

**INDIAN INSTITUTE OF TECHNOLOGY DELHI**

**SYLLABUS FOR THE POST OF TECHNICAL OFFICER**

**Written Test : 100 Marks and Duration of Exam : 90 Minutes**

**Note: Candidates shall be given a choice to select any one area from the following broad subject areas:**

- i. Electrical/Electronic/Instrumentation & Allied**
- ii. Mechanical/Civil/Textile & Allied**
- iii. Chemistry/Chemical Engg./Biochemistry/Biosciences & Allied**
- iv. Computer science and IT**
- v. Physics/Optics/Material science & Allied**

➤ **Specialization (i): Electrical/Electronic/Instrumentation & Allied**

Electrical circuit analysis (Voltage and current sources, resistor, inductor, and capacitors. Kirchhoff's laws, mesh and nodal analysis, superposition principle, Thevenin's theorem, Norton's theorem, maximum power transfer and reciprocity theorems, Peak, average and r.m.s. values of ac quantities, fundamentals of R, L and C circuits), Steady state phasor analysis, single and 3- phase circuits.

Electronic Devices: Characteristics and applications of pn junction diodes, Zener diodes, BJTs and MOSFETs).

Electronic Circuits: Digital Electronic Circuits (Combinational logic circuits, minimization of Boolean functions, Adders, Multiplexers, Encoders, Decoders, Comparators, Sequential circuits, Latches, Flip-flops, Registers, Counters, IC families: TTL logic and CMOS logic, sample-and-hold circuit, analog-to digital converters and digital-to analog converters), Analog Electronics (Small signal analysis of transistor circuits, feedback amplifiers, Characteristics of operational amplifiers, Applications of op-amps (difference amplifier, adder, subtractor, integrator, differentiator), instrumentation amplifier, precision rectifier, active filters), Oscillators, Integrated Circuits.

Digital signal processing, Analog Communication, Digital Communication.

Electronic Instrumentation, Principle of measurement of A.C./D.C. Voltage and current, measurement of Resistance, Cathode Ray Oscilloscope, Digital frequency counter, LCR Bridge, Function Generator, Signal Generation, Electrical Machines, Electrical Measurements and Instrumentation, Circuit Theory.

Transformers, Electromechanical energy conversion of DC machines and induction machines, Distribution and estimation switchgear and protection, Power generation transmission & distribution, AC transmission system, Power electronics, Transformer construction and working, AC Motors, DC Motors, Generator and starters.

➤ **Specialization (ii): Mechanical/Civil/Textile & Allied**

**Mechanical Engineering**

Engineering Mechanics, Hydraulics and Fluid Mechanics, Thermodynamics, Steam Nozzles and Turbines, IC Engines and Nuclear Power Plants, Compressors, Gas Dynamics and Gas Turbines Heat Transfer, Refrigeration and Air Conditioning, Production Engineering, Industrial Engineering and Production Management, Strength of Materials, Hydraulic Machines Steam Boilers and Engines, Machine Design, Engineering Materials, Theory of machines, Workshop Technology, Automobile Engineering

**Civil Engineering**

**Construction Materials:** Structural steel - composition, material properties and behaviour; Concrete - constituents, mix design, short-term and long-term properties; Bricks and mortar; Timber; Bitumen; Cost estimation;

**Structural Mechanics:** System of forces, free-body diagrams, equilibrium equations; Friction and its applications; Principles of virtual work; Bending moment and shear force; Simple stress and strain relationships; Theories of failures; Simple bending theory, flexural and shear stresses, shear centre; Uniform torsion, buckling of column, combined and direct bending stresses; Analysis of trusses, arches, beams, cables and frames; Slope deflection and moment distribution methods; Influence lines

**Concrete Structures:** Limit-state method; Working stress method; Singly-reinforced and doubly-reinforced beam; one-way and two-way slab; Axially and eccentrically-loaded columns; Column footing; Concept of prestressed concrete

**Steel Structures:** Structural steel sections; Riveted, bolted and welded connections; Tension members; Compression members; Roof trusses; Beams; Columns

**Soil Mechanics:** Soil classification and identification; Weight volume relationship; Mohr's circle, Permeability - one dimensional flow, Darcy's law; Seepage through soils; Principle of effective stress, Quicksand condition; Compaction; Consolidation; Shear strength of soils.

**Foundation Engineering:** Sub-surface investigations – Sampling and standard penetration tests; Earth pressure – Rankine's theory for active and passive earth pressure; Stability of slopes - Finite and infinite slopes, Stress distribution in soils; Shallow foundations – Bearing capacity, Terzaghi's bearing capacity equation; Deep foundations - Types of deep foundation, Load capacity of piles in sands and clays.

**Environmental Engineering:** Quality standards, basic unit processes and operations for water treatment. Drinking water standards, water requirements, basic unit operations and unit processes for surface water treatment, distribution of water; Sewage and sewerage treatment, quantity, and characteristics of wastewater. Primary, secondary and tertiary treatment of wastewater, effluent discharge standards; primary and secondary treatment. Unit operations and unit processes of domestic wastewater, sludge disposal; Municipal solid waste management; Air pollution and control; Noise pollution.

**Fluid Mechanics:** Fluid statics; Continuity, momentum, energy and corresponding equations; Potential flow; Laminar and turbulent flow; Flow in pipes, pipe networks;

Concept of boundary layer; Forces on immersed bodies; Basics of hydraulic machines, specific speed of pumps and turbines; Channel Hydraulics - Energy-depth

relationships, specific energy, critical flow, slope profile, hydraulic jump, uniform flow and gradually varied flow

**Hydrology:** Hydrologic cycle, precipitation, evaporation, evapo-transpiration, watershed, infiltration, unit hydrographs, hydrograph analysis, flood estimation and routing, reservoir and channel routing, surface run-off models, groundwater hydrology; Application of Darcy's law.

**Irrigation:** Crop water requirements; Design of lined and unlined canals, head works, gravity dams and spillways; Types of irrigation systems, irrigation methods; Water logging and drainage; Canal regulatory works, cross-drainage structures, outlets and escapes.

**Surveying:** Principles of surveying; Errors and their adjustment; Maps - scale, coordinate system; Distance and angle measurement - Levelling and trigonometric levelling; Traversing and triangulation survey; Total station; Horizontal and vertical curves; Photogrammetry - scale, flying height; Basics of GIS, GPS, and Remote sensing

**Transportation Engineering:** Highway alignment and engineering surveys; Geometric design of highways - cross-sectional elements, sight distances, horizontal and vertical alignments; Highway materials - desirable properties of subgrade soil, stone aggregates and bituminous materials, and quality control tests; Design of bituminous paving mixes; stresses in bituminous and concrete pavements; Drainage aspects of highways; Road maintenance and construction Equipment; Traffic studies on volume, speed and travel time - delay and O-D studies.

Geometric design of railway track; Airport runway length, taxiway and exit taxiway design;

**Civil Engineering Drawing:** Lines, dimensioning; Projection of points and lines; Theory of projections; Section; Isometric views

**Basics of Information Technology:** Computer organization; Operating systems; Basics of networking

### Textile Engineering

Simple Mathematics and Problem solving, Data sufficiency and Logical

Reasoning, statistical analysis of Data – mean, median, mode, measures of dispersion

Basic Properties of natural and Synthetic fibres ; Sampling and basic statistics: Selection of samples for testing; Different types of sampling of textile materials; Quality control charts and their interpretation; Standard tests, analysis of data and test reports. Measurement of length, fineness and crimp of fibres; Measurement of twist, linear density and hairiness of yarn; Evenness testing of silvers, rovings and yarns; Uster classimat; Tensile testing of fibers, yarns and fabrics; Tearing, bursting and abrasion resistance tests for fabrics; Pilling resistance of fabrics; Crease and wrinkle behavior; Fastness characteristics of textiles; Matching of shade; Special tests for carpets and nonwoven fabrics.

Testing for technical textiles : Impact testing, comfort properties of textiles

**Preparatory processes for textiles (Methods. Various chemicals used, process parameters, precautions):** Singeing, Desizing, Scouring, Bleaching, Mercerization (Changes in cellulose during the process and properties achieved, types), Methods to evaluate efficiency of process - Weight loss, TEGEWA rating, Absorbency, Whiteness index. Barium activity number.

**Dyeing of textiles (Methods of dyeing, Process, chemicals used, (Dye fibre interactions):** Dyeing of Cellulosic fibres, Dyeing with Direct dyes, Dyeing with Reactive dyes, Dyeing with Vat dyes; Dyeing of Wool fibre: Dyeing with acid dyes; Dyeing of polyester: Dyeing with disperse dyes; Testing of colour fastness. Fastness to washing, Fastness to rubbing, Fastness to Light.

**Printing of Textiles;** General ingredients of Print paste. Styles of Printing, Methods of Printing, Printing of cotton by direct, resist and discharge styles, Post-printing operations (Fixation and washing-off), Pigment printing (recipes for kerosene-water emulsion based system and Process. Advantages and limitations)

**Finishing of Textiles:** Processes and Evaluation, Softening/stiffening finishing of textiles, Wrinkle-free, Water repellent, flame retardant, rot proof finishing, Bio-polishing

**General machines used for textile chemical processing (Concept of Fabric/liquor flow, addition of chemicals, applicability according to form/type of substrate, advantages and limitations):** Jigger, Winch, Soft-flow, Jet dyeing machine, padding mangle, stenters, steamers, launderometer, cone-calorimeter

**Characterization/testing equipment principles:**

Computer color matching (CCM), UV-VIS spectrophotometry, particle size analysis, viscosity measurement, pH measurement, optical microscopy, calorimetry.

Data interpretation, Trend analysis, Basic statistics and Problem solving

Engineering principles of opening, cleaning, blending, carding, stripping, combing, drawing, twisting, and winding; Working principles of conventional and modern preparatory-to-spinning machines viz. blowroom, card, draw frame, comber, and roving frame; Theories of hook formation, drafting, noil extraction, false twist. Roller arrangements in draw frame and their impact, Epicyclic gearing in comber and roving frame, Bobbin building and twisting mechanisms in roving frame and ring frame, Spinning tension in ring frame, Ring and traveller in ring frame, Operating principles of yarn-forming machines viz. ring, rotor, friction, compact, vortex, and air-jet; Structural characteristics and properties of different types of yarns. Gearing diagrams and calculations of speed, draft, twist, and production; Pneumatics and electrical circuits & drives; Automation in spinning machines, Open-loop and close-loop systems in spinning machines, Stop motions and control systems in spinning machines, Troubleshooting in spinning machines; Safety issues; Latest developments in spinning machine, Online quality monitoring in modern spinning machines

Textile fibres and their classification (based on origin and chemical structure). Identification of fibres by microscopy, solubility and chemical methods. General

structure of natural fibers (Cotton, silk, wool). Application of important cellulosic and protein fibers. Preparation of viscose fibers. Synthesis (monomers and reactions) of fibre forming polymers such as nylon 6, poly(ethylene terephthalate) and acrylic. Amorphous and crystalline phases, glass transition temperature, crystallization and melting temperature, Fibre properties (moisture absorption, mechanical properties, electrical properties, flammability) of cottons, viscose, silk, wool, nylon 6 and polyester. Basics of melt spinning and solution spinning process, Single and Twin-Screw Extruders, Polymer Characterization Techniques like melt flow index, intrinsic viscosity, moisture regain etc. Fibre Characterization techniques like thermal DSC, TGA, TMA and DMA, FTIR, Birefringence, Sonic Modulus, Density Measurements, X Ray Diffraction, Experiments on Creep and Stress Relaxation.

➤ **Specialization(iii): Chemistry/Chemical Eng./Biochemistry/Biosciences & Allied**

**Chemistry**

Metric system, introduction to matter, atomic structure, chemical bonding, periodic table, chemical reactions and equations, gases, solutions, pH and introductory organic chemistry. Knowledge of physicochemical methods such as UV-visible, IR, NMR (proton and carbon) and quantitative techniques used in chemical analyses. Fundamental of analytical chemistry, scientific notation, significant figures, errors in chemical analysis, titrimetric methods. Use of computers, work processing spreadsheet. An overview of safety, health and environmental regulations, and the potential hazards in the maintenance of chemistry laboratory/equipments such as pH meter, conductivity meter, and spectrometer.

**Chemical Engineering**

Material and Energy Balances, Fluid Mechanics, Thermodynamics, Chemical Reaction Engineering, Process Dynamics and Control, Mass Transfer, Heat Transfer, Unit Operations, Process Safety, Fluid Particle mechanics, Transport Phenomena and Chemical Process Technology.

**Biochemistry and Molecular Biosciences**

Importance of water in life processes; Structure and function of biomolecules: Proteins, Carbohydrates, Lipids, and Nucleic acids; Enzyme kinetics and bioenergetics; Metabolic pathways: Glycolysis, TCA cycle, pentose phosphate pathway, oxidative phosphorylation, gluconeogenesis, glycogen, and fatty acid metabolism; Nitrogen metabolism. Photosynthesis. Biochemical techniques: Chromatography, Electrophoresis, UV-visible and fluorescence Spectroscopy, and Mass spectrometry.

Cell structure and organelles; Biological membranes, Transport across membranes; Signal transduction; Central dogma, DNA replication, transcription, and translation; Biochemical regulation of gene expression.

Recombinant DNA technology and applications: Plasmid vectors, DNA cloning, polymerase chain reaction (PCR), site directed mutagenesis, gene editing, DNA/RNA labelling and sequencing; Southern, northern, and western blotting; DNA fingerprinting, RFLP; Gene transfer technologies. Immune system: Innate and adaptive; Cells of the immune system; Antibody structure, function, and diversity; B- and T Cell receptors; B cell and T cell activation; Complement system; Immunological

techniques: Immuno-diffusion, immune-electrophoresis, RIA and ELISA, flow cytometry.

## ➤ **Specialization (iv): Computer science and IT**

### **Computer Hardware**

Microprocessors architectures, types of CPUs, Processor technologies, Pins/Sockets, RAM, ROM, Cache Memory, Buffer Memory, Virtual Memory, Timeline (EDO, NON-EDO, SD, RD, DDR, DDR2, DDR3) etc., BIOS setup, upgrade and security, Motherboards types, chipsets, expansion slots, and other components, Switch Mode Power supplies, hard drives, Functioning of HDD, Interface Types (IDE or PATA, SATA, SCSI, SSD, PATA), Data storage technique (Tracks, Sectors, Cylinders, Cluster MBR, FAT Area, DIR Area, Zero Track,) removable media, CD/DVD/Blu-ray ,video types and interfaces: LED, LCD, DVI, HDMI, VGA etc., multimedia, Portable Computing, Mobile Devices, Printers.

### **Operating Systems**

Windows System administration, OS installation methods, Safe Mode, Safe Mode Boot options, Last Known Good Configuration etc., Windows Diagnostic Tools, System Restore, Creating Restore point, restore using Restore point, etc., Windows Recovery tools and methods. Backup/Recovery and Restore procedures in windows and other operating systems.

Linux Operating System. Difference between Windows and Linux OS, Installation of Linux OS, Boot Loaders, Ke(iv)nel. Shells, utilities etc., Linux Administration Basics Installation of various Packages in Linux, Linux Networking, Configuration of basic networking services in Linux, Print Sharing SAMBA services, Upgradation and Patch Management in Linux.

### **Application Softwares**

Installation of Microsoft Office (Word, Excel, PowerPoint), MS Teams, Cisco WebEx etc and general packages used in engineering.

Basic operating of Word Processing, Creating, opening and closing Documents, use of shortcuts, Creating and Editing of Text, Formatting the Text, Insertion & creation of Tables.

Basics of Excel worksheet, understanding basic commands, creating simple worksheets, understanding sample worksheets, use of simple formulas and functions, Printing of simple excel sheets.

### **Computer Networking**

Network Topologies: Type of Networks and Internet, Media Types, Network Equipments Types and functions: Hubs, Switches, Routers, Modems, Transceivers, Firewalls, Wireless Controllers, Access Points. TCP/IP, Ethernet, Wi-Fi, Bluetooth, Mobile Networking, Protocols: ARP, EIGRP, TCP, UDP, HTTP, FTP, SSH, DNS, DHCP, NTP, RADIUS etc.

### **Computer/ Mobile devices Security**

Malwares, Adware, Spywares, Phishing Attacks, etc. Prevention and Cure.

### **Databases**

Database system, Relational databases Database system ,ER-Diagram Constraints, ER-Diagrams, Logical view of data, keys, integrity rules. Normalization (1NF, 2NF, 3NF, BCNF), Database administration.

Relational algebra: Selection and projection, set operations, renaming, Joins, Division, syntax, semantics. Operators, grouping and ungrouping, relational comparison. Constraints, Views and SQL (MySQL/ PostgreSQL): data definition, aggregate function, Null Values, nested sub queries, Joined relations.

### **Programming**

Basic Programming in Python/C language/bash/shell scripting.

### **Web Technology**

Fundamentals of Web: Internet, WWW, Web Browsers, and Web Servers, URLs, MIME, HTTP, HTML tags, Form controls, Cascading Style sheets, inline, embedded and external style sheets, Building CSS menu, Creating user style sheets, Server side and client side scripting, Programming in Java Script.

### **Additional for Technical Officer**

Verbal and Nonverbal Reasoning, Classification; Analogy; Logical Deduction; Quantitative Problems and Series Completion; Units and Dimensional Analysis, Precision and significant figures.

Discrete Mathematics: Propositional and first order logic. Sets, relations, functions, partial orders and lattices. Groups. Graphs: connectivity, matching, coloring. Combinatorics: counting, recurrence relations, generating functions. Linear Algebra: Matrices, determinants, system of linear equations, eigenvalues and eigenvectors, LU decomposition.

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

Probability: Random variables. Uniform, normal, exponential, poisson and binomial distributions. Mean, median, mode and standard deviation. Conditional probability and Bayes theorem.

Computer Science and Information Technology: Digital Logic Boolean algebra. Combinational and sequential circuits. Minimization. Number representations and computer arithmetic (fixed and floating point).

Computer Organization and Architecture: Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipe lining. Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).

Programming and Data Structures: Programming in C. Recursion. Arrays, stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs.

Algorithms: Searching, sorting, hashing. Asymptotic worst case time and space complexity.

Algorithm design techniques: greedy, dynamic programming and divide-and-conquer. Graph search, minimum spanning trees, and shortest paths.

Theory of Computation: Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and context-free languages, pumping lemma. Turing machines and undecidability.

Compiler Design: Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation.

Operating System: Processes, threads, inter-process communication, concurrency and synchronization. Deadlock. CPU scheduling. Memory management and virtual memory. File systems.

Databases: ER-model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., Band B+ trees). Transactions and concurrency control.

Computer Networks: Concept of layering. LAN technologies (Ethernet). Flow and error control techniques, switching. IPv4/IPv6, routers and routing algorithms (distance vector, link state). TCP/UDP and sockets, congestion control. Application layer protocols (DNS, SMTP, POP, FTP, HTTP). Basics of Wi-Fi, Network security: authentication, basics of public key and private key cryptography, digital signatures and certificates, firewalls.

### ➤ **Specialization (v) : Physics/Optics/Material science & Allied**

Classical Mechanics, Electromagnetic Theory (Solution of electrostatic and magnetostatic problems including boundary value problems, Biot-Savart's law, Ampere's law, Faraday's law, Maxwell's equations, scalar and vector potentials, Coulomb and Lorentz gauges, Electromagnetic waves and their reflection, refraction, interference, diffraction and polarization, Poynting vector, Poynting theorem, energy and momentum of electromagnetic waves; radiation from a moving charge), Quantum Mechanics (Uncertainty principle; Schrodinger equation, one, two and three dimensional potential problems, particle in a box, harmonic oscillator, hydrogen atom, angular momentum and spin, time independent perturbation theory).

Reflection of Light (Spherical mirrors, Images formed by spherical mirrors, Mirror formula), Refraction of Light, Refractive index, Spherical lenses, prisms, images formed by spherical lenses, Lens formula and magnification, Snell's law, Total internal reflection (TIR), Critical angle of refraction, TIR in nature and its application, Dispersion, Reflection and Transmission Coefficients, Brewster law, Polarized light, Wave Plate, Optical Instruments (Simple and Compound Microscope, Telescope, refractometer), Interferometers (Michelson and Newton, Mach Zehnder, Fabry Perot), Autocollimator, Focometer, Goniometer, optical spectrometer and optical spectrum analyzer, photo-detectors, cameras (CCD, CMOS).

Optical fibers: Types of optical fibres (Step index, graded index, Single mode, multi-mode), basic knowledge of modes in optical fibers, attenuation, dispersion, fabrication and characterization of optical fibres, optical fibre sensors.

Optoelectronics: Optical sources (LEDs, Lasers, Einstein A and B coefficients, Spontaneous and stimulated emission, Basic characteristics of laser emission, laser classes, laser types, essential elements of lasers, HeNe laser, Nd:Yag laser, semiconductor lasers, basic knowledge of laser safety and handling, applications of lasers), optical detectors, optoelectronic devices and applications.

Magnetic Properties: Types of magnetism (Ferro-, para-, ferri-, dia- and antiferro-), Susceptibility measurements, Gauss meters and Solenoid valve.

Fabrication and measurements of optical elements (Grinding, Polishing, Abrasives for polishing, Pitch polishing, Lapping, Edging, Centering), Special optical characteristics of materials such as glass and plastics, molding, Surface Roughness, Surface flatness, Surface profile, Surface topology parameters, Basic Measuring instruments (Vernier caliper, micrometer, Spherometer, height gauges, slip gauges, Dial indicators).

Electronics Basics: DC Voltmeter, DC Ammeter, DC Power supply, Measurement of R, L, C, Self-Inductance. Measurement of frequency using bridges, True RMS responding and average responding rectifier type voltmeters, Digital Multi Meter, Q-factor, Time domain response of RC and RL circuits, DC Bridges - Wheatstone bridge and Kelvin's Double Bridge, AC Bridges - General Balance Equation for Four-Arm Bridge, Stepper motor, Single phase and 3 phase sources, Variac (single/3 phase).

Cathode Ray Oscilloscope (CRO): Electrostatic Deflection, Screens for CRT's, Attenuators, Probes, Connectors, Dual beam oscilloscope, Dual trace oscilloscope, Digital Storage Oscilloscope, Applications of CRO for measurement of voltage, current, Phase and Frequency.

Electronic Devices and Circuits: p-n junction (forward and reverse biased junctions), metal-semiconductor junctions, varactor diode, solar cells, LEDs, Tunnel diode and Zener diode, Junction break down, Simple transistor amplifier, differential amplifier, Op-amp, Simple circuits using op-amp, Waveform generators, 555 timer, Simple active filters, Logic gates, multiplexers, Flip-flops, Counters, shift registers, Digital-to-Analog Converters, Analog-to-Digital Converters.

Transducer and Sensors: Resistive Transducer - Strain Gauge type, Capacitive Transducers, Flow Meter, Piezoelectric effect, Thermocouple, Thermistor, Pyrometers, Platinum resistance thermometer.