GATE Syllabus

Instrumental Engineering

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INSTRUMENTAL ENGINEERING

Subject Code: IN

Course Structure

Sections/Units	Topics
Section A	**Engineering Mathematics**
Unit 1	Linear Algebra
Unit 2	Calculus
Unit 3	Differential Equations
Unit 4	Analysis of complex variables
Unit 5	Probability and Statistics
Unit 6	Numerical Methods
Section B	**Electric Circuits**
Section C	**Signals and Systems**
Section D	**Control Systems**
Section E	**Analog Electronics**
Section F	**Digital Electronics**
Section G	**Measurements**
Section H	**Sensors and Industrial Instrumentation**
Section I	**Communication and Optical Instrumentation**

Course Syllabus

Section A: Engineering Mathematics

Unit 1: Linear Algebra

- Matrix algebra
- Systems of linear equations

- Eigen values and Eigen
- Vectors

Unit 2: 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

Unit 3: Differential equations

- First order equation (linear and nonlinear)
- Higher 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

Unit 4: Analysis of complex variables

- Analytic functions
- Cauchy's integral theorem and integral formula
- Taylor's and Laurent's series
- Residue theorem
- Solution of integrals

Unit 5: Probability and Statistics

- Sampling theorems
- Conditional probability
- Mean, median, mode and standard deviation
- Random variables
- Discrete and continuous distributions
- Normal, Poisson and binomial distributions

Unit 6: Numerical Methods

- Matrix inversion
- Solutions of non-linear algebraic equations
- Iterative methods for solving differential equations
- Numerical integration
- Regression and correlation analysis

Section B: Electrical Circuits

Unit 1: Voltage and current sources

- Independent, dependent, ideal and practical
- V-i relationships of resistor, inductor, mutual inductor and capacitor
- Transient analysis of RLC circuits with dc excitation

Unit 2: Kirchoff's laws

- Mesh and nodal analysis
- Superposition
- Thevenin
- Norton
- Maximum power
- Transfer
- Reciprocity theorems

Unit 3: 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
- One-port and two-port networks
- Driving point impedance and admittance
- Open- and short circuit parameters

Section C: Signals and Systems

- 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 D: 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, P-I, P-I-D, cascade, feedforward, and ratio controllers.

Section E: Analog Electronics

➢ Characteristics and applications of:
- Diode
- Zener diode
- BJT
- MOSFET

➢ Small signal analysis of transistor circuits, feedback amplifiers

➢ Characteristics of operational amplifiers

➢ Applications of opamps:
- Difference amplifier

- Adder
- Subtractor
- Integrator
- Differentiator
- Instrumentation amplifier
- Precision rectifier
- Active filters and other circuits

- Oscillators, signal generators, voltage controlled oscillators and phase locked loop

Section F: Digital Electronics

- Combinational logic circuits, minimization of Boolean functions
- IC families: TTL and CMOS
- Arithmetic circuits, comparators, Schmitt trigger, multi-vibrators, sequential circuits, flipflops, shift registers, timers and counters
- Sample-and-hold circuit, multiplexer, analog-todigital (successive approximation, integrating, flash and sigma-delta) and digital-toanalog 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, 8-bit microprocessor and microcontroller: applications, memory and input-output interfacing
- Basics of data acquisition systems

Section G: Measurements

- SI units, systematic and random errors in measurement, expression of uncertainty - accuracy and precision index, propagation of errors
- PMMC, MI and dynamometer type instruments:
  - DC potentiometer
  - Bridges for measurement of R, L and C, 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

Section H: 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 (including low pressure)
  - Flow (differential pressure, variable area, electromagnetic, ultrasonic, turbine and open channel flow meters)
  - Temperature (thermocouple, bolometer, RTD (3/4 wire)
  - Thermistor
  - Pyrometer and semiconductor
  - Liquid level, pH, conductivity and viscosity measurement

Section I: Communication and Optical Instrumentation

- Amplitude- and frequency modulation and demodulation
- Shannon's sampling theorem, pulse code modulation
- Frequency and time division multiplexing, amplitude-, phase-, frequency-, pulse shift keying for digital modulation
- Optical sources and detectors: led, laser, photo-diode, light dependent resistor and their characteristics
- Interferometer: applications in metrology
- Basics of fiber optic sensing