All India Institute of Medical Sciences, Jodhpur

Indicative Syllabus for the Examination for the Post of Junior Engineer (Electrical Engineering)

Please Note: Questions in the Examination may test the candidate's knowledge, skills and aptitude which the Institute expects from a graduate in Electrical Engineering with training and experience. The mentioned syllabus is only indicative and not exhaustive. Questions may / may not be related to the below listed topics.

Fundamentals of Electrical Engineering

D.C. Circuits: Units and dimensions, Ohm's Law, Kirchhoff's Law, Superposition theorem, Thevenin's theorem and their application for analysis of series and parallel resistive circuits excited by independent voltage sources, Power & Energy in such circuits. Mesh & nodal analysis, Star Delta circuits.

Single phase AC Circuits: Generation of sinusoidal AC voltage, definition of average value, R.M.S. value, form factor and peak factor of AC quantity , Concept of phasor, Concept of Power factor, Concept of impedance and admittance, Active, reactive and apparent power, analysis of R-L, R-C, R-L-C series & parallel circuit

Three phase AC Circuits: Necessity and advantages of three phase systems, Meaning of Phase sequence, balanced and unbalanced supply and loads. Relationship between line and phase values for balanced star and delta connections. Power in balanced & unbalanced three-phase system and their measurements

Magnetic Circuits: Basic definitions, magnetization characteristics of Ferro magnetic materials, self inductance and mutual inductance, energy in linear magnetic systems, coils connected in series, AC excitation in magnetic circuits, magnetic field produced by current carrying conductor, Force on a current carrying conductor. Induced voltage, laws of electromagnetic Induction, direction of induced E.M.F. single phase transformer- general construction, working principle, e.m.f. equation, open circuit and short circuit test

Electrical Machines: D.C. Motor & D.C. Generator, Three phase Induction motor and Synchronous Machines, their general construction, working principle, e.m.f equation and applications. Types of losses occurring in electrical machines.

Electrical Measurements and Instrumentation

Introduction, History and Overview of measurement system, Fundamental of Measurement system, static and Dynamic Characteristics, Error analysis, Loading effects, calibration of instruments. Galvanometers – Theory & operation of ballistic galvanometer, D'arsonal galvanometer, galvanometer motion & damping, Sensitivity, Flux meter, Vibration galvanometer, Spot deflection galvanometer. Definition of analog & digital instruments, Classification of analog instruments, their operating principle, Operating force, Types of supports, Damping, Controlling.

Different types of Ammeter & Voltmeter – PMMC, MI, Electrodynamometer, Hotwire, Electrostatic, Induction, Rectifier, Ferro dynamic & Electro-thermic, Expression for control & deflection torque, their advantages, disadvantages & error, Extension of range of instruments using shunt & multiplier, Ohmmeter – series & stunt type, Multi-meter.

Measurement of power: Power in AC and DC Circuit, Electrodynamometer type of wattmeter, Construction, theory, operation & error, Low power factor & UPF wattmeter, Double element and three element dynamometer wattmeter, Measurement of power in three phase circuit, one, two & three wattmeter method, Measurement of reactive power by single wattmeter

Electronic Energy meter – Single Phase and Three Phase, Testing by Phantom Loading , Trivector meter – Maximum demand meter , Power Analyser ,Power factor meter. Instrument transformers: Potential and current transformers, ratio and phase angle errors, testing of instrument transformers, Difference between CT and PT, errors and reduction of errors, Measurement of power using CTs &PTs.

Miscellaneous Instruments & Measurements:- Frequency meter – Vibrating reed, Resonance type & Weston type, Synchronoscope, IR Tester & Ratio meter. Resistance Measurement – Classification of low, medium & high resistance – Wheatstone Bridge, Kelvin's double bridge & loss of charge methods for resistance measurement, Earth resistance measurement. Magnetic Measurement – B-H Curve, Hysteresis Loop determination, Power loss in sheet metal – Lloyd Fischer square for measurement of power loss.

Network Analysis

Introduction to circuit elements R,L,C and their characteristics in terms of Linearity & time dependant nature, KCL and KVL, Mesh and Nodal analysis, dual networks, analysis of magnetically coupled circuits, Dot convention, coupling co-efficient, Tuned circuits, controlled and uncontrolled sources, voltage & current sources, source transformation

Network topology, concept of Network graph, Tree, Tree branch & link, Incidence matrix, cut set and tie set matrices. Transient analysis:- Transients in RL, RC& RLC Circuits, initial conditions in network, time constants. Network driven by constant driving sources & their solutions, RLC networks with sinusoidal and other driving sources Steady state analysis - Concept of phasor & vector, impedance & admittance, Series & parallel resonance

Network Theorems (for both AC and DC circuits) – Thevenin's & Norton's theorem, Superposition, Reciprocity, Compensation, Substitution, Maximum power transfer

Frequency domain analysis – Laplace transform solution of Integral-differential equations. Transform of Waveform – synthesized with step ramp, Gate and sinusoidal functions. Initial & final value theorem. Network Theorems in transform domain. Concept of signal spectra, Fourier series co-efficient of a periodic waveform. Wave form symmetries. Trigonometric & Exponential form of Fourier series, steady state response to periodic signals.

Network function & Two port networks – concept of complex frequency, Network & Transfer functions, poles and zeros, Necessary condition for driving point & transfer function, Time domain behavior from pole and zero plot. Two port parameters – Z, Y, ABCD, Hybrid parameters, their inverse & image parameters, relationship between parameters. Interconnection of two ports networks. Terminated two port networks.

Analog Electronics

Semiconductor Diodes : Theory of P-N junction, temperature dependence and break down characteristics, junction capacitances, Zener diode, Varactor diode, Tunnel diode, PIN diode, LED, Photo diode, Schottky diode, Diode applications: series –parallel configurations, full wave and half wave rectification, voltage multiplier circuits, diode testing

Transistors: BJT, types & configuration, working principal, characteristics, and region of operation, load line, biasing methods, Small signal analysis of transistor (low frequency) using hparameters, thermal runaway and thermal stability. FET, MOSFET, Transistor as an amplifier, gain, bandwidth, frequency response,

Feedback amplifier and Oscillators: Feedback amplifier, negative feedback, voltage-series, voltage shunt, current series and current shunt feedback, Sinusoidal oscillators, L-C (Hartley-Colpitts) oscillators, RC phase shift, Wien bridge, and Crystal oscillators. Power amplifiers, class A, class B, class A B, C amplifiers, their efficiency and power Dissipation, Push-pull and complimentary symmetry push-pull amplifier.

Wave Shaping circuits: Switching characteristics of diode and transistor, turn ON, OFF time, reverse recovery time, transistor as switch, Multivibrators, Bistable, Monostable, Astablemultivibrators. Clipper and clamper circuit, Differential amplifier, calculation of differential, common mode gain and CMRR using h- parameters, Darlington pair, Boot strapping technique. Cascade and cascade amplifier.

Operational Amplifier: Operational amplifier basics, practical Op-amp circuits & characteristics, slew rate, bandwidth, offset voltage ,basic current, application, inverting, non-inverting amplifier, summer, average, differentiator, integrator, differential amplifier, instrumentation amplifier, log and antilog amplifier, voltage to current and current to voltage converters, comparators Schmitt trigger , active filters, 555 timer and its application.

Material Science

Classes of Engineering Materials:-Atomic Structure and bonding in materials. Crystal Structure of the material, Crystal System, unit cells and space lattices and defects. Classification of solids from electrical engineering point of view. Conducting material – properties of conductors, characteristics of good conductor material, commonly used conducting materials, conductor materials for overhead lines, types of conductors, conductor for underground cables, conductor materials used for electrical machines winding, resistor materials, types of resistors, materials for bus bar. Metals and Alloys.

Dielectric Materials: Dielectric strength, factors affecting dielectric strength, dielectric loss, dissipation factor, factors affecting dielectric loss, permittivity & polarization, charging and discharging of dielectric, conduction through dielectric. Application of dielectric, different types of capacitors and materials used for them. Insulating materials, their properties – thermal, chemical, mechanical & electrical. Insulating materials like ceramic, mica, glass, rubber, resins, wax varnishes, Class of Insulation. Transformer oils & their testing. Piezoelectricity & Ferro electricity.

Applications of semi conductor materials: type of semi conductors, working and applications of semiconductors, Temperature sensitive elements, photoconductive cells, photo voltaic cells; Varistor, Hall effect generator, LCD, Light dependent resistors, LEDs, piezo – electric materials, semiconductor laser and its characteristics, photo conductors – photo diodes, avalanche photo diode, photo transistors.

Classification of magnetic materials: Dia-magnetism, Para magnetism, Ferro- magnetism, magnetization curve, hysteresis loop, Magnetostriction, Factors affecting permeability and hysteresis, Anti – ferromagnetism, Ferromagnetism, Magnetic resonance, B-H curve for different magnetic materials, loss of magnetism, impurities in ferromagnetic materials, soft and hard magnetic materials, ferrites.

Special Purpose Materials: - Thermo couple, soldering, fuse, contact, refractory, fluorescent & phosphorescent, galvanizing and impregnation. Superconductivity & Its Application, Thermoelectric generator, Thermionic conductors. Physical properties & Electrical Properties of SF6 and its applications, Optical fibers, Materials of MHD generator, Thermoelectric generators.

Power System

An overview of Electrical Energy Generation: General discussion on various types of conventional, non-conventional & distributed Generation power sector reforms, ecological aspects of Power Generation. Comparison of isolated versus interconnected power system. Hydro-Electric Stations: Choice of site operation & working. Thermal Power Stations: Choice of coal fired station site, operation & working. Problems associated with modern large interconnected power system. Power Plant Economics - Load curves, base load, peak load, load factor, demand factor, diversity factor, capacity factor, utilization factor, cost of electricity, capital cost, fuel and operation cost.

Transmission Line Components & Under Ground Cabling: Inductance resistance and capacitance of transmission line, Calculation of inductance for 1-ϕ and 3-ϕ, Single and double circuit line, types of conductors and spacing of conductors, constants of overhead transmission lines. Concept of GMR and GMD, Calculation of capacitance for 2 wire and 3 wire systems, Effect of ground or capacitance, Capacitance calculation for symmetrical and asymmetrical 1-phase and three phase, Single and double circuit line, Charging current, Transposition of line, Composite conductor, Skin and proximity effect, bundle conductor. Underground Cable Comparison of cables and overhead transmission lines, Classification of cables, requirement of cable construction, capacitance of single and multi-core cable, economic core diameter, dielectric stress in cable, Grading of cables, ionization of Heating of cables, Phenomena of dielectric losses and sheath loss in cables, Thermal resistance of cables.

Transmission systems & performance of transmission line: Various systems of transmission, effect of system voltage, comparison of conductor materials required for various overhead systems. Short, Medium & long transmission line and their representation, Nominal T, Nominal Π, Equivalent T and equivalent Π, network models, ABCD constants for symmetrical & asymmetrical network, Mathematical solution to estimate regulation & efficiency of all types of lines. Surge Impedance, loading, Interpretation of long line equation and its equivalent equation. Tuned power lines. Power flow through transmission line, Circle diagram, Method of voltage control, Static & rotating VAR generator, transformer control. Phenomenon of corona, potential gradient, break down voltages, corona power loss.

Insulator & Mechanical design: Mechanical Design Types of conductors used in overhead transmission line, Types of line supports and towers, Distribution of conductors over transmission towers, Spacing between conductors, Length of span and sag- tension calculation for transmission line, Wind & ice loading, support of line at two different levels, string chart, Sag template, Stringing of conductor, Vibration and Vibration dampers. Insulator Materials used for transmission line insulations, Types of insulator for overhead transmission line failure of insulator, Voltage distribution of suspension insulator, String efficiency, Shielding and grading.

Voltage control & Distribution system Ac single phase, 3 phase, 3wire & 4 wire distribution, Kelvin's law for most economical size of conductor Substation layout showing substation equipment, bus bar single bus bar and sectionalized bus bar, main and transfer for bus bar system, sectionalized double bus bar system, ring mains.

Digital Electronics Logic Design

Number Systems and Codes: Digital number systems, base conversion, Binary, Decimal, octal, Hexadecimal, number system with radix r, Gray codes. Alphanumeric codes – ASCII code and BCD codes, concept of parity, complement r's & (r-1)'s, subtraction with complements, signed Binary numbers, Error Detecting & Correcting codes. Basic Theorems & Properties of Boolean algebra: AND, OR, NOT operators, laws of Boolean algebra, Demorgon's theorem, Boolean expression & logic diagram. Negative logic, Alternate logic gate representation (concept of bubbled gates) canonical and standard Forms (Minterms & Maxterms), sum of minterms & product of maxterms, conversion between canonical forms. Truth table & maps, 2,3,4,5 and 6 variable maps, solving digital problems using Maps, Don't care conditions, Tabular minimization. Sum of product & product of sum reduction, Exclusive OR & Exclusive NOR circuits, Parity generator & checkers.

Combinational Circuits: Design procedure, Adders (half and Full), subtractor (half and full) code convertors, Analysis of design, Universal building blocks, Implementation of any logic circuit with only NAND gates or with only NOR gates, Binary serial adder, parallel adder, serial/parallel adder, look ahead carry generator, BCD adder, Binary multiplier, Magnitude comparator, Decoder, Demultiplexer, Encoders, priority encoder, Multiplexers & implementation of combinational logic diagram.

Sequential Logic Circuit :Latches, SR latch with NAND & NOR gates, D latch, edge triggered flip flop, J-K flip flop, T flip flop, Master slave flip flop, Analysis of clocked sequential circuit, state table, state diagram, state reduction state equations, state assignments, flip flop excitation table & characteristic equations, Design procedure for sequential circuits, Design with state reduction, Applications of flip flop.

Registers and Counters : Asynchronous and Synchronous counter, counters with MOD numbers, Down counter, UP/DOWN counter, propagation delay in ripple counter, programmable counter, Pre- settable counter, BCD counter, cascading, counter applications, Decoding in counter, Decoding glitches, Ring Counter, Johnson counter, Rotate left & Rotate right counter, Registers – Buffer, Shift left, shift right, shift left/Right registers, parallel in parallel out, serial in serial out, parallel in serial out, serial in parallel out registers.

Random Access Memory, Timing waveform, Memory Decoding, Internal Construction, Coincident decoding, Address multiplexing, Read only memory – Combinational circuit implementation, Type of ROMs, combinational PLDs, Programmable Logic Array (PLA), Programmable Array Logic (PAL), sequential programmable device. Analog to digital conversion – Ramp type, dual slope, integration, successive approximation, parallel conversion, parallel/ serial conversion, convertor specifications, Digital to Analog convertors – Binary weighted & R/2R D to A convertor

Electrical Machines

Transformer: Working principle, e.mf. equation, construction, phasor diagrams, equivalent circuit, voltage regulation, losses, separation of hysteresis and eddy current losses, efficiency, tests: open circuit and short circuit, load, Sumpner's test, Condition for maximum efficiency and regulation, Power and distribution transformer, all day efficiency, Excitation phenomenon. Autotransformer: working, advantages, its equivalent circuit and phasor diagram.

Three phase transformer: its construction, groups and connections, their working and applications; Scott connection; Parallel operation of Transformers: application, advantages, requirement and load sharing; Tap changers, cooling, conservator and breather. Pulse and high frequency transformers.

Three phase Induction Motor: Working principle, construction, comparison of slip ring and squirrel cage motors, steady state analysis, phasor diagram and equivalent circuit, power flow diagram, torque-speed and power-speed characteristics, Losses and efficiency, No load and block rotor test, circle diagram

Starting of squirrel cage and slip ring motors, power factor control, Cogging & Crawling, Double cage & Deep bar Indication Motor, impact of unbalanced supply and harmonics on performance, speed control, braking, Induction Generator. Applications

Single Phase Motors: Single Phase Induction motor; double revolving field theory, equivalent circuit and its determination, performance calculation, starting methods and types of single phase Induction motors: their working principle and applications, comparison with three phases Induction Motor. Single phase A.C. series motor, Servo motors, Linear Induction Motor

Control System

Modeling of dynamic systems: Electrical, Mechanical and hydraulic systems, Concept of transfer function, Laplace Transform, State space description of dynamic systems: Open and closed loop systems, Signal flow graph, Mason's formula, Components of control systems: Error detectors (Synchros & Potentiometer), Servomotors (AC & DC), tacho-generators, power amplifier, steeper motors.

Time –domain analysis of closed loop systems: Test signals, time response of first and second order systems, Time domain performance specifications, Steady state error & error constants Feedback control actions: Proportional, derivative and integral control.

Solution of state equation: Eigen values & eigenvectors digitalization state transitive matrix, stability Routh-Hurwitz stability analysis.

Characteristics equation of closed loop system root loci, construction of loci, Effect of adding, poles and Zeros on the loci, Stability by root loci. Frequency, Domain analysis, Bode plots, Effect of adding, poles and Zeros, Polar plot, Nyquist stability analysis, Relative stability: Gain and phase margins.

Design of control systems with PD/PI/PID Control in time domain and Frequency domain, lead -lag, Lag - lead compensation, Design of compensating networks.

Power Electronics

Power Supplies Power supply, rectifiers (half wave, full wave), performance parameters of power supplies, filters (capacitor, inductor, inductor-capacitor, pi filter), bleeder resistor, voltage multipliers .Regulated power supplies (series and shunt voltage regulators, fixed and adjustable voltage regulators, current regulator), switched regulator (SMPS), comparison of linear and switched power supply, switch mode converter (flyback, buck, boost, buk-boost converters).

Thyristors Silicon controlled rectifies (SCR), constructional features, principle of operation, SCR terminology, turn - on methods, turn- off methods, triggereing methods of SCR circuits, types of commutation, comparison of thyristors and transistors, thermal characteristics of SCR, causes of damage to SCR, SCR overvoltage protection circuit, seies and parrel operation of SCRs, Line commutated converters (half wave rectifier with inductive and resistive load, single phase and three phase full wave rectifiers).

Other members of SCR family Triacs, Diacs, Quadracs, recovery characteristics, fast recovery diodes, power diodes, power transistor, power MOSFET, Insulated gate bipolar transistor (IGBT), loss of power in semiconductor devices, comparison between power MOSFET, power transistor and power IGBT.