Research Aptitude Test

Syllabus

RESEARCH METHODOLOGY

Research Aptitude: Research: Meaning, characteristics and types; Steps of research; Methods of research; Research Ethics; Paper, article, workshop, seminar, conference and symposium; Thesis writing; its characteristics and format.

Reasoning (Including Mathematical): Number series; letter series; codes; Relationships; classification.

Logical Reasoning: Understanding the structure of arguments; Evaluating and distinguishing deductive and inductive reasoning; Verbal analogies; Word analogy – Applied analogy; Verbal classification.

Reasoning Logical Diagrams: Simple diagrammatic relationship, multi-diagrammatic relationship; Venn diagram; Analytical Reasoning.

Data Interpretation: Sources, acquisition and interpretation of data; Quantitative and qualitative data; Graphical representation and mapping of data.

Communication: Nature, Characteristics and Types; Barriers; Effective classroom communication; Non-verbal communication

ELECTRONICS AND COMMUNICATION ENGINEERING

Network graphs: matrices associated with graphs; incidence, fundamental cut set and fundamental circuit matrices. Energy bands in silicon, intrinsic and extrinsic silicon.

Carrier transport in silicon: diffusion current, drift current, mobility, and resistivity. Generation and recombination of carriers, PN junction diode, Zener diode, tunnel diode, BJT, JFET, MOS capacitor, MOSFET, LED, PIN and avalanche photo diode, Basics of LASERs. Small Signal Equivalent circuits of diodes, BJTs, MOSFETs and analog CMOS. Simple diode circuits, clipping, clamping, rectifier. Biasing and bias stability of transistor; FET amplifiers. Amplifiers: Boolean algebra, minimization of Boolean functions; logic gates; Definitions and properties of Laplace transform continuous-time and discrete-time Fourier series, continuous-time and discrete-time Fourier Transform.

Digital modulation: amplitude, phase and frequency shift keying schemes (ASK, PSK, FSK), TDMA, FDMA and CDMA and GSM.

Plane waves: propagation through various media; reflection and refraction; phase and group velocity; skin depth.

Transmission lines: characteristic impedance; impedance transformation; Smith chart; impedance matching; S parameters, pulse excitation.

Waveguides: modes in rectangular waveguides; boundary conditions; cut-off frequencies; dispersion relations. Basics of propagation in dielectric waveguide and optical fibers.

Basics of Antennas: parameters, array antennas, measurements; frequency band, microwave components, TWT, Gun diode, different types of radar, radar antennas, radar range equation.

COMPUTER SCIENCE AND ENGINEERING/COMPUTER APPLICATION

Programming Fundamentals: Variables, Data Types, Operator & Expression, Data Declaration & Definition, Operator & Expression, C as a Structured Language, Console input and output, Formatted Input/ Output, Control Statement, Nested switch, Iteration Statements for loop, Pointers, Memory Organization, Pointer Arithmetic, Array & String, Complier Vs Interpreters, Arguments & local variables, Storage Class & Scope, Declaration and Initializing Structure, Pre-processor Directive Macro Substitution, File handling, Void Pointer, Bitwise Operator, Graphics In C.

Data Structures: Introduction to Data Structure, Implementation of Data Structure, Array as Data Structure, Polynomial Representation Using Arrays, Sparse Matrices, Drawback of Sequential Storage, Implementation of Linked List, Other Operation & Applications, Generalized Linked List, Operation on Stack, Static & Dynamic Implementation of a Stack, Operation on a Queue, Static & Dynamic Implementation of Queue, Tree Terminology, Binary Search Tree Traversal.

Database Management System: Database and Need for DBMS, Views of data-schemas and instances, Database Design using ER model, Relational Model, Relational Database design, Storage and File Structure, Transaction and Concurrency control, Crash Recovery and Backup, Security and privacy.

Algorithms: Divide and Conquer, Greedy Method, Dynamic Programming, Backtracking, Branch and Bound.

Computer Networks: Introduction to Networking, Common Network Architecture, The OSI Reference Model, Local Area Networks, Broad Band Networks, IP Addressing & Routing, Domain Network Services, Network Applications, SNMP, Network Security.

Operating Systems: Operating system functions and characteristics, Real time systems, Methodologies for implementation of O/S service system, Functions of the system, File access and allocation methods, Structured Organizations, Storage allocation methods, Virtual memory concepts, Hardware Management, Deadlock detection and recovery.

MANAGEMENT

General Management: Concept of Management, Evolution of Management, Functions & Principles of Management.

Managerial Communication: Introduction, Types, Medium, Barriers and Techniques. **Organizational Behavior:** Concepts and Significance of OB, Understanding and Managing Behavior - Personality, Perception, Values, Attitudes, Learning and Motivation, Leadership, Managing Conflicts, Organizational Development.

Economics: Introduction, Demand & Supply, Monetary Policy, Fiscal Policy, Union Budget, Current Affairs.

Human Resources Management: Concepts, Human Resource Planning, Recruitment and Selection, Job Analysis, Performance Appraisal, Career Planning, Methods of Training and Development, Dispute Resolution and Grievance Management, Labour Welfare and Social Security Measures.

Financial Management: Concept, Functions, Financial Instruments, Capital Structure & its Theories, Cost of Capital, Capital Budgeting, Working Capital Management.

Marketing Management: Concepts, Nature and Scope, Marketing Mix – Product, Price, Place and Promotion, Role and Relevance of segmentation, Targeting and Positioning, Product Life Cycle, Branding and Packaging, Retailing, Consumer Behavior, Marketing of Services.

Information Technology Management: Concept and Meaning of Technology and Technology Management- Technology; Role and Significance of Technology Management, Impact of Technology on Society and Business- Technology and competition; Forms of Technology- Process technology; Product technology

MATHEMATICS

Calculus: Partial derivatives, total derivative, maxima and minima for multi variable functions Multiple integrals, area and volume; Vector Calculus and Vector theorems

Algebra & Analysis: Countability, Archimedean property, supremum, infimum. Sequences and series, Continuity, differentiability, Riemann sums and Riemann integral, Improper Integrals. Metric spaces, connectedness, compactness, completeness; uniform convergence, contraction mapping principle. Counting techniques, Group Theory, homomorphism, auto-morphisms; cyclic groups, permutation group, Rings, ideals, domains and fields, Vector spaces, linear transformations, Matrices and Algebra of Matrices, systems of linear equations, eigenvalues and eigenvectors, Cayley-Hamilton Theorem, Inner product spaces, Gram-Schmidt orthonormalization process, Jordan canonical form; bilinear and quadratic forms. Analytic functions, Cauchy-Riemann equations, Complex integration: Cauchy's integral theorem Contour integral, Cauchy's integral formula, Power series and expansions, calculus of residues. Conformal mappings, Mobius transformations.

Differential equations: existence and uniqueness for initial and boundary value problems, linear ordinary differential equations of higher order with constant coefficients and variable constant, series solutions (power series, Frobenius method),special functions: Legendre, Bessel, hypergeometric, hermite and laguerre functions and their orthogonal properties; Systems of ordinary differential equations, partial differential equations of first and higher order Laplace, Heat and Wave equations, Integral transform techniques

Numerical Analysis: Solution of transcendental and algebraic equation, system of equation, Interpolation and extrapolation, Numerical differentiation and integration, Numerical solution of initial value problems for ordinary differential equations

Linear Programming: Linear programming models, optimal solution, simplex theory, simplex method, unbounded solution and multiple solution, revised simplex method, Duality, transportation and assignments problems, network analysis using PERT and CPM, Queuing theory

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.

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 pseudo forces. Variational principle. Generalized 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. Magneto statics: 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.

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. 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.

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). Digital techniques and applications (registers, counters, comparators and similar circuits). A/D and D/A converters.

Atomic & Molecular Physics
Quantum states of an electron in an atom. Electron spin. 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. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Lasers: spontaneous and stimulated emission, Einstein A & B coefficients.

Condensed Matter Physics
Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. 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.

Nuclear and Particle Physics
Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi empirical mass formula, liquid drop model. Deuteron problem. Evidence of shell structure, single-particle shell model, its validity and limitations. Rotational spectra. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P, and T invariance.

CHEMISTRY

Physical Chemistry:
Quantum chemistry, thermodynamics, chemical kinetics, statistical thermodynamics, electrochemistry, spectroscopy (rotational, vibrational, UV-visible, NMR), surface chemistry, and group theory applications in chemical systems.

Inorganic Chemistry:
Atomic structure, periodic properties, chemical bonding, and coordination chemistry, including theories like crystal field and ligand field, reaction mechanisms involving coordination complexes. Solid-state chemistry, symmetry and point groups, concepts of acids and bases, recent trends in materials chemistry and nuclear chemistry

Bioinorganic chemistry:
Photosystems, porphyrins, metalloenzymes, oxygen transport, electron- transfer reactions; nitrogen fixation, metal complexes in medicine.

Organometallic Chemistry: Organometallic compounds: synthesis, bonding and structure, and reactivity, Organometallics in homogeneous catalysis, Cages and metal clusters compounds.

Organic Chemistry: Reaction mechanisms, reactive intermediates (carbenes, nitrenes, radicals), stereochemistry, and pericyclic reactions. Name reactions, reagents, and organic synthesis strategies. Spectroscopic techniques for structure determination (NMR, IR, MS, UV), along with concepts from photochemistry and supramolecular chemistry. Biomolecules (carbohydrates, proteins, nucleic acids), green chemistry, and polymers, tying in real-world and research applications.

Molecular spectroscopy: Rotational and vibrational spectra of diatomic molecules; electronic spectra; IR and Raman activities – selection rules; basic principles of magnetic resonance.

MECHANICAL ENGINEERING

Production Techniques:
Metal casting, Metal forming, powder metallurgy, plastic forming and molding, Metal joining, Metrology, metal cutting theory, machining processes, welding processes and Nonconventional manufacturing processes

Materials Science and Engineering:
Introduction, Structure of Materials (Metal and Ceramics), Dislocations, heat treatment of steel and strengthening Mechanisms of Metals, Phase diagrams, Iron-carbide phase diagram, Phase transformation in Metals, Mechanical and thermal properties of Metals, Polymers (Structure, processes and properties) and introduction to non-destructive testing.

Production Planning and Control:
Forecasting and product planning, Process planning, job design and work measurements, Facilities location and layout, Capacity planning, aggregate planning and scheduling, Inventory and quality control.

Design of Machine Elements:
Criteria for static failure and fatigue failure, design of screws and bolted joints, design of welded joints and riveted joints, Mechanical springs, Design of rolling element bearings, journal bearings and hydrodynamic lubrication, Design of gears, clutches, brakes, couplings, flat and V-belt drives, Computer-aided design, and geometric modeling of mechanical parts.

Kinematics & Dynamics of Machines and Vibrations:
Basics of mechanisms, inversions, Velocity and acceleration analysis, Instantaneous centres, transmission angle, Principle of virtual work, D'Alembert's principle, Kinetic Modeling, kinetics of mechanism (Four-bar mechanisms) and synthesis of cam – follower motion, Flywheels, governors, gyroscope and balancing, Free and forced vibration, Multi-degree of freedom (two dof) free and forced vibrations, mode shapes, approximate methods of solutions.

Mechanics of Solids:
Fundamental principle of mechanics, Introduction to mechanics of deformable bodies, slender members, energy Methods, Stress and strain: stress-strain-temperature relations, Symmetric and asymmetric bending, torsion, Curved beams and thick shells, Buckling.

Thermodynamics:
Properties of pure substance, First law of thermodynamics, Second law of thermodynamics, Entropy, Irreversibility, energy and thermodynamic relations.

Applied Thermodynamics:
Air standard cycles, gas power cycles, I.C. engines, Vapour compression and absorption cycle, Psychometrics and air conditioning, Vapour power cycles, boilers, its mountings and accessories, steam turbines, gas turbines, compressors.

Fluid Mechanics and Machines:
Fluid statics, Conservation laws, Viscous and inviscid flow analysis, Dimensional analysis, Analysis of fluid machines.

Heat Transfer:
Conduction: steady state and unsteady state heat conduction, Convection: analytical and empirical relations for forced and free convection heat transfer, condensation and boiling, Radiation heat transfer: basic laws, shape factor, radiation heat exchange between surfaces, Heat exchanger: analysis and design, Mass transfer: diffusion and convective mass transfer.

LAW

Constitutional and Administrative Law: Essential Features of Indian Constitution; Schedules, Parts of Constitution, Preamble; Fundamental Rights, Fundamental Duties and Directive Principles of State Policy; Organs of State-Parliament and State Legislatures, Executive-President and Vice President, Governor; and Judiciary-Supreme Court and High courts; Amending Process of the Constitution; Emergency provisions; Article 370, Principles of Natural Justice, Rule of law; Delegated legislation; Separation of powers, Writs.

Jurisprudence: Nature and Scope of Jurisprudence; Sources of Law-Legislation, Custom and Judicial Precedent; Doctrine of Precedent-Ratio *decidendi* and Obiter dicta; Analytical School; Natural Law School; Historical School; Sociological School; Theories of Punishment; Legal Concepts-Right, Duty, Ownership, Possession and Person; Law and Morality; Hart and Fuller controversy.

Law of Torts and Consumer Protection Law:
Nature and Definition of Torts; Foundation of Tortious Liability; General Defenses to an Action of Torts; Vicarious, Absolute and Strict Liability; Contributory Negligence; Damages; Specific Torts – Negligence, Nuisance, Trespass and Defamation; The Consumer Protection Act, 2019 – Definitions, Consumer rights and Redressal mechanism.

Commercial Laws: Essential elements of Contract and E-contract; Breach of Contract, Frustration of contract, Void and Voidable agreements; Specific Contracts-Bailment, Pledge, Indemnity, Guarantee and Agency; Partnership and limited liability Partnership; Company Law-Incorporation of a Company, Prospectus, Shares and Debentures; Directors and meetings; Corporate Social Responsibility.

Law of Crimes: General Principles of Criminal Law-Meaning, Nature, Essentials and Stages of offence/crimes; Common Intention, Common object; General Exceptions; Criminal Attempt; Conspiracy and Abetment; Offences against Women-Rape, Sexual harassment, cruelty by husband, acid attack, stalking, voyeurism, sexual abuses, Trafficking; Offences against Human Body; Offences against Property; Defamation, death penalty.