

GATE

Graduate Aptitude Test in Engineering

Instrumentation Engineering (IN)

Detailed Examination Syllabus

Compiled and formatted for quick reference and structured study planning

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Section 1 • Engineering Mathematics

■ Linear Algebra

Matrix algebra, systems of linear equations, consistency and rank, Eigenvalues and Eigenvectors.

■ Calculus

Mean value theorems, theorems of integral calculus, partial derivatives, maxima and minima, multiple integrals, Fourier series, vector identities, line, surface and volume integrals, Stokes, Gauss and Green's theorems.

■ Differential Equations

First order equations (linear and nonlinear), second order linear differential equations with constant coefficients, method of variation of parameters, Cauchy's and Euler's equations, initial and boundary value problems, solution of partial differential equations: variable separable method.

■ Analysis of Complex Variables

Analytic functions, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, residue theorem, solution of integrals.

■ Probability and Statistics

Sampling theorems, conditional probability, mean, median, mode, standard deviation and variance; random variables: discrete and continuous distributions: normal, Poisson and binomial distributions.

■ Numerical Methods

Matrix inversion, solutions of non-linear algebraic equations, iterative methods for solving differential equations, numerical integration, regression and correlation analysis.

Section 2 • Electricity and Magnetism

Coulomb's Law, Electric Field Intensity, Electric Flux Density, Gauss's Law, Divergence, Electric field and potential due to point, line, plane and spherical charge distributions, Effect of dielectric medium, Capacitance of simple configurations, Biot-Savart's law, Ampere's law, Curl, Faraday's law, Lorentz force, Inductance, Magnetomotive force, Reluctance, Magnetic circuits, Self and Mutual inductance of simple configurations.

Section 3 • Electrical Circuits and Machines

■ Circuit Elements & Transients

Voltage and current sources: independent, dependent, ideal and practical; v-i relationships of resistor, inductor, mutual inductance and capacitor; transient analysis of RLC circuits with dc excitation.

■ Network Theorems

Kirchhoff's laws, mesh and nodal analysis, superposition, Thevenin, Norton, maximum power transfer and reciprocity theorems.

■ AC Circuit Analysis

Peak, average and rms values of ac quantities; apparent, active and reactive powers; phasor analysis, impedance and admittance; series and parallel resonance, locus diagrams, realization of basic filters with R, L and C elements; transient analysis of RLC circuits with ac excitation.

■ Two-Port Networks

One-port and two-port networks, driving point impedance and admittance, open- and short-circuit parameters.

■ Machines

Single phase transformer: equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three phase induction motors: principle of operation, types, performance, torque-speed characteristics,

no-load and blocked rotor tests, equivalent circuit, starting and speed control; types of losses and efficiency calculations of electric machines.

Section 4 • Signals and Systems

Periodic, aperiodic and impulse signals; Laplace, Fourier and z-transforms; transfer function, frequency response of first and second order linear time invariant systems, impulse response of systems; convolution, correlation. Discrete time system: impulse response, frequency response, pulse transfer function; DFT and FFT; basics of IIR and FIR filters.

Section 5 • Control Systems

Feedback principles, signal flow graphs, transient response, steady-state errors, Bode plot, phase and gain margins, Routh and Nyquist criteria, root loci, design of lead, lag and lead-lag compensators, state-space representation of systems; time-delay systems; mechanical, hydraulic and pneumatic system components, synchro pair, servo and stepper motors, servo valves; on-off, P, PI, PID, cascade, feed forward, and ratio controllers, tuning of PID controllers and sizing of control valves.

Section 6 • Analog Electronics

Characteristics and applications of diode, Zener diode, BJT and MOSFET; small signal analysis of transistor circuits, feedback amplifiers. Characteristics of ideal and practical operational amplifiers; applications of op-amps: adder, subtractor, integrator, differentiator, difference amplifier, instrumentation amplifier, precision rectifier, active filters, oscillators, signal generators, voltage controlled oscillators and phase locked loop, sources and effects of noise and interference in electronic circuits.

Section 7 • Digital Electronics

Combinational logic circuits, minimization of Boolean functions. IC families: TTL and CMOS. Arithmetic circuits, comparators, Schmitt trigger, multivibrators, sequential circuits, flip-flops, shift registers, timers and counters; sample-and-hold circuit, multiplexer, analog-to-digital (successive approximation, integrating, flash and sigma-delta) and digital-to-analog converters (weighted R, R-2R ladder and current steering logic). Characteristics of ADC and DAC (resolution, quantization, significant bits, conversion/settling time); basics of number systems, Embedded Systems: Microprocessor and microcontroller applications, memory and input-output interfacing; basics of data acquisition systems, basics of distributed control systems (DCS) and programmable logic controllers (PLC).

Section 8 • Measurements

■ Fundamentals

SI units, standards (R, L, C, voltage, current and frequency), systematic and random errors in measurement, expression of uncertainty – accuracy and precision, propagation of errors, linear and weighted regression.

■ Bridges

Wheatstone, Kelvin, Megohm, Maxwell, Anderson, Schering and Wien bridges for measurement of R, L, C and frequency; Q-meter.

■ Instruments

Measurement of voltage, current and power in single and three phase circuits; ac and dc current probes; true rms meters, voltage and current scaling, instrument transformers, timer/counter, time, phase and frequency measurements, digital voltmeter, digital multimeter; oscilloscope, shielding and grounding.

Section 9 • Sensors and Industrial Instrumentation

■ Sensing Elements

Resistive, capacitive, inductive, piezoelectric, Hall effect sensors and associated signal conditioning circuits.

■ Transducers

Transducers for industrial instrumentation: displacement (linear and angular), velocity, acceleration, force, torque, vibration, shock, pressure (including low pressure), flow (variable head, variable area, electromagnetic, ultrasonic, turbine and open channel flow meters), temperature (thermocouple, bolometer, RTD (3/4 wire), thermistor, pyrometer and semiconductor).

■ Process Measurement

Liquid level, pH, conductivity and viscosity measurement. 4–20 mA two-wire transmitter.

Section 10 • Communication and Optical Instrumentation

■ Modulation

Amplitude and frequency modulation and demodulation; Shannon's sampling theorem, pulse code modulation; frequency and time division multiplexing, amplitude-, phase-, frequency-, quadrature amplitude, pulse shift keying for digital modulation.

■ Optical & Spectroscopic Instrumentation

Optical sources and detectors: LED, laser, photo-diode, light dependent resistor, square law detectors and their characteristics; interferometer: applications in metrology; basics of fiber optic sensing. UV-VIS Spectrophotometers, Mass spectrometer.