TEERTHANKER MAHAVEER UNIVERSITY

(Established under Govt. of U. P. Act No. 30, 2008)
Delhi Road, Moradabad (U.P.)

SYLLABUS FOR RESEARCH APTITUDE TEST IN ELECTRICAL NGINEERING

The syllabus for Research Aptitude Test (RAT) in Electrical Engineering is divided in two parts viz. Part A and Part B as described below:

PART – A

Part A of the RAT shall be designed to assess the research skills/aptitude of the candidate consisting of questions from the following areas:

1. **Research Methodology:** meaning, characteristics, and ethical issues in research; types of research; research methods.

2. **Logical Reasoning:** arguments, deductive and inductive research; logical and Venn diagram; inferences; analogies.

3. **Data Interpretation:** interpretation of data; mapping and analysis of data, tools for data analysis; quantitative and qualitative research.

4. **General Awareness about Basic Science:** basic science up to the level of SSC.

5. **Mathematical Reasoning:** number series, letter series, codes; relationships, classification.

PART – B

Part-B of RAT is designed to assess the subject specific knowledge of the candidate covering the syllabus given as below:

Electric Circuits: circuits elements, network graph, Kirchhoff's laws, mesh and nodal analysis, network theorems and applications, natural response and forced response, transient response and steady state response for arbitrary inputs, resonance, basic filter concepts; ideal current and voltage sources properties of networks in terms of poles and zeros, transfer function, resonant circuits, three phase circuits, two-port networks, elements of two-element network synthesis, three phase circuits.

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; Fourier, Laplace and Z transforms.

Electrical Machines: magnetic circuits, analysis and design of power transformers - equivalent circuit, Phasor diagram, tests, regulation and efficiency; three phase transformers -connections, parallel operation; auto-transformer; conversion principles; dc machines - types, windings, generator characteristics, armature reaction and commutation, starting and speed control of motors; three phase induction motors - principles, types, performance characteristics, starting and speed control; single phase induction motors;

synchronous machines - performance, regulation and parallel operation of generators, motor starting, characteristics and applications; fractional KW motors, servo and stepper motors.

Power Systems: basic power generation concepts- types of power stations, hydro, thermal and nuclear stations. pumped storage plants economics and operating factors; transmission line models and performance; voltage control. load flow studies. optimal power system operation, load frequency control, cable performance, insulation; corona and radio interference; distribution systems; per-unit quantities; bus impedance and admittance matrices; load flow; voltage control; power factor correction; economic operation; symmetrical components; fault analysis; principles of over-current, differential and distance protection; solid state relays and digital protection; circuit breakers; system stability concepts, swing curves and equal area criterion; HVDC transmission and FACTS concepts.

Control Systems: principles of feedback; transfer function; block diagrams; steady-state errors; Routh and Niquist techniques; bode plots; root loci; lag, lead and lead-lag compensation; state space model; state transition matrix, controllability and observability, stability of sampled data system, elements of non-linear control analysis, control system components, electromechanical, hydraulic, pneumatic components.

Electrical and Electronic Measurements: bridges and potentiometers; PMMC, moving iron, dynamometer and induction type instruments; measurement of voltage, current, power, energy and power factor; instrument transformers; digital voltmeters and multimeters; phase, time and frequency measurement; Q-meters; oscilloscopes; potentiometric recorders; error analysis, transducers and their applications to the measurement of non-electrical quantities like temperature, pressure, flow-rate displacement, acceleration and noise level etc, data acquisition systems, A/D and D/A converters.

Analog and Digital Electronics: characteristics of diodes, BJT, FET, Zener, tunnel, Schottky, photo diodes and their applications, rectifier circuits; 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; Schmitt trigger; multi-vibrators; sample and hold circuits; A/D and D/A converters; 8-bit microprocessor basics, architecture, programming and interfacing.

Power Electronics and Drives: semiconductor power diodes, transistors, thyristors, triacs, GTOs, MOSFETs and IGBTs - static characteristics and principles of operation; triggering circuits; phase control rectifiers; bridge converters - fully controlled and half controlled; principles of choppers and inverters; basis concepts of adjustable speed dc and ac drives, pulse width modulation, sinusoidal modulation with uniform sampling, switched mode power supplies.

EM Theory: electric and magnetic fields, electric field and potential due to point, line, plane and spherical charge distributions, Gauss's Law, Amperes Law and Biot-Savart's laws, fields in dielectrics, conductors and magnetic materials, Maxwell's equations, time varying fields, Plane-Wave propagating in dielectric and conducting media, transmission lines.

TEERTHANKER MAHAVEER UNIVERSITY

(Established under Govt. of U. P. Act No. 30, 2008)
Delhi Road, Moradabad (U.P.)

SYLLABUS FOR RESEARCH APTITUDE TEST IN ELECTRONICS & COMMUNICATION ENGINEERING

The syllabus for Research Aptitude Test (RAT) in Electronic & Communication is divided in two parts viz. Part A & Part B described below:

PART – A

Part A of the RAT shall be designed to assess the research skills/aptitude of the candidate consisting of questions from the following areas:

1. **Research Methodology:** meaning, characteristics, and ethical issues in research; types of research; research methods

2. **Logical Reasoning:** arguments, deductive and inductive research; logical and Venn diagram; inferences; analogies.

3. **Data Interpretation:** interpretation of data; mapping and analysis of data, tools for data analysis; quantitative and qualitative research.

4. **General Awareness about Basic Science:** basic science up to the level of SSC.

5. **Mathematical Reasoning:** number series, letter series, codes; relationships, classification.

PART – B

Part-B of RAT is designed to assess subject specific knowledge of the candidate covering the syllabus given as below:

1. **Basic circuit theory:** Network graphs, nodal and mesh analysis, Network theorems, Linear constant coefficient differential equations, Solution of network equations using Laplace transform: frequency domain analysis of RLC circuits, 2port network Parameters, State equations for networks.

2. **Analog Circuits:** Simple diode circuits, clipping, clamping, rectifier, Amplifiers, Frequency response of amplifiers, Filters, oscillators, Function generators and wave Shaping circuits, 555 Timers.

3. **Digital circuits:** Boolean algebra, logic gates, digital IC families, Combinational Circuits, Sequential circuits, Sample and hold circuits, ADCs, DACs, Semiconductor Memories.

4. **Communications:** Probability theory & Statistics Random signals and noise, Analog Communication systems: amplitude and angle modulation and demodulation systems, Super heterodyne receivers; SNR calculations for amplitude modulation (AM) and

Frequency modulation (FM), Sampling theorem, Digital communication systems: PCM, DPCM, digital modulation schemes, TDMA, FDMA and CDMA and GSM, Optical fibre Communication.

5. **Signals and Systems:** Laplace transform, continuous time and discrete time Fourier series, continuous time and discrete time Fourier Transform, DFT and FFT, Z-transform, LTI Systems, Signal transmission through LTI systems, Convolution, FIR and IIR Filters, Open loop and closed loop systems, first order, second order, higher order Systems.

6. **Computer Networks**: ISO/OSI stack, LAN technologies (Ethernet, Token ring, etc), Flow and error control techniques, Routing algorithms, Congestion control, TCP/UDP And sockets, IP (v4), Application layer protocols (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.

7. **Microprocessor and Computer Organization:** Microprocessor (8085): architecture, Programming, memory and I/O interfacing, Machine instructions and addressing modes, ALU and data path, CPU control design, Memory interface, I/O interface, Instruction Pipelining, Cache and main memory, Secondary storage, Microcontrollers.

8. **Digital Signal Processing**: Multirate filters, Trans-multiplexers, Wavelets, DSP applications – equalization, beam forming, echo cancellation, filter banks.

TEERTHANKER MAHAVEER UNIVERSITY

(Established under Govt. of U. P. Act No. 30, 2008)
Delhi Road, Moradabad (U.P.)

SYLLABUS FOR RESEARCH APTITUDE TEST IN CIVIL ENGINEERING

The syllabus for Research Aptitude Test (RAT) in Civil is divided in two parts viz. Part A & Part B described below:

PART – A

Part A of the RAT shall be designed to assess the research skills/aptitude of the candidate consisting of questions from the following areas:

1. **Research Methodology:** meaning, characteristics, and ethical issues in research; types of research; research methods

2. **Logical Reasoning:** arguments, deductive and inductive research; logical and Venn diagram; inferences; analogies.

3. **Data Interpretation:** interpretation of data; mapping and analysis of data, tools for data analysis; quantitative and qualitative research.

4. **General Awareness about Basic Science:** basic science up to the level of SSC.

5. **Mathematical Reasoning:** number series, letter series, codes; relationships, classification.

PART – B

Part-B of RAT is designed to assess subject specific knowledge of the candidate covering the syllabus given as below:

Concrete Technology: Constituent materials and their properties, types of cement& their properties, different type of tests on cement. fresh concrete, workability; strength, elasticity and fracture of hardened concrete: Time dependent properties of concrete, durability of concrete; Concrete admixtures, mix design methods; Manufacture and processes Codal provisions Special concretes.

Fluid Mechanics: Bernoulli's theorem, applications of energy and momentum equations. Impact of jet on fixed and moving plates and vanes, resistance to flow, elementary concept of viscous shear. Laminar and turbulent flow through pipes and velocity distributions. Elements of Boundary layer theory, drag and lift, elements of aero-foil theory. Dimensional analysis parameters of flow and their significance, Hydraulic similitude and scale models .Flow measurements by pitot tube, venturimeter, orifice meter. Flow through orifices, mouthpieces, notches and weirs. Hydraulic turbines: types, selection, impulse and reaction turbines, governing of turbines, turbine characteristics. Pumps: Centrifugal pumps, Characteristics, Introduction of Modern Pumping machinery, Reciprocating Pumps, Cavitations in turbine and pumps.

Environmental Engineering: Ecology, Environment and Human Health - their linkages Sources of water surface, ground and others. Ground water engineering Basic aquifer parameters and hydraulics, well system, ground water pollution and control. Water quality parameters: Their role and standards. Water demand for various purposes; Estimation of population growth. Basic hydraulics (including pumping) related to water supply & wastewater collection, pipe network design. Sewerage system Types of collection & disposal system, design approach to sanitary and storm sewers, sewer appurtenances, street inlets, inverted siphon. House plumbing for water supply & wastewater drainage. Different sources of pollution Important cases for atmospheric, hydrosphere and land pollution and related control strategies. Water-borne, air-borne and vector-borne common diseases – Transmission modes and control measures. Excreta disposal in unsewered areas- various options and their selection. Noise pollution and engineering approaches for its abatement.

Engineering Geology & Rock Mechanics: Scope of Engineering Geology in construction Jobs & water resources development, geology in regional & town planning, Engineering Considerations of structural features (folds, faults & joints) of rocks in mega projects like construction of dams, tunnels ,bridges & reservoirs, Engg. Properties of rocks as material for construction & sites for construction, Groundwater potential & its exploration, Natural disasters (earthquakes, mass movement) & their engineering considerations, Geophysical investigations, site improvement techniques used in rocks.

Structural Design: Materials for reinforced concrete. Concrete mix design. Limit state & working stress concepts for under reinforced balanced and over reinforced sections, rectangular, T-beam and design of singly and doubly reinforced & L beams. One way and two way slabs. Columns, isolated and combined footings, retaining walls, stair cases. Short term and long deflections, estimation of probable maximum crack width.

Advanced structural Design & Analysis: Analysis and design of building frames subjected to wind load; Earthquake forces and structural response. Ductile detailing of RCC frames. Design of beam-column joints ; Design of deep beam. Design of shear walls. finite element method, Methods of structural analysis; flexibility and stiffness matrices; analysis of trusses, beams and frames.

Steel design: Structural Steel & their properties. Riveted, bolted and welded connections. Tension, compression and flexural members. Roof trusses, plate girders, gantry girders & industrial buildings. Column bases & Grillage foundations

Structural Mechanics: Slope and deflection of beams by integration, area, moment and conjugate beam methods. Thin and thick cylinders. Theories of elastic failures. Close coiled, open coiled and leaf springs Basic concepts, Analysis of statically determinate structures: trusses, frames, three hinged arches, cables and suspension bridges. Moving loads on beams and trusses –influence line. Strain energy due to axial, bending, shear and torsional loads, Castigliano's theorem. Deflection of beams and frames, Buckling of columns, critical loads, axially and eccentrically loaded columns, initially curved columns, various theories. Analysis of beam columns. Shear center and unsymmetrical bending.

Geotechnical Engineering: Introduction to geotechnical problems in civil engineering; Soil types and formation Simple soil properties, Grain size distribution, Atterberg limits; Soil identification and classification; Total, effective and neutral stresses; Darcy's law; Permeability and capillarity of soil, Seepage, Flow nets, Piping, Stress distribution in soils; Laboratory compaction and field compaction One-dimensional consolidation and simple settlement analysis Shear strength Determination of total and effective strength parameters; Earth pressure : classical theories, graphical methods stability of slopes. Foundation requirements and selection; Different

methods for determining bearing capacity of shallow foundations; Settlement considerations, Allowable, total and differential settlements, Settlement of structures; Eccentrically loaded footings, Methods of proportioning; Raft foundations; Pile foundations, types of Piles; Allowable load of piles, Pile driving, Pile load test, Dynamic formulae, Group action; Well and caisson foundations, Design principles; Bearing capacity analysis and methods of construction; Excavation and bracings.

Pre-stressed Concrete Design: Materials, pre-stressing systems, losses in pre-stress. Analysis and design of simple and continuous beams by working stress and limit-state methods. Deflection and cracking consideration. Anchorage and bond. End block stresses.

Advanced Foundation Engineering: Bearing capacity: Shallow and deep foundations; Settlement analysis: Shallow and deep foundations; Different types of foundations and their designs: Raft, Piles, and Well foundation; Sheet pile walls: Cantilevered and anchored; Excavation and bracings; Design of retaining walls. Foundations subjected to dynamic loads; Design of machine foundations. Shallow foundations: All types of footings and raft subjected to axial, eccentric and lateral loads; Pile foundations: Types, design and placement; Well foundations Types, design and methods of construction; Retaining Structures

Water Resources Engineering: Hydrologic-cycle, Meteorological aspects of hydrology. Rain-fall, types, measurement, average depth over a basin, depth duration curves. Water losses; Interception, evaporation, transpiration. Runoff, factors affecting. runoff. Stream flow measurement and hydrograph representation, estimation of runoff from rain fall by empirical formulae, rational & infiltration method, unit hydrograph method and Scurve method. Urban runoff: Hydrological models. Construction and use of mass and flow duration curves, Floods, Hydrologic Routing, reservoir routing, channel routing-analytical and graphical methods. Elements of Sediment transportation. River engineering - Stages of river, meanders, river training. Land erosion and control. Ground water: Aquifers, ground water availability and yield. Groundwater withdrawals, infiltration wells and galleries, artesian, open and tubewells. Remote sensing applications in hydrology.

Construction Economics and Management: Engineering Economics :Cash flow diagram, Tune value of money, Inflation, Interest, Depreciation, Present worth and capitalized cost, Equivalent uniform annual cost and rate of return evaluations, Benefit cost analysis, Analysis of variable costs, Types of capital financing, Valuation. Tendering and Contract: Organizational structure, Methods of tendering, Specifications, Conditions of contract, Contract law, Disputes and Arbitrations. Construction Planning and Management; Time, Cost and research management of projects for planning, Scheduling, Control and forecasting using networks with CPM/PERT. Personnel, Material and Finance Management, Safety Engineering Construction Equipments.

TEERTHANKER MAHAVEER UNIVERSITY

(Established under Govt. of U. P. Act No. 30, 2008)
Delhi Road, Moradabad (U.P.)

SYLLABUS FOR RESEARCH APTITUDE TEST IN COMPUTER SCIENCE & ENGINEERING

The syllabus for Research Aptitude Test (RAT) in Computer Science is divided in two parts viz. Part A & Part B described below:

PART – A

Part A of the RAT shall be designed to assess the research skills/aptitude of the candidate consisting of questions from the following areas:

1. **Research Methodology:** meaning, characteristics, and ethical issues in research; types of research; research methods

2. **Logical Reasoning:** arguments, deductive and inductive research; logical and Venn diagram; inferences; analogies.

3. **Data Interpretation:** interpretation of data; mapping and analysis of data, tools for data analysis; quantitative and qualitative research.

4. **General Awareness about Basic Science:** basic science up to the level of SSC.

5. **Mathematical Reasoning:** number series, letter series, codes; relationships, classification.

PART – B

Part-B of RAT is designed to assess subject specific knowledge of the candidate covering the syllabus given as below:

Algorithm Design and Analysis
Elementary Data Structures, Greedy Method: Knapsack Problem, Job Sequencing with Deadlines, Optimal Merge Patterns; Dynamic Programming, Optimal Binary Search Trees, 0/1 Knapsack, Reliability Design, Traveling Salesperson Problem; Backtracking: 8 – Queens Problem, Sum of Subsets, Hamiltonian Cycles, Knapsack Problem; Basic Search and Traversal Techniques, Non- Deterministic Algorithm: Non-Deterministic Programming Constructs; NP-Hard and NP-Complete Problems.

Advanced Networking
Circuit Switching Networks : AT & T's Dynamic Routing Network, Routing in Telephone Network, Dynamic Non Hierarchical Routing, Trunk Status Map Routing, Real Time Network Routing, Dynamic Alternative Routing, Distributed Adaptive Dynamic Routing, Optimized Dynamic Routing; Packet Switching Networks: Distance Vector Routing-Link State Routing-Inter Domain Routing, Classless Inter- domain Routing, Interior Gateway Routing Protocols, Routing Information Protocol, High Speed Networks.

Theory of Computer Science

Introduction to Languages; Recursive Definitions; Regular Expressions; Finite Automata; Kleen'S Theorem; Non- Deterministic Finite Automata; Finite Automata with Output; Regular Languages; Pumping Lemma for Regular Languages; Non-Regular Languages; Context-Free Grammars; Regular Grammars; Chomsky's Normal Form: Adding a Pushdown Stack to FA, Push Down Automata; Context Free Languages (CFLs), Pumping Lemma for CFLs, Turing and Post Machines; Recursively Enumerable Languages; Context- Sensitive Grammar.

Software Engineering

Software Life Cycle Models, Software Project Planning, Software Risk Management; Software Design: Design Definition, Modularity, Strategy of Design, Function Oriented Deign, IEEE Recommended Practice for Software Design Description, Object Oriented Design; Software Metrics: Software Metrics, Token Count, Software Reliability, Software Reliability Models, Capability Maturity Model; Software Testing, Testing Tools; Software Maintenance, Reverse Engineering, Software Re-engineering, Configuration Management.

Parallel and Distributed Computing

Introduction: Computational Demands of Modern Science, Advent of Practical Parallel Processing; PRAM Algorithms, Mapping and Scheduling, Parallel Algorithms, Graph Algorithms,. Introduction To Distributed Network Systems: LAN, WAN, NOS, DOS, Distributed File Servers, Distributed Real Time Systems, Cient- server Computing; Procedure Call Mechanism and Message Passing.

Soft Computing

Fundamentals of ANN, ANN Terminologies, Models of ANN, Self Organizing Feature Maps. Fuzzy System, Fuzzy Composition, Fuzzy Rules: Takagi and Mamdani – Fuzzy Inference Systems: Fuzzification, Inference, Rulebase, Defuzzification. Genetic Algorithm (GA): Biological Terminology, Elements of GA: Encoding, Selection, Crossover, Mutation, Reinsertion, Theoretical Foundation: Schema, Fundamental Theorem of GA, Building Block Hypothesis.

Current Trends and Technologies

Mobile Computing : Mobile Connectivity, Cells, Framework, Wireless Delivery Technology and Switching Methods, Mobile Information Access Devices, Mobile Data Internetworking Standards, Mobile Computing Applications; Mobile Databases – Protocols, Scope, Tools and Technology. Security and Cryptography: Introduction to Security, Security Attacks, Services and Mechanisms, Data Encryption Standard, Advanced Encryption Standard, Public– key Cryptography and RSA, Message Authentication and Hash Functions, Hash and MAC Algorithms, Digital Signatures and Authentication Protocols; Network Security : Authentication Applications, Electronic Mail Security, IP Security, Web Security, Intruders, Malicious Software, Firewalls.

TEERTHANKER MAHAVEER UNIVERSITY

(Established under Govt. of U. P. Act No. 30, 2008)
Delhi Road, Moradabad (U.P.)

SYLLABUS FOR RESEARCH APTITUDE TEST IN MECHANICAL ENGINEERING

The syllabus for Research Aptitude Test (RAT) in Mechanical is divided in two parts viz. Part A & Part B described below:

PART – A

Part A of the RAT shall be designed to assess the research skills/aptitude of the candidate consisting of questions from the following areas:

1. **Research Methodology:** meaning, characteristics, and ethical issues in research; types of research; research methods

2. **Logical Reasoning:** arguments, deductive and inductive research; logical and Venn diagram; inferences; analogies.

3. **Data Interpretation:** interpretation of data; mapping and analysis of data, tools for data analysis; quantitative and qualitative research.

4. **General Awareness about Basic Science:** basic science up to the level of SSC.

5. **Mathematical Reasoning:** number series, letter series, codes; relationships, classification.

PART – B

Part-B of RAT is designed to assess subject specific knowledge of the candidate covering the syllabus given as below:

Mechanical Engineering Design: Load analysis; modes of failure; theories of failure; safety factors; reliability; selection of materials; design of machine elements subjected to static and fatigue loading; shafts; gears; bearings, etc.; design against creep and fracture.

Mechanisms: Kinematic and dynamic analysis & synthesis of planar and spatial mechanisms; Euler-Savary equation; cubic of stationary curvature; numerical methods in kinematics and dynamics.

Vibrations: Free, damped and forced vibrations of single degree, multi degree and continuous mechanical systems; vibration measuring instruments; vibration isolation; numerical methods; transient and non-linear vibrations.

Production Engineering: Mechanical Behavior of metals, Advanced casting processes, Advanced finishing processes Theories of fracture creep and fatigue, Smart Materials, Advanced manufacturing processes Unconventional Machining Processes, Fundamentals of automated production, Flexibility, Computer controlled machines, Computer aided process planning, Computer Integrated Manufacturing, Flexible Manufacturing Systems.

Industrial Engineering: Statistical Process Control, Total Quality Management, Enterprise Resource Planning, Supply Chain Management, Inventory Control, MRP. Business Process Redesign, Value Engineering, Materials Handling, Environmental issues and Green Practices, Technology Management, Reliability, Experimental Design, Statistical tools and application. Project Management, Dynamic Programming and Non Linear programming, Game Theory, Decision tree, Monte Carlo simulation, Ergonomics.

Thermodynamics: Laws of thermodynamics, Entropy, Irreversibility and Availability, Behaviour of ideal and real gases, Calculation of work and heat in ideal processes. Analysis of thermodynamics cycles related to energy conversion.

Fluid Mechanics: Fluid Mechanics: Fluid properties; Control-volume analysis of mass, momentum and energy; Equations of continuity ,momentum and energy, Bernoulli's equation, Boundary layer theory; Flow through pipes, Laminar and Turbulent Flow and Compressible flow.

Heat Transfer: Modes of heat transfer, Resistance concept, unsteady heat conduction, Fins, Effect of turbulence, Radiative heat transfer, black and grey sufaces shape factors, network analysis, Heat exchangers.

I.C. Engines: Requirements and suitability of fuels in IC engines, Normal and abnormal combustion in SI and CI engines, Engine performance calculations, Turbocharging, Supercharging, Pollutant formation and control methods, Emission norms, Stratified charge engines, Homogenous charge compression ignition (HCCI) engines, Zero emission vehicles.
Refrigeration and air-conditioning: Refrigeration system, expansion devices, condensers and evaporators, Psychrometric chart, Vapor Absorption system, Humidefication, Dehumedification, Adiabatic mixing, Multistage multi evaporation system, Three fluid absorption system, Solar refrigeration system.

Energy Conversion System: Basic cycles related to energy conversion systems, Combined cycle, Cogeneration system, Steam generator, Steam turbine, Gas turbines, Nuclear power plant, Hydroelectric plant.

Gas Dynamics: Basic equations of fluid flow, Wave propagation, Shock waves, Expansion waves, Rayleigh line, Fanno line, Rarefied Gas Dynamics, Measurement in compressible flow.

TEERTHANKER MAHAVEER UNIVERSITY

(Established under Govt. of U. P. Act No. 30, 2008)
Delhi Road, Moradabad (U.P.)

SYLLABUS FOR RESEARCH APTITUDE TEST IN MATHEMATICS

The syllabus for Research Aptitude Test (RAT) in Mathematics is divided in two parts viz. Part A & Part B described below:

PART – A

Part A of the RAT shall be designed to assess the research skills/aptitude of the candidate consisting of questions from the following areas:

1. **Research Methodology:** meaning, characteristics, and ethical issues in research; types of research; research methods

2. **Logical Reasoning:** arguments, deductive and inductive research; logical and Venn diagram; inferences; analogies.

3. **Data Interpretation:** interpretation of data; mapping and analysis of data, tools for data analysis; quantitative and qualitative research.

4. **General Awareness about Basic Science:** basic science up to the level of SSC.

5. **Mathematical Reasoning:** number series, letter series, codes; relationships, classification.

PART – B

Part-B of RAT is designed to assess subject specific knowledge of the candidate covering syllabus given as below:

Complex Analysis: Analytic functions, conformal mappings, bilinear transformations; complex integration: Cauchy's integral theorem and formula; Liouville's theorem, maximum modulus principle; Taylor and Laurent's series; Residue theorem and applications for evaluating real integrals.

Ordinary Differential Equations: First order ordinary differential equations, Existence and Uniqueness theorems, systems of linear first order ordinary differential equations, Linear ordinary differential equations of higher order with constant coefficients; Linear second order ordinary differential equations with variable coefficients; method of Laplace transforms for solving Ordinary differential equations, series solutions; Legendre and Bessel functions and their orthogonality.

Algebra: Normal Subgroups and homomorphism theorems, automorphisms; Group actions, Sylow's theorem and their applications; Euclidean domains, Principle ideal domains and unique factorization domains. Prime ideals and maximal ideals in commutative rings; Fields, Finite fields.

Numerical Analysis; Numerical solution of algebraic and transcendental equations: bisection, secant method , Newton-Raphson method, Fixed point iteration; interpolation; error of polynomials interpolation, Lagrange, Newton interpolations; Numerical differentiation; Numerical integration: Trapezoidal and Simpson rules, Gauss Legendre quadrature, method of undetermined parameters; least square polynomials approximation; Numerical solution of systems of linear equations: direct methods(Gauss elimination, LU decomposition); iterative methods(Jacobi and gauss-Seidel); Matrix eigenvalue problems: power method, Numerical solution of ordinary differential equations: initial values problems, Taylor series methods, Euler's method, Runge–Kutta methods.

Partial Differential Equation: Linear and quasilinear first order partial differential equations, method of characteristics; second order linear equations in two variables and their classification; Cauchy, Dirichlet and Neumann problems; solution of Laplace, wave and diffusion equations in two variables; Fourier series and Fourier transform and Laplace transform methods of solutions for the above equations.

Mechanics: Virtual work, Lagrange's equations for holonomic systems, Hamiltonian equation, Equation of continuity, Equation of motion in cylinder, Vortices.

Topology: Basic concepts of topology, Product topology, Connectedness, Compactness, Countability and separation axioms, Urysohn's Lemma.

Probability and Statistics: Probability space, conditional probability, Bay's theorem, independence, Random variables, joint and conditional distributions, standard probability distributions and their properties, expectation, conditional expectation, moments; weak and strong law of large numbers ,central limit theorem; Sampling distributions, UMVU estimators, maximum likelihood estimators, Testing of hypotheses, Standard parametric tests based on normal, X^2, t , F-distributions; Linear regression; Interval estimation.

Linear programming: Linear programming problem and its formulation, convex sets and their properties, graphical method, basic feasible solution, Simplex method, Big- M and two phase method; infeasible and unbounded LPP's, alternate optima; Dual problems and duality theorems, dual simplex method and its application in post optimality analysis; Balanced and unbalanced transportation problems, u-u method for solving transportation problems; Hungarian method for solving assignment problems, Assignment problems, Transportation problems.

Calculus of Variation and Integral Equations: Variation problems with fixed boundaries; sufficient conditions for extremum, linear integral equations of Fredholm and Volterra type and their iterative solutions.

TEERTHANKER MAHAVEER UNIVERSITY

(Established under Govt. of U. P. Act No. 30, 2008)
Delhi Road, Moradabad (U.P.)

SYLLABUS FOR RESEARCH APTITUDE TEST IN PHYSICS

The syllabus for Research Aptitude Test (RAT) in Physics is divided in two parts viz. Part A & Part B described below:

PART – A

Part A of the RAT shall be designed to assess the research skills/aptitude of the candidate consisting of questions from the following areas:

1. **Research Methodology:** meaning, characteristics, and ethical issues in research; types of research; research methods

2. **Logical Reasoning:** arguments, deductive and inductive research; logical and Venn diagram; inferences; analogies.

3. **Data Interpretation:** interpretation of data; mapping and analysis of data, tools for data analysis; quantitative and qualitative research.

4. **General Awareness about Basic Science:** basic science up to the level of SSC.

5. **Mathematical Reasoning:** number series, letter series, codes; relationships, classification.

PART – B

Part-B of RAT is designed to assess subject specific knowledge of the candidate covering the syllabus given as below:

Classical Mechanics: Lagrangian Formulation of Mechanics - Generalized coordinates, Langrange's equations of motion, properties of kinetic energy function, theorem on total energy, generalized momenta, cycliccoordinates, integrals of motion, Jacobi integrals and energy conservation, Concept of symmetry, invariance under Galilean transformation, velocity dependent potential; Hamiltonian Formulation of Mechanics - Hamilton's function and Hamilton's equation of motion, configuration space, phase-space and state space; Variational Principle - Variational principle, Euler's equation, applications of variational principle, shortest distance problem, brachistochrone, Geodesics of a Sphere; Rotational Motion - Rotating frames of reference, inertial forces in rotating frames, Larmour precision, electromagnetic analogy of inertial forces, effects of Coriolis force, Focoult's pendulum.

Mathematical Methods in Physics: Complex Analysis - Analytical functions, Cauchy-Riemann conditions, Line integrals, Cauchy's theorem, Cauchy integral formula, Derivatives of analytical functions, Power Series, Taylor's theorem, Laurent's theorem, Calculus of residues, revaluation of real definite integrals; Linear spaces and operators - Vector spaces and subspaces, Linear dependence and independence, Basis and Dimensions, linear operators, Inverses, Matrix representation, Similarity transformations, Eigenvalues and eigenvectors, Inner product, Orthogonality, Introduction only to Gramm-Schmidt orthogonalization procedure, Self adjoint and

Unitary transformations, Eigenvalues & eigenvectors of termitian & Unitary transformations, Diagonalizationp; Special Function - Legendre Hermite, Laguerre function: Generating function, Recurrence relations and their differential equations Orthogonality properties, Bessels's function of first kind, Spherical Bessel function, Associated Legendre function, Spherical harmonics; Fourier Series and Integral transforms- Fourier Series: Definition, Dirichlet's condition, Convergence, Fourier Integral and Fourier transform, Convolution theorem, Parseral's identity, Applications to the solution of differential equations, Laplace transform and its properties, Applications to the solution of differential equations, Fourier transform & Laplace transform of Dirac Delta function.

Classical Electromagnetism: Electrostatics and Magnetostatics: Mathematical preliminaries - boundary value problems using Green function techniques - special techniques for calculating potentials – electrostatics of dielectric media - magnetic vector potential and the gauge problem - Biot-Savart law - magnetic dipole moment and the Larmor precession; Maxwell Electrodynamics: Motion of charges in external fields - electromagnetic waves in vacuum and propagation through continuous media - gauge transformations - Lorentz covariant formulation of electrodynamics - energy-momentum of electromagnetic field and Poynting's theorem – Lagrangian and Hamiltonian formulation of electrodynamics; Thermodynamic and Statistical Physics: First- and second-order phase transitions. Diamagnetism, paramagnetism, and ferromagnetism. Ising model. Bose-Einstein condensation. Diffusion equation. Random walk and Brownian motion. Introduction to non-equilibrium processes.

Statistical Mechanics: Statistical Description of System of Particles - Specification of the state of the system, Macroscopic and Microscopic states, Phase space, Statistical ensemble, Postulate of equal a priori probability, Probability calculations, Behaviour of density of states, Liouville's theorem(Classical), Quasi-static processes; Statistical Thermodynamics - Equilibrium conditions and constraints, Distribution of energy between systems in equilibrium, Approach to thermal equilibrium, Temperature, Heat reservoir, Sharpness of the probability distribution, Dependence of the density of states on the external parameters, Equilibrium between interacting systems.

Quantum Mechanics: Free Particle - The Schrodinger equation, Hamiltonian, commutation relations, Wave functions, probability interpretation, currents, measurement, plane waves, normalization, boundary conditions, discrete space and regularization, delta function, wave packets, group velocity, postulates of quantum mechanics, bracket notation, Fourier transform, vector space - matrices, Hermitian and unitary matrices, tensor product, projection operator - Schrodinger and Heisenberg pictures, evolution operator; Spin-1/2 System - Stern-Gerlach experiment, illustrating quantum mechanics, atom in a magnetic field, dynamics of two level systems; Perturbation Theory - Time-independent (degenerate and non-degenerate) perturbation theory -time-dependent perturbation theory, sinusoidal perturbations, Fermi golden rule - scattering Theory; Relativistic Quantum Mechanics - Dirac equation and Klein-Gordon equation.

Atomic and 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.

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. 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. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions.

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.

Semiconductor devices: 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.

Electronics and Experimental Methods: Transducers (temperature, pressure/vacuum, magnetic fields, vibration, optical, and particle detectors). Measurement and control. Signal conditioning and recovery. Impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding. Fourier transforms, lock-in detector, box-car integrator, modulation techniques.

TEERTHANKER MAHAVEER UNIVERSITY

(Established under Govt. of U. P. Act No. 30, 2008)
Delhi Road, Moradabad (U.P.)

SYLLABUS FOR RESEARCH APTITUDE TEST IN CHEMISTRY

The syllabus for Research Aptitude Test (RAT) in Chemistry is divided in two parts viz. Part A & Part B described below:

PART – A

Part A of the RAT shall be designed to assess the research skills/aptitude of the candidate consisting of questions from the following areas:

1. **Research Methodology:** meaning, characteristics, and ethical issues in research; types of research; research methods

2. **Logical Reasoning:** arguments, deductive and inductive research; logical and Venn diagram; inferences; analogies.

3. **Data Interpretation:** interpretation of data; mapping and analysis of data, tools for data analysis; quantitative and qualitative research.

4. **General Awareness about Basic Science:** basic science up to the level of SSC.

5. **Mathematical Reasoning:** number series, letter series, codes; relationships, classification.

PART – B

Part-B of RAT is designed to assess subject specific knowledge of the candidate covering the syllabus given as below:

INORGANIC CHEMISTRY

Role of solvents in chemical reactions, physical properties of a solvent, types of solvents and their general characteristics, reactions in non-aqueous solvents with reference to liquid NH3 and liquid SO2 Spectroscopic ground states, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d1-d9 states), calculation of Dq, B and β parameters, charge transfer spectra, spectroscopic method for assignment of absolute configuration in optically activemetal chelate and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

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

MATERIALS CHEMISTRY

Corrosion: Definition, Classification, Units and rate of corrosion, Electrochemical corrosion reaction, Rusting, Polarization, Activation Polarization, Concentration Polarization, Passivity,

Inhibitors, Electrochemical series of metals, Galvanic series of metals and Alloys, Galvanic corrosion, Ceramic corrosion, Pitting corrosion, Inter-granular corrosion, Stress corrosion.

Magnetic Properties: Classification of magnetic materials, diamagnetism, paramagnetism, ferromagnetism, magnetic anisotropy, ferromagnetic domains, origin of domain wall anti-ferromagnetism, antiferromagnetic, domains, ferrimagnetism, normal spinel's inverse spinels, ferromagnetic domain.

Polymer Chemistry: General characteristics of chain growth polymerization, alkene polymerization by free radical, anionic and cationic initiators, General characteristics of step growth polymerization, synthesis of polymers by step polymerization, polyesters, polycarbonates, polyamides, polyphenylene oxide.

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

ORGANIC CHEMISTRY

Name Reactions and their Mechanisms: Formations and stabilities of carbonium ions, carbanions, carbenes, nitrenes, radicals and arynes, Reactive intermediates, Nucleophilic, Electrophilic, Radical substitution, Addition and Elimination reactions. Diels-alder reactions, Friedel crafts reactions, Hoffmann reactions, Hydroboration, Lossen, Mannich, Michael addition, Perkin, Grignard, Reimer-Tiemann, Reformatsky, Wittig, Wolff-Kishner. Oppenaur oxidations, Aldol, Clasien, Schmidt, Condensations, Beckmann and Fries,

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

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

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

PHYSICAL CHEMISTRY

Energetic and Dynamics of Chemical Reactions: Law of conservation of energy, Energy and enthalpy of reactions, Entropy, free-energy, relationship between free energy change and equilibrium. Rates of chemical reactions (first- and second-order reactions). Arrhenius equation and concept of transition state. Mechanisms, including SN1 and SN2 reactions, electron transfer reactions, catalysis. Colligative properties of solutions.

Thermodynamics: First law of thermodynamics, relation between Cp and Cv; enthalpies of physical and chemical changes; temperature dependence of enthalpies. Second law of thermodynamics, entropy, Gibbs-Helmoholtz equation. Third law of thermodynamics and calculation of entropy.

Chemical Equilibrium: phase diagram of one-and two-component systems, phase rule.

Ionic Equilibrium: Ostwald dilution law, Concepts of acid base, Ionic product of water, pH and theory of buffer solutions, Solubility and solubility product, Salt hydrolysis.

Electrochemistry: Electrochemical cell reactions, Nernst equation, Electrode Kinetics, electrical double layer, electode/electrolyte interface, Batteries, primary & secondary Fuel Cells, corrosion and corrosion prevention.

Reaction Kinetics: Methods of determining rate laws. Mechanisms of photochemical, chain and oscillatory reactions. Collision theory of reaction rates; steric factor, treatment of unimolecular reactions. Theory of absolute reaction rates, comparison of results with Eyring and Arrhenius

equations. Ionic reactions: salt effect. Homogeneous catalysis and Michaelis-Menten kinetics; heterogeneous catalysis.

Solids: Crystalline and Amorphous Solid, Unit cell, Summary of crystal lattices, Reciprocal lattice, Bonding & packing in crystals, Lattice planes, Symmetry elements, Space lattice, X-ray diffraction, Dislocation in solids, Schottky and Frenkel defects, Electrical properties; Insulators and semiconductors; superconductors; band theory of solids, Solid-state reactions.

States of Matter: Gaseous laws, Kinetic theory of gases, Molecular velocities, Critical Phenomenon of real gases, Liquefaction of gases, Intermolecular forces and structure of liquids.

Nuclear Chemistry: Radioactive decay and equilibrium. Nuclear reactions; Q value, cross sections, types of reactions, Chemical effects of nuclear transformations; fission and fusion, fission products and fission yields. Radioactive techniques; tracer technique, neutron activation analysis, counting techniques such as G.M. ionization and proportional counter.