

SYLLABUS FOR WRITTEN TEST
INSTRUMENTATION AND SIGNAL PROCESSING
DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Part A : Mathematics

Linear Algebra: Matrix Algebra, Systems of linear equations, Eigenvalues, Eigenvectors.

Calculus: Mean value theorems, Theorems of integral calculus, Evaluation of definite and improper integrals, Partial Derivatives, Maxima and minima, Multiple integrals, Fourier series, Vector identities, Directional derivatives, Line integral, Surface integral, Volume integral, Stokes's theorem, Gauss's theorem, Divergence theorem, Green's theorem.

Differential equations: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Method of variation of parameters, Cauchy's equation, Euler's equation, Initial and boundary value problems, Partial Differential Equations, Method of separation of variables.

Complex variables: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula, Taylor series, Laurent series, Residue theorem, Solution integrals.

Probability and Statistics: Sampling theorems, Conditional probability, Mean, Median, Mode, Standard Deviation, Random variables, Discrete and Continuous distributions, Poisson distribution, Normal distribution, Binomial distribution, Correlation analysis, Regression analysis.

Part B : Specialization (30 marks)

Signals and Systems:

Continuous and Discrete Signal and Systems - Periodic, aperiodic and impulse signals; Sampling theorem; Laplace and Fourier transforms; impulse response of systems; transfer function, frequency response of first and second order linear time invariant systems, convolution, correlation. Discrete time systems - impulse response, frequency response, DFT, Z - transform; basics of IIR and FIR filters.

Analog and Digital Electronics:

Basic characteristics and applications of diode, BJT and MOSFET; Characteristics and applications of operational amplifiers - difference amplifier, adder, subtractor, integrator, differentiator, instrumentation amplifier, buffer, filters and waveform generators. Number systems, Boolean algebra; combinational logic circuits - arithmetic circuits, comparators, Schmitt trigger, encoder/decoder, MUX/DEMUX, multi-vibrators; Sequential circuits - latches and flip flops, state diagrams, shift registers and counters; Principles of ADC and DAC; Microprocessor- architecture, interfacing memory and input-output devices.

Measurements:

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. Bridges: Wheatstone, Kelvin, Maxwell, Anderson, Schering and Wien for measurement of R, L, C and

frequency, Q-meter. 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.

Control Systems:

Mathematical modeling and representation of systems, Feedback principle, transferfunction, Block diagrams and Signal flow graphs, Transient and Steady-state analysis of linear time invariant systems, Stability analysis using Routh-Hurwitz and Nyquist criteria, Bode plots, Root loci, Lag, Lead and Lead-Lag compensators; P, PI and PID controllers; State space model, Solution of state equations of LTI systems

Sensors and Industrial Instrumentation:

Resistive-, capacitive-, inductive-, piezoelectric-, Hall effect sensors and associated signal conditioning circuits; transducers for industrial instrumentation: displacement -linear and angular, velocity, acceleration, force, torque, vibration, shock, pressure, flow -variable head, variable area, electromagnetic, ultrasonic, turbine and open channel flow meters, temperature -thermocouple, bolometer, RTD, thermistor, pyrometer and semiconductor; liquid level, pH, conductivity and viscosity measurement. 4-20 mA two-wire transmitter.

Digital Signal Processing:

Fourier Analysis: Fourier analysis of continuous and discrete-time signals with periodic and aperiodic nature; discrete Fourier transform and its properties; signal analysis and synthesis based on DFT, fast Fourier transform algorithms: radix-2, radix-3 DIT, DIF FFT algorithms, butterfly structures, relationship between FFT and DFT.

Structure and Design of Digital Filters: Fundamental structures of digital filters, general considerations for design of digital filters; Internal representation of LTI systems; Design of FIR filters: Low pass, Band pass, High Pass filter designs, Parks-McClellan Method, Half-band FIR filters, Phase response of FIR filters, Analyzing FIR filters; Design of IIR Filters: Pole and zeros to analyze IIR filters, Impulse invariant Bilinear transform IIR filter designs, Optimized IIR filter design method, Comparison of FIR and IIR Filters.

Digital Signal Processing Techniques: Discrete Hilbert transform, sample rate conversion, multi-rate systems, comb filters, signal averaging, frequency sampling filters, quantization effects.

Biomedical Instrumentation:

Transducers and Electrodes: Principles and classification of transducers for Biomedical applications; Electrode theory, different types of electrodes. **Cardiovascular System Measurements:** Measurement of blood flow, blood flow, cardiac output, cardiac rate, heart sounds; Electrocardiograph; Phonocardiograph; Plethysmograph; Echo- cardiograph.

Respiratory System Measurements: Measurement of gas volume, flow rate, carbon-dioxide and oxygen concentration in exhaled air.

Instrumentation for Clinical Laboratory: Measurement of pH value of blood, ESR measurement, haemoglobin measurement, O₂ and CO₂ concentration in blood, GSR measurement, polarographic measurements. Measurement of Electrical Activity in Neuromuscular System and Brain: Neuron potential, muscle potential, electromyograph, brain potentials, electroencephalograph.

Medical Imaging Systems: Basic physics, Instrumentation, and image formation techniques in medical imaging modalities such as X-Ray, Computed Tomography, Single Photon Emission Computed Tomography, Positron Emission Tomography, Magnetic Resonance Imaging, Ultrasound.

Power System Instrumentation:

Voltage and Current Transformers: Voltage transformers for measurement and protection, errors, transient performance; capacitive voltage transformers and their transient behaviour; Current transformers for measurement and protection, composite errors, transient response.

Hydro Electric Power-Plant Instrumentation: Measurement of flow, level, pressure, temperature, hydraulic head and mechanical vibrations; Temperature scanners; Alarm annunciators.

Thermal Power-Plant Instrumentation: Measurement of gas flow; Gas and feed-water analysis; Flame monitoring; Steam turbine instrumentation.

Nuclear Power-Plant Instrumentation: Reactor safety, neutron flux measurement; Reactor power level and coolant measurements.