

RA	Robotics and Automation
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Part A: Common Section

Section A.1: Engineering Mathematics

Linear Algebra: Matrices- transpose, determinant, rank, eigenvalues and eigenvectors, trace, adjoint, solutions to system of linear equations.

Calculus: Functions of a single variable, limit, continuity, and differentiability, mean value theorems, indeterminate forms; evaluation of definite and improper integrals; double and triple integrals; partial derivatives, total derivative, Taylor series (in one and two variables), maxima and minima; gradient, divergence and curl, vector identities.

Differential Equations: First-order equations (linear and nonlinear); higher-order linear differential equations with constant coefficients; Euler-Cauchy equation; initial and boundary value problems; Laplace transforms; solutions of heat, wave, and Laplace's equations; Fourier series.

Probability and Statistics: Axioms of probability, conditional probability, mean, median, mode, standard deviation, random variables, expectation, binomial, Poisson, and normal distributions; hypothesis testing, Probability Density Function (PDF), Cumulative Distribution Function (CDF).

Numerical Methods: Solutions of linear and non-linear algebraic equations; integration by trapezoidal and Simpson's rules; finite differences, explicit single and multi-step methods for differential equations.

Section A.2: Basics of Mechatronics

Network Elements: Ideal voltage and current sources, dependent sources, R, L, C, M elements; Network solution methods: Kirchoff's laws (KCL, KVL), Node and Mesh analysis; Network Theorems: Thevenin's, Norton's Superposition and Maximum Power Transfer theorem; Transient response of DC and AC networks, sinusoidal steady-state analysis, resonance, two-port networks, balanced three-phase circuits, complex power and power factor in AC circuits.

Digital Circuits: Boolean algebra, combinational (multiplexers, encoders, decoders), and sequential circuits (flip-flops, counters).

Sensors: Resistive, capacitive, inductive, piezoelectric, Hall effect sensors and associated signal conditioning circuits; transducers for industrial instrumentation- displacement (linear and angular), velocity, acceleration, force, torque, pressure.

Actuators: Principles of operation, performance, torque-speed characteristics of hydraulic and pneumatic actuators, DC motors, stepper motors, and servo motors.

Engineering Mechanics: Free-body diagrams and equilibrium; friction and its applications- rolling friction, belt-pulley; trusses and frames; kinematics and dynamics of rigid bodies in plane motion.

Programming: Flowcharts and pseudo code; Programming in Python: data types, operators, expressions, conditional statements (if, elif, else, case) looping statements (while, for), loop control statements (break and continue), functions, arrays, dictionary, strings, recursion.

Data Structures: Stack, queue, linked list, binary search tree, binary heap, graph.

Section A.3: Principles of Robotics and Automation

Robotic classification- serial and parallel manipulators, geometrical configuration, Links and joints, Coordinate systems and degrees-of-freedom; Rotation matrices in 2D and 3D; homogeneous transformations, forward kinematics. Robot applications- point-to-point and continuous path control, types of end-effectors, robot accuracy and repeatability.

Computer Integrated Manufacturing- Automation in Manufacturing, Programmable Logic Controllers (PLCs) in manufacturing, Automated material handling systems, Automated storage and retrieval systems, Automated identification, detection and capture systems; computer numerical control; Basics of single and multi-axis positioning systems; Basics of concurrent design and manufacturing planning for automation.

Part B1: Electrical Engineering

Section B1.1 Analog Circuits and Embedded Systems

Analog filters - low-pass, high-pass, band-pass and band-reject; Amplifiers: biasing, equivalent circuit and frequency response, feedback amplifiers, operational amplifiers- characteristics and applications; oscillators; Voltage Controlled Oscillators and timers, Schmitt triggers, sample and hold circuits, Analog-to-Digital (A/D) and Digital-to-Analog (D/A) converters; Switched Mode Power Supplies (SMPS).

Microprocessor and microcontroller applications, components of microcontrollers (CPU, memory, I/O ports, timers), interrupt handling; memory and input-output interfacing; basics of data acquisition systems.

Section B1.2 Signals and Systems

Representation of continuous and discrete time signals, shifting and scaling properties, linear time-invariant and causal systems, Fourier series representation of continuous and discrete time periodic signals, Shannon's sampling theorem, Definitions and properties of Fourier Transform, Laplace Transform and Z transform; R.M.S. value, average value calculation.

Section B1.3 Control Systems

Mathematical modeling and representation of systems, feedback principle, transfer function, 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.

Part B2: Mechanical Engineering

Section B2.1 Mechanics of Materials

Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; concept of shear centre; deflection of beams; torsion of circular shafts; Euler's theory of columns; Castigliano's theorems; thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.

Section B2.2 Kinematics and Dynamics

Displacement, velocity, and acceleration analysis of plane mechanisms; dynamic analysis of linkages; gears and gear trains; balancing of reciprocating and rotating masses; gyroscope, Vibrations- free and forced vibration of single degree of freedom systems, the effect of damping, vibration isolation; resonance; critical speeds of shafts.

Section B2.3 Machine Design and Computer Integrated Manufacturing

Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, rolling and sliding contact bearings, brakes and clutches, springs. Basic concepts of Computer Aided Design (CAD)/Computer Aided Manufacturing (CAM) and their integration tools; additive manufacturing.