memory, File systems, I/O systems, Protection and security.

Databases: ER-model, Relational model (relational algebra, tuple calculus), Database design (integrity constraints, normal forms), Query languages (SQL), File structures (sequential files, indexing, B and B+ trees), Transactions and concurrency control.

Information Systems and Software Engineering: information gathering, requirement and feasibility analysis, data flow diagrams, process specifications, input/output design, process life cycle, planning and managing the project, design, coding, testing, implementation, maintenance.

Computer Networks: ISO/OSI stack, LAN technologies (Ethernet, Token ring), Flow and error control techniques, Routing algorithms, Congestion control, TCP/UDP and sockets, IP(v4), Application layer protocols (icmp, dns, smtp, pop, ftp, http); Basic concepts of hubs, switches, gateways, and routers. Network security – basic concepts of public key and private key cryptography, digital signature, firewalls.

Web technologies: HTML, XML, basic concepts of client-server computing.

Advances in Computer Science & IT : Introduction to AI and its applications, Machine learning and its Algorithms, Data Analytics, Data Mining, IoT, Cloud Computing, Mobile Application Development, Block Chain and its applications etc.

ELECTRONICS AND COMMUNICATION ENGINEERING (ECE)

Circuits:

Thevenin and Norton's maximum power transfer, Wye-Delta transformation. Time domain analysis of simple RLC circuits, Solution of network equations using Laplace transform: frequency domain analysis of RLC circuits.

Digital Circuits:

Boolean algebra, minimization of Boolean functions; logic gates; digital IC families (DTL, TTL, ECL, MOS, CMOS). Combinatorial circuits: arithmetic circuits, multiplexers, decoders, PROMs and PLAs. Sequential circuits: latches and flip-flops, counters and shift-registers. Sample and hold circuits, ADCs, DACs. Semiconductor memories. Microprocessor: architecture, programming, memory and I/O interfacing.

Analog Circuits:

Analog Circuits: Small Signal Equivalent circuits of diodes, BJTs, MOSFETs and analog CMOS. Simple diode circuits, clipping, clamping, rectifier. Biasing and bias stability of transistor and FET amplifiers. Amplifiers: single and multi-stage, differential and operational, feedback, and power. Frequency response of amplifiers. Simple op-amp circuits. Filters. Sinusoidal oscillators; criterion for oscillation; single-transistor and op-amp configurations. Function generators and wave-shaping circuits, 555 Timers. Power supplies.

Communication Systems:

Random signals and noise: probability, random variables, probability density function, autocorrelation, power spectral density. Analog communication systems: amplitude and angle modulation and demodulation systems, spectral analysis of these operations, signal-to-noise ratio (SNR) calculations for amplitude modulation (AM) and frequency modulation (FM) for low noise conditions. Digital communication systems: pulse code modulation (PCM), differential pulse code modulation (DPCM), digital modulation schemes: amplitude, phase and frequency shift keying schemes (ASK, PSK, FSK), matched filter receivers, bandwidth consideration and probability of error calculations for these schemes. Basics of TDMA, FDMA and CDMA and GSM.

Syllabus of RAT in Electrical Engineering

Section 1: Engineering Mathematics

Linear Algebra: Matrix Algebra, Systems of linear equations, Eigenvalues, Eigenvectors.

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, 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.

Numerical Methods: Solutions of nonlinear algebraic equations, Single and Multi-step methods for differential equations.

Transform Theory: Fourier Transform, Laplace Transform, z-Transform.

Electrical Engineering

Section 2: Electric Circuits

Network graph, KCL, KVL, Node and Mesh analysis, Transient response of dc and ac networks, Sinusoidal steady-state analysis, Resonance, Passive filters, Ideal current and voltage sources, Thevenin's theorem, Norton's theorem, Superposition theorem, Maximum power transfer theorem, Two-port networks, Three phase circuits, Power and power factor in ac circuits.

Section 3: Electromagnetic Fields

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 4: Signals and Systems

Representation of continuous and discrete-time signals, Shifting and scaling operations, Linear Time Invariant and Causal systems, Fourier series representation of continuous periodic signals, Sampling theorem, Applications of Fourier Transform, Laplace Transform and z-Transform.

Section 5: Electrical Machines

Single phase transformer: equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three phase transformers: connections, parallel operation; Auto-transformer. Electromechanical energy conversion principles. DC machines: separately excited, series and shunt, motoring and generating mode of operation and their characteristics, starting and speed control of dc motors. Three phase induction motors: 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, regulation and parallel operation of generators, starting of synchronous motor, characteristics; Types of losses and efficiency calculations of electric machines.

Section 6: Power Systems

Power generation concepts, ac and dc transmission concepts, Models and performance of transmission lines and cables, 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 and distance protection; Circuit breakers, System stability concepts, Equal area criterion.

Section 7: 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, Routh-Hurwitz and Nyquist criteria, Bode plots, Root loci, Stability analysis, Lag, Lead and Lead-Lag compensators; P, PI and PID controllers; State space model, State transition matrix.

Section 8: Electrical and Electronic Measurements 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.

Section 9: Analog and Digital Electronics

Characteristics of diodes, BJT, MOSFET; Simple diode circuits: clipping, clamping, rectifiers; Amplifiers: Biasing, Equivalent circuit and Frequency response; Oscillators and feedback amplifiers; Operational amplifiers: Characteristics and applications; Simple active filters, VCOs and Timers, Combinational and Sequential logic circuits, Multiplexer, Demultiplexer, Schmitt trigger, Sample and hold circuits, A/D and D/A converters, 8085 Microprocessor: Architecture, Programming and Interfacing.

Section 10: Power Electronics

Characteristics of semiconductor power devices: Diode, Thyristor, Triac, GTO, MOSFET, IGBT; DC to DC conversion: Buck, Boost and Buck-Boost converters; Single and three phase configuration of uncontrolled rectifiers, Line commutated thyristor based converters, Bidirectional ac to dc voltage source converters, Issues of line current harmonics, Power factor, Distortion factor of ac to dc converters, Single phase and three phase inverters, Sinusoidal pulse width modulation.

Mechanical and Automation Engineering (MAE)

Applied Mechanics And Design

Engineering Mechanics: Free body diagrams and equilibrium; trusses and frames; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion, including impulse and momentum (linear and angular) and energy formulations; impact.

Strength of Materials: Stress and strain, stress-strain relationship and elastic constants, Mohr's circle for plane stress and plane strain, thin cylinders; shear force and bending moment diagrams; bending and shear stresses; deflection of beams; torsion of circular shafts; Euler's theory of columns; strain energy methods; thermal stresses.

Theory of Machines: Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of slider-crank mechanism; gear trains; flywheels.

Vibrations: Free and forced vibration of single degree of freedom systems; effect of damping; vibration isolation; resonance, critical speeds of shafts.

Design: Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; principles of the design of machine elements such as bolted, riveted and welded joints, shafts, spur gears, rolling and sliding contact bearings, brakes and clutches.

Fluid Mechanics and Thermal Sciences

Fluid Mechanics: Fluid properties; fluid statics, manometry, buoyancy; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; viscous flow of incompressible fluids; boundary layer; elementary turbulent flow; flow through pipes, head losses in pipes, bends etc.

Heat-Transfer: Modes of heat transfer; one dimensional heat conduction, resistance concept, electrical analogy, unsteady heat conduction, fins; dimensionless parameters in free and forced convective heat transfer, various correlations for heat transfer in flow over flat plates and through pipes; thermal boundary layer; effect of turbulence; radiative heat transfer, black and grey surfaces, shape factors, network analysis; heat exchanger performance, LMTD and NTU methods.

Thermodynamics: Zeroth, First and Second laws of thermodynamics; thermodynamic system and processes; Carnot cycle, irreversibility and availability; behaviour of ideal and real gases, properties of pure substances, calculation of work and heat in ideal processes; analysis of thermodynamic cycles related to energy conversion.

Applications: *Power Engineering:* Steam Tables, Rankine, Brayton cycles with regeneration and reheat. *I.C. Engines:* air-standard Otto, Diesel cycles. *Refrigeration and air-conditioning:* Vapour refrigeration cycle, heat pumps, gas refrigeration, Reverse Brayton cycle; moist air: psychrometric chart, basic psychrometric processes. *Turbomachinery:* Pelton-wheel, Francis and Kaplan turbines — impulse and reaction principles, velocity diagrams. Manufacturing and Industrial Engineering

Engineering Materials: Structure and properties of engineering materials, heat treatment, stress-strain diagrams for engineering materials.

Metal Casting: Design of patterns, moulds and cores; solidification and cooling; riser and gating design, design considerations.

Forming: Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy.

Joining: Physics of welding, brazing and soldering; adhesive bonding; design considerations in welding.

Machining and Machine Tool Operations: Mechanics of machining, single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, principles of design of jigs and fixtures

Metrology and Inspection: Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly.

Computer Integrated Manufacturing: Basic concepts of CAD/CAM and their integration tools.

Production Planning and Control: Forecasting models, aggregate production planning, scheduling, materials requirement planning.

Inventory Control: Deterministic and probabilistic models; safety stock inventory control systems. **Operations Research:** Linear programming, simplex and duplex method, transportation, assignment, network flow models, simple queuing models, PERT and CPM.

MATHEMATICS

Real Analysis: Elementary set theory, finite, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, supremum, infimum.

Sequences and series, convergence, limsup, liminf, Sequences and series of functions, uniform convergence, power series, Fourier series Continuity, uniform continuity, differentiability, mean value theorem.

Functions of several variables, directional derivative, partial derivative, derivative as a linear transformation, inverse and implicit function theorems, Maxima and Minima, Riemann Integration, Multiple Integrals; line surface and Volume Integrals, Green's Stokes and Gauss Theorem, Metric Spaces and completeness; Weirstrass Approximation Theorem, compactness, Lebesgue measure and measurable functions.

Functional Analysis: Banach Spaces, Hahn- Banach Spaces extension theorem, open mapping and closed graph theorems, principle of uniform boundedness, Hilbert Spaces, orthonormal bases, Riesz representation theorem, bounded linear operators.

Linear Algebra: Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations.

Algebra of matrices, rank and determinant of matrices, linear equations.

Eigenvalues and eigenvectors, Cayley-Hamilton theorem.

Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms.

Inner product spaces, orthonormal basis.

Quadratic forms, reduction and classification of quadratic forms

Complex Analysis: Algebra of complex numbers, the complex plane, polynomials, power series, transcendental functions such as exponential, trigonometric and hyperbolic functions. Analytic functions, Cauchy-Riemann equations.

Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, Maximum modulus principle, Schwarz lemma, Open mapping theorem, LM inequality

Taylor series, Laurent series, calculus of residues

Conformal mappings, Mobius transformations.

Algebra: Groups, subgroups, normal subgroups, quotient groups, homomorphism, cyclic groups, permutation groups, Cayley's theorem, class equations, Sylow theorems.

Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domain, principal ideal domain, Euclidean domain.

Fields, finite fields, field extensions, Galois Theory.

Ordinary Differential Equations (ODEs): Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs. System of linear Differential equations of first order.

General theory of homogenous and non-homogeneous linear ODEs, Linear ordinary differential equations of higher order with constant coefficients, Linear second order DE with variable coefficients, Method of Laplace transform for solving ODE, variation of parameters, method of undetermined coefficients, series solutions: Legendre's and Bessel's, Sturm-Liouville boundary value problem, Green's function.

Partial Differential Equations (PDEs): Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs. Linear and Quasi Linear first order PDE, method of characteristics, Classification of second order PDEs, General solution of higher order PDEs with constant coefficients, Method of separation of variables for Laplace, Heat and Wave equations.

Numerical Analysis: Numerical solutions of algebraic and transcendental equations, bisection, secant and Newton-Raphson method, fixed point iteration Rate of convergence, Interpolation; error of polynomial interpolation, Lagrange's and Newton Interpolations; Solution of systems of linear algebraic equations using Gauss elimination and Gauss-Seidel methods, Finite differences, Lagrange, Hermite and spline interpolation, Numerical differentiation and integration; Trapezoidal and Simpson's Rule, Gauss Legendre's Quadrature, method of undetermined parameters; least square polynomial approximations, Numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods.

Calculus of Variations: Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema. Variational methods for boundary value problems in ordinary and partial differential equations.

Mechanics: Generalized Coordinates; Lagrange's Equations; Hamiltonian canonical equations; Hamilton's principle and principle of least action; Two dimensional motion of rigid body; Euler's Dynamical Equations for the motion of rigid body about an axis; Theory of small oscillation; Virtual Work and moment of inertia.

Probability & Statistics: Sample space, discrete probability functions and continuous probability functions, independent events, Baye's theorem. Random variables and standard probability distribution functions, and their properties, expectation and moments, conditional expectations. Independent random variables, marginal and conditional distributions. Characteristic functions. Probability inequalities (Tchebyshef, Markov, Jensen). Modes of convergence, weak and strong laws of large numbers, Central Limit theorems (i.i.d. case), Sampling Distributions, Testing of Hypotheses, standard parametric tests based on Normal, Chi-Square, t and F – distributions, Linear regression, Interval estimation.

Mathematical Programming: Linear programming problem(LPP) and its formulations, Convex Sets and their properties, graphical Methods, basic feasible solutions, simplex method, Big-M and two phase method, infeasible and unbounded LPP's, alternate optimal solutions; Dual problem and duality Theorems, Solving LPP using duality and reading dual solutions from simplex table, dual simplex method and its applications in post optimality analysis and sensitivity analysis; different methods for solving transportation problems, balanced and unbalanced transportation problems, and assignment problem.

Non-linear programming, graphical solutions, KT conditions, Lagrange's method of undetermined multipliers, Quadratic Programming.

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PHYSICS

Mathematical Methods of Physics

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

Classical Mechanics

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

Electromagnetic Theory

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

Quantum Mechanics

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

Thermodynamic and Statistical Physics

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

Electronics and Experimental Methods

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices), device structure, device characteristics, frequency dependence and applications. Opto-electronic devices (solar cells, photo-detectors, LEDs). Operational amplifiers and their applications. Digital techniques and applications (registers, counters, comparators and similar circuits). A/D and D/A converters. Microprocessor and microcontroller basics. Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting.

Atomic & Molecular Physics

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

Condensed Matter Physics

Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Josephson junctions. Superfluidity. Defects and dislocations. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasi crystals.

Nuclear and Particle Physics

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi-empirical mass formula, liquid drop model. Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Evidence of shell structure, single-particle shell model, its validity and limitations. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions. Classification of fundamental forces.

Inorganic Chemistry

Chemical periodicity, Structure and bonding in homo- and hetero-nuclear molecules, including shapes of molecules (VSEPR Theory), Concepts of acids and bases, Hard-Soft acid base concept, Non-aqueous solvents, Main group elements and their compounds: Allotropy, synthesis, structure and bonding, industrial importance of the compounds Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties, reaction mechanisms, Inner transition elements: spectral and magnetic properties, redox chemistry, analytical applications, Organometallic compounds: synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis, Cages and metal clusters, Analytical chemistry- separation, spectroscopic, electro- and thermoanalytical methods, Bioinorganic chemistry: photosystems, porphyrins, metalloenzymes, oxygen transport, electron-transfer reactions; nitrogen fixation, metal complexes in medicine, Characterisation of inorganic compounds by IR, Raman, NMR, EPR, Mössbauer, UV-vis, NQR, MS, electron spectroscopy and microscopic techniques, Nuclear chemistry: nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis.

Organic Chemistry

IUPAC nomenclature of organic molecules including regio- and stereoisomers, Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction, Aromaticity: Benzenoid and non-benzenoid compounds – generation and reactions, Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzyne and nitrenes, Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways, Common named reactions and rearrangements – applications in organic synthesis, Organic transformations and reagents:

Functional group interconversion including oxidations and reductions; common catalysts and reagents (organic, inorganic, organometallic and enzymatic). Chemo, regio and stereoselective transformations, Concepts in organic synthesis: Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups, Asymmetric synthesis: Chiral auxiliaries, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Resolution – optical and kinetic, Pericyclic reactions – electrocycloaddition, cycloaddition, sigmatropic rearrangements and other related concerted reactions. Principles and applications of photochemical reactions in organic chemistry, Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S), Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids, Structure determination of organic compounds by IR, UV-Vis, ^1H & ^{13}C NMR and Mass spectroscopic techniques.

Physical Chemistry

Basic principles of quantum mechanics: Postulates; operator algebra; exactly- solvable systems: particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunneling, Approximate methods of quantum mechanics: Variational principle; perturbation theory up to second order in energy; applications, Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle, Chemical bonding in diatomics; elementary concepts of MO and VB theories; Huckel theory for

conjugated π -electron systems, Chemical applications of group theory; symmetry elements; point groups; character tables; selection rules, Molecular spectroscopy: Rotational and vibrational spectra of diatomic molecules; electronic spectra; IR and Raman activities – selection rules; basic principles of magnetic resonance, Chemical thermodynamics: Laws, state and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; elementary description of phase transitions; phase equilibria and phase rule; thermodynamics of ideal and non-ideal gases, and solutions, Statistical thermodynamics: Boltzmann distribution; kinetic theory of gases; partition functions and their relation to thermodynamic quantities – calculations for model systems, Electrochemistry: Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations, Chemical kinetics: Empirical rate laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants; unimolecular reactions; enzyme kinetics; salt effects; homogeneous catalysis; photochemical reactions, Colloids and surfaces: Stability and properties of colloids; isotherms and surface area; heterogeneous catalysis, Solid state: Crystal structures; Bragg's law and applications; band structure of solids, Polymer chemistry: Molar masses; kinetics of polymerization, Data analysis: Mean and standard deviation; absolute and relative errors; linear regression; covariance and correlation coefficient.

Interdisciplinary topics

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

ENGLISH

1. Chaucer to Shakespeare
2. Jacobean to Restoration Periods
3. Augustan Age: 18th Century Literature
4. Romantic Period
5. Victorian Period
6. Modern Period
7. Post Modern Period
8. American and other non-British Literatures
9. Literary Theory and Criticism
10. Rhetoric and Prosody
11. British Literature from Chaucer to the Present day
12. Criticism and Literary Theory