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Scheme of Examination for the post of Junior Technical Superintendent

Stage I- Written Examination

Subject (All questions will be objective type with no negative marking)		Maximum Marks	Time duration
Part-A	**English Language-** Comprehension, Grammar, Sentence correction, One words, Antonyms, Synonyms, Idioms and Phrases, Clauses, Articles, Prepositions etc.	**40**	**Total 2 Hours (120 Minutes)**
	Mathematics & Numerical Ability: Arithmetic - upto 10th Standard. Numerical Computation, Numerical Reasoning, Data Reasoning and Data Interpretation etc.		
	Reasoning Ability: Number series, Letter series, Coding decoding, Direction sense, Blood relations, Mathematical reasoning, Statements and Conclusions, Logical Reasoning etc.		
	General Awareness and Current Affairs: Current Affairs, Government Schemes. Economics, Geography, Indian History, Indian Polity, Indian Constitution.		
Part-B	**Domain Knowledge** (Candidate is to attempt one department i.e., Civil Engg./ Electrical Engg./ Metallurgy Eng. and Materials Science/ Mechanical Engg./ Computer Science Engg./ Basic Sciences (Physics+Chemistry +Mathematics) / Astronomy, Astrophysics & Space Eng./ Biosciences & Biomedical Eng.)	**60**	
Total		**100**	-

Stage II - Skill & Job Suitability Test

Sr. No.	Name of Test	Maximum Marks
1.	Lab Activity	20
2.	Job Suitability Test	20

Notes: -

1. Only those candidates who score minimum cut off marks in the written examination, as may be fixed by the IIT Indore at its discretion, will be called for Lab Activity & Job Suitability Test.
2. In the Stage-II, lab activity will be conducted first and only those candidates who score minimum qualifying marks in lab activity shall only be assessed in the Job Suitability Test.

Syllabus for Domain knowledge- Junior Technical Superintendent

1. For Disciplines of Engineering-

Sr. No.	Subject/Department	Topics
1.	Department of Civil Engineering	Mechanical behaviors of mild steel, cast iron, bricks and concrete, bucking of columns, unsymmetrical bending of angle sections, shear force and bending moments of determinate beams, building bye lays, Bernoulli's Theorem, Reynolds number, continuity equation for fluid flow, flow through pipes, losses in pipes, orifices, venturimeter and notches, hydraulic jump, theodolite traversing, tacheometry, trigonometric leveling, triangulation and Total station.
2.	Department of Metallurgical Engineering and Materials Science	Classifications of engineering materials, Structure and properties of materials, The Iron-Iron Carbide Phase Diagram, Imperfections in solids, Introduction to rolling; forging, drawing, extrusion, casting and welding. Corrosion and degradation of materials. Introduction to metallographic specimen preparation, Metallography and image analysis; Optical microscopy of ferrous and nonferrous samples; Quantitative metallography; X-Ray diffraction in material analysis; Thermal analysis for phase transformation studies.
3.	Department of Mechanical Engineering	Introduction to Thermodynamics, Heat transfer, mass transfer, Energy conversion, creep, fatigue, fracture, Introduction to engineering drawing and orthographic projections and isometric views, Kelvin Bridge. Measurement of Inductance using Maxwell Bridge, U-tube manometer, Inclined manometer. Strength of materials, Kinematics and dynamics, Computer aided design and manufacturing, Robotics.
4.	Department of Electrical Engineering	Electrical part: Basic electrical circuit elements (resistor, capacitor, inductor), Kirchoff's voltage law (KVL), Kirchoff's current law (KCL), A few important circuit theorems (Mesh analysis, Nodal analysis, Superposition theorem, Thevenin theorem, Norton theorem, Star-delta theorem), simple and complex circuits. R-L-C circuits, Transients in R-L, R-C, R-L-C, Sinusoidal Steady State, Real/Reactive Power, Phasors, Three phase power, Magnetic circuit, Working principles of Transformers/AC/DC machines. Electronics part: Functional Characteristics of Diode, Diode based circuits (Clippers, clampers), Rectifiers, Bipolar Junction Transistor (BJT), Boolean Algebra,

		Number System, Logic Gates, Flip Flops.
5.	Department of Computer Science and Engineering	Basic Knowledge in Microsoft Excel and Word, Linux and Windows installation, Computer Hardware, and Software installation.
6.	Astronomy, Astrophysics & Space Engineering	**Mechanics and Electromagnetism:** Inertial and non-inertial frames of reference, Effect of centrifugal and Coriolis forces due to earth's rotation, Center of mass (C.M), Lab and C.M frame of reference, motion of CM of system of particles subject to external forces, conservation of linear and angular momenta, elastic, and inelastic collisions in one and two dimensions, Laws of Electromagnetism (Gauss law of electricity, Gauss law of magnetism, Faraday' law of electromagnetic induction, Ampere's circuital law); Concept of different charge and current densities (free charges, bound charges), Displacement current and generalized Ampere's law, Maxwell's equations, Electric and magnetic polarization vectors, Vector and scalar potentials, Poynting theorem, Polarization of EM wave; Propagation of plane EM waves in different media. Postulates of special theory of relativity, Length contraction, time dilation and its verification, Concept of simultaneity, Relativistic velocity transformation relations. **Mechanical Properties of Matter:** Modulus of rigidity, Poisson's ratio, relation connecting different elastic-constants, Young modulus, Viscosity, Damped harmonic oscillations, Compound pendulum. Strain and stress. **Kinetic Theory, Thermodynamics and Radiation:** Maxwell's speed distribution, Mean free path, Elementary treatment of transport phenomena, Real gases, van der Waals equation, Second law of thermodynamics, Concept of entropy, Entropy of ideal gases, Entropy as a thermodynamic variable, S-T diagram, Internal energy, Enthalpy, Helmholtz function and Gibb's free energy, Maxwell's thermodynamical equations and their applications, Energy and heat capacity equations, Phase transition, Coexistence of phases, Triple point, The blackbody spectrum, Wien's displacement law, Rayleigh-Jean's law, Planck's quantum theory of radiation. **Optics:** Light: Fermat's principle of least time, reflection and refraction,Geometrical optics: Focal length of a spherical surface, Concave and convex mirror and lenses, magnification, compound lenses, telescope and microscope, Resolving power, Theory of interference, Young's double-slit experiment, Newton's rings, Michelson interferometer and their applications, Fabry-

		Perot interferometer, Diffraction, Grating and its resolving power, Refractive index, dispersion and absorption, Polarization and Polarisers, Fraunhoffer diffraction due to single and double slits, plane transmission grating, Resolving power of grating, telescope and Microscope. Polarized light and its mathematical representation, Production of polarized light by reflection, refraction and scattering. Polarization by double refraction and Huygen's theory, Nicol prism, Retardation plates, Production and analysis of circularly and elliptically polarized light. Optical activity and Fresnel's theory, Biquartz polarimeter, Basic concepts of Laser. **Physics of Semiconductor and Electronics:** Physical basis for band formation in solids and difference between metal, insulator and semiconductor. Intrinsic and extrinsic semiconductors, Fermi-Dirac distribution, Fermi level. Thermal generation and recombination of electron hole pairs. Einstein's relation between mobility and diffusion. Drift and diffusion currents, P-N junction diode, depletion width and potential barrier, junction capacitance, I-V characteristics. Rectifiers, ripple factor, filter circuits, rectification efficiency and percentage regulation. Clipping and clamping circuits, Zener diode and voltage regulation, Bipolar Junction Transistors. Electronic Devices (Field effect transistors, I-V Characteristics of JFET and MOSFET, FET biasing, FET as an amplifier, Silicon controlled rectifier, I-V Characteristics, phase controlled rectifier. Unijunction transistor, inverting and noninverting amplifier. Cathode ray oscilloscope. Photodiode, Light emitting diode and solar cell.) Boolean algebra, logic gates, NAND and NOR gates as universal gates. Simplification of Boolean expressions using K- maps. Half and full adders and subtractors. Single stage amplifier in CE,CB and CC modes. RC coupled CE amplifier and its frequency response, tuned voltage amplifier. Power amplifier classification, distortion and efficiency, push pull amplifier, Feedback in amplifiers, positive and negative feedback, effect of negative feedback on the characteristics of different types of amplifiers, voltage and current series feedback circuits. **Modern Physics and Quantum mechanics:** Wave-particle duality, Photoelectric effect, Compton Effect, Matter waves and de-Brogle wavelength. X-ray diffraction

		and Bragg's Law. Electron waves and Davisson Germer experiment, Brief review of Bohr and Sommerfeld model of atom. Effect of finite nuclear mass in relation to Rydberg constant. Idea of discrete energy levels and electron spin: Fanck – Hertz and Stern – Gerlach experiments Significance of four quantum numbers and concept of atomic orbitals, Orbital magnetic dipole moment, Spin and total angular momenta, Larmor precession, Vector model of atom, Electronic configuration and atomic states, Spin-orbit interaction and fine structure, Intensity of spectral lines, **Mathematical Physics and Computational Mathematics:** Probability, Matrix, Orthogonal and unitary matrices, inverse of a matrix, similarity transformations, eigenvalue problems and diagonalization of matrices (Examples of non-degenerate and degenerate cases), Differential Equations, Special Functions (Bessel, Legendre (spherical harmonics), Hermite and Laguerre: generating functions, Beta and Gamma functions, Dirac delta function), Fourier theorem, Fourier analysis of square wave, saw-tooth wave, half wave and full wave rectifier waveforms, basic programming and knowledge of Operating System.
7.	Biosciences & Biomedical Engineering	Knowledge of absorption, FTIR, fluorescence, and other spectroscopic characterization techniques. Biological macromolecules such as proteins, nucleic acids, lipids, and carbohydrates. RBC, WBC, platelets, immune system cells, etc. Properties of matter. Pathogens such as viruses, bacteria, fungi, etc. Cells, cellular structure, organelles, Cellular transport and signalling. Infections and infectious diseases. Genetic engineering techniques and methods. Knowledge of absorption, FTIR, fluorescence, and other spectroscopic characterization techniques. Biological macromolecules such as proteins, nucleic acids, lipids, and carbohydrates. RBC, WBC, platelets, immune system cells, etc. Properties of matter. Pathogens such as viruses, bacteria, fungi, etc. Cells, cellular structure, organelles, Cellular transport and signalling. Infections and infectious diseases. Genetic engineering techniques and methods. Sensors, electrodes, primary electrical and electronic circuits. Biomaterials: types, characterizations, properties, etc. Biomechanics and bioelectronics.

2. FOR DISCIPLINES OF SCIENCES-

Sr. No.	Subject/Department	Topics
1.	Chemistry	**Section 1: Physical Chemistry** **Quantum Mechanics:** Postulates of quantum mechanics. Time dependent and time independent Schrödinger equations. Born interpretation. Particle in a box. Harmonic oscillator. Rigid rotor. Hydrogen atom: atomic orbitals. Idea of eigenvalue equation of the form $\hat{A}\Psi = a\Psi$, construction of Hamiltonian operator; solution of $H\Psi = E\Psi$ for particle in a 1-d box: normalization and orthogonality of Ψ, nodes in excited states, and calculation of average values like $< x >$, $< x^2 >$, $< p >$ and $< p^2 >$, demonstration of the uncertainty product inequality, $\Delta x \Delta p \geq h/4\pi$, discussion on the uncertainty principle, The H atom problem: Hamiltonian in Cartesian and polar coordinates; separation of radial and angular parts; emergence of magnetic quantum number; mathematical forms of orbital functions (ns and np) and degeneracy; shapes of orbitals (s, p). **Equilibrium:** Laws of thermodynamics. Standard states. Thermochemistry. Thermodynamic functions and their relationships: Gibbs-Helmholtz and Maxwell relations, van't Hoff equation. Non-ideal solutions. Ionic mobility and conductivity. Debye-Hückel limiting law. Debye-Hückel-Onsager equation. Standard electrode potentials and electrochemical cells. Potentiometric and conductometric titrations. Phase rule. Clausius Clapeyron equation. **Kinetics:** Transition state theory: Eyring equation, thermodynamic aspects. Potential energy surfaces and classical trajectories. Elementary, parallel, opposing and consecutive reactions. Steady state approximation. Mechanisms of complex reactions. Unimolecular reactions. Kinetics of polymerization and enzyme catalysis. Fast reaction kinetics: relaxation and flow methods. Kinetics of photochemical and photophysical processes. **Spectroscopy and photochemistry:** Einstein's law; primary photophysical processes; potential energy diagram; Franck-Condon principle; fluorescence and phosphorescence; photochemical reactions, quantum yield; photosensitization; photochemical equilibrium; dimerization of anthracene. Alkalimetal spectra (S, P, D, F series): its origin, multiplicity of spectral lines, idea of spin quantum number; physical idea of spin-orbit coupling, rotational (rigid rotator model) and vibrational (harmonic oscillator model) spectra of diatomics: frequency

		expressions, applications to estimate molecular parameters, idea of n →π* and π→π* electronic spectra; conjugated polyenes and 1-d box model. **Section 2: Inorganic Chemistry** **Periodicity:** General trends of periodic table, s-block, p-block, Hydrides, halides, oxides, oxoacids, nitrides, sulfides – shapes and reactivity. Acid-base concepts. **Transition Metals:** Coordination chemistry – structure and isomerism, theories of bonding (VSEPR, VBT, CFT, and MOT). Energy level diagrams in various crystal fields, CFSE, applications of CFT, Jahn-Teller distortion. Electronic spectra of transition metal complexes: spectroscopic term symbols, selection rules, Orgel diagrams, charge-transfer spectra. Magnetic properties of transition metal complexes. Reaction mechanisms: kinetic and thermodynamic stability, substitution, and redox reactions. **Organometallics:** 18-Electron rule; metal-alkyl, metal-carbonyl, metal-olefin and metal- carbene complexes and metallocenes. Fluxionality in organometallic complexes. Types of organometallic reactions. Homogeneous catalysis: Hydrogenation, hydroformylation, acetic acid synthesis, metathesis, and olefin oxidation. Heterogeneous catalysis: Fischer- Tropsch reaction, Ziegler-Natta polymerization. **Bioinorganic Chemistry:** Ion (Na^+ and K^+) transport, oxygen binding, transport and utilization, electron transfer reactions, nitrogen fixation, metalloenzymes containing magnesium, molybdenum, iron, cobalt, copper and zinc. **Solids:** Crystal systems and lattices, Miller planes, crystal packing, crystal defects, Bragg's law, ionic crystals, structures of AX, AX2, ABX3 type compounds, spinels, band theory. **Instrumental Methods of Analysis:** UV-visible spectrophotometry, NMR and ESR spectroscopy, mass spectrometry. Chromatography including GC and HPLC. Electroanalytical methodspolarography, cyclic voltammetry, ion-selective electrodes. Thermoanalytical methods. **Section 3: Organic Chemistry** **Stereochemistry:** Chirality of organic molecules with or without chiral centres and determination of their absolute configurations. Relative stereochemistry in compounds having more than one stereogenic centre. Homotopic, enantiotopic and diastereotopic atoms, groups and faces. Stereoselective and stereospecific synthesis.

		Conformational analysis of acyclic and cyclic compounds. Geometrical isomerism. **Reaction Mechanisms:** Basic mechanistic concepts – kinetic versus thermodynamic control, Hammond's postulate and Curtin-Hammett principle. Methods of determining reaction mechanisms through identification of products, intermediates and isotopic labelling. Nucleophilic and electrophilic substitution reactions (both aromatic and aliphatic). **Organic Synthesis:** Synthesis, reactions, mechanisms and selectivity involving the following classes of compounds – alkenes, alkynes, arenes, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, nitriles, halides, nitro compounds, amines and amides. Carbon-carbon bond forming reactions through enolates (including boron enolates), enamines and silyl enol ethers. Michael addition reaction. Stereoselective addition to C=Ogroups (Cram and Felkin-Anh models). **Pericyclic Reactions and Photochemistry:** Electrocyclic, cycloaddition and sigmatropic reactions. Orbital correlations - FMO and PMO treatments. Photochemistry of alkenes, arenes and carbonyl compounds. Photooxidation and photoreduction. Di-π-methane rearrangement, Barton reaction. **Biomolecules:** Structure, properties and reactions of mono- and di-saccharides, physicochemical properties of amino acids, chemical synthesis of peptides, structural features of proteins, nucleic acids, steroids, terpenoids, carotenoids, and alkaloids. **Spectroscopy:** Applications of UV-visible, IR, NMR and Mass spectrometry in the structural determination of organic molecules. **<u>Section 4: Laboratory Experiments</u>** **Quantitative Analysis:** Volumetric (acid-base, redox and complexometric titrations), Colorimetric (e.g., estimating Cu content in brass) and Gravimetric (e.g., estimation of Ni). **Kinetics Study:** Examining the order of chemical reactions. (Such as acid base catalyzed ester hydrolysis). **Viscometry Study:** Determine the intrinsic viscosity and the molecular weight of a polymer. **Qualitative Analysis:** Determine different radicals (both cations and anions) present in unknown salt. **Functional Group Analysis:** Identify different functional groups present in organic compounds using chemical methods and spectroscopic techniques.

		Synthesis and Characterization: Synthetic procedures for some commonly used compounds: Urea, Paracetamol, Aspirin and their derivatives and their characterization. **Extraction and Identification:** DNA from green peas, caffeine from tea leaves, glucosamine from crab shell. **Safety in Chemistry Lab:** Operation of fire extinguisher, Use of personal protective equipment, Introduction to Material Safety Data Sheet (MSDS) and personal protection equipment, General laboratory safety rules.
2.	Physics	**General Physics:** Units and measurements, Dimensional analysis, Newton's laws of motion, Force and acceleration, Graphical representations, Circular motions, Torque and angular momentum, Moment of inertia, Work and Energy, Collisions and conservation laws, Friction, Potential energy and equilibrium, Simple harmonic motion, Forced vibration and resonance, Newton's law of Gravitation and motion under gravity, Elasticity and Young's modulus, Heat transfer and concept of temperature, Ideal gas, Thermal expansion. **Waves and Optics:** Transverse and Longitudinal waves, Standing waves, Sound waves, Rectilinear propagation of light, reflection and refraction, lenses and curved mirrors, focal length, formation of images, interference and diffraction, electromagnetic spectrum. **Basics of Vector Analysis:** Concepts of scalar and vector, vector addition and subtraction, dot and cross products. **Electricity and Magnetism:** Electrostatics, Coulomb's law, Potential and Electric field, Capacitors, Current electricity, Ohm's law, V-I characteristics, Resistors in series and parallel, Electromagnetic induction, LCR circuit and resonance, Magnetic field lines, Oersted experiment, Biot-Savart law, Lorentz force. **Atoms and Nuclei:** Rutherford's experiment, Bohr's model of atom, Atomic spectra, Radioactivity, gamma-rays, alpha and beta decay. **Instrumentation and data analysis:** Vernier Caliper, Screw gauge, Simple pendulum, Voltmeter and Ammeter, Different types of thermometers, Prism, lenses and mirrors, Plane and crossed gratings, Gas discharge tubes, Solenoids and magnetic fields, Oscilloscopes, Radioactive sources and radiation hazards Collection and organization of data, Basics of probability and statistics.
3.	Mathematics	Sets, Relations and Functions, Trigonometric Functions, Inverse Trigonometric Functions, Complex Numbers and Quadratic Equations, Inequalities, Principle of Mathematical Induction, Permutations and Combinations, Binomial Theorem, Straight Lines, Conic Sections, Three-

		dimensional Geometry, Vectors, Matrices, Determinants, Linear Programming. Sequence and Series, Limits, Continuity and Differentiability, Applications of Derivatives, Differential Equations, Integrals, Applications of the Integrals. Probability and Statistics: Events, axiomatic probability, conditional probability, theorem of total probability, Bayes theorem, Collection of data, presentation of data, bar graphs, histograms, frequency polygons, Mean, median and mode, variance and standard deviation.