

PI	Production and Industrial Engineering
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Section 1:	Engineering Mathematics
Linear Algebra: Matrix algebra; Systems of linear equations; Eigenvalues and eigenvectors. Calculus: Functions of single variable; Limit, continuity and differentiability; Mean value theorems, Evaluation of definite integrals; Partial derivative; Total derivative; Maxima and minima; Gradient, divergence and curl; Vector identities; Directional derivatives; Line, Surface and Volume integrals; Stokes, Gauss and Green's theorems; Taylor series. Differential Equations: First order equations: linear and nonlinear; Higher order linear differential equations with constant coefficients; Cauchy's and Euler's equations; Initial and boundary value problems; Laplace transform. Probability and Statistics: Definitions of probability and sampling theorems; Conditional probability; Mean, median, mode and standard deviation; Linear regression, Random variables, Poisson, normal, binomial and exponential distributions. Numerical Methods: Numerical solutions of linear and nonlinear algebraic equations; Integration by trapezoidal and Simpson's rules; Single and multi-step methods for differential equations.	
Section 2:	General Engineering
Engineering Materials: Structure, physical and mechanical properties, and applications of common engineering materials (metals and alloys, semiconductors, ceramics, polymers, and composites – metal, polymer and ceramic based); Iron-carbon equilibrium phase diagram; Heat treatment of metals and alloys and its influence on mechanical properties; Stress-strain behavior of metals and alloys. Applied Mechanics: Engineering mechanics – equivalent force systems, free body concepts, equations of equilibrium; Strength of materials – stress, strain and their relationship; Failure theories; Mohr's circle (stress); Deflection of beams, bending and shear stresses; Thick and thin cylinders; Torsion. Theory of Machines and Design: Analysis of planar mechanisms, cams and followers; Governors and fly wheels; Design of bolted, riveted and welded joints; Interference/shrink fit joints; Friction and lubrication; Design of shafts, keys, couplings, spur gears, belt drives, brakes and clutches. Thermal and Fluids Engineering: Fluid mechanics – fluid statics, Bernoulli's equation, flow through pipes, laminar and turbulent flows, equations of continuity and momentum, capillary action; Dimensional analysis; Thermodynamics – zeroth, first and second laws of thermodynamics, thermodynamic systems and processes, calculation of work and heat for systems and control volumes; Air standard cycles; Heat transfer – basic applications of conduction, convection and radiation.	
Section 3:	Manufacturing Processes I
Casting: Types of casting processes and applications; Sand casting: patterns – types, materials and allowances; molds and cores – materials, making, and testing; design of gating system and riser; analysis of solidification and microstructure development; Other casting techniques: Pressure die casting, centrifugal casting, investment casting, casting defects and their inspection by non-destructive testing. Metal Forming: Stress-strain relations in elastic and plastic deformation; von Mises and Tresca yield criteria, concept of flow stress; Hot, warm and cold working; Bulk forming processes – forging, rolling, extrusion and wire drawing; Sheet metal working processes – blanking, punching, bending and deep drawing; Ideal work and slab analysis; Defects in metal working and their causes. Joining of Materials: Classification of joining processes; Principles of fusion welding processes using different heat sources (flame, arc, resistance, laser, and electron beam), heat transfer and associated losses; Arc welding processes - SMAW, GMAW, GTAW, plasma arc, submerged arc welding processes; Principles of solid state welding processes - friction welding, friction stir welding, ultrasonic welding; Welding defects - causes and inspection; Principles of adhesive joining, brazing and soldering processes. Powder Processing: Production of metal/ceramic powders, compaction and sintering of metals and ceramic	

powders.

Polymers and Composites: Polymer processing – injection, compression and blow molding, extrusion, calendaring and thermoforming; Molding of composites.

Section 4: Manufacturing Processes II

Machining: Orthogonal and oblique machining, single point cutting tool and tool signature, chip formation, cutting forces, merchant's analysis, specific cutting energy and power; Machining parameters and material removal rate; Tool materials, tool wear and tool life; Thermal aspects of machining, cutting fluids, machinability; Economics of machining; Machining processes - turning, taper turning, thread cutting, drilling, boring, milling, gear cutting, thread production; Finishing processes – grinding, honing, lapping and super-finishing.

Machine Tools: Lathe, milling, drilling and shaping machines – construction and kinematics; Jigs and fixtures – principles, applications, and design.

Advanced Manufacturing: Principles and applications of USM, AJM, WJM, AWJM, EDM, LBM, EBM, PAM, CHM, ECM; Effect of process parameters on material removal rate, surface roughness and power consumption; Additive manufacturing techniques: Fundamentals, stereolithography, fused filament fabrication, selective laser sintering, selective laser melting, directed energy deposition.

Computer Integrated Manufacturing: Basic concepts of CAD and CAM, CNC; Automation in manufacturing; Industrial robots – configurations, drives and controls; Cellular manufacturing and FMS - group technology; Introduction to Internet of Things and digital twins.

Section 5: Quality and Reliability

Metrology and Inspection: Accuracy and precision; Types of errors; Limits, fits and tolerances; Gauge design, Interchangeability, selective assembly; Linear, angular, and form measurements (straightness, flatness, roundness, runout and cylindricity) by mechanical and optical methods; Inspection of screw threads and gears; Surface roughness measurement by contact and non-contact methods.

Quality Management: Quality – concepts and cost; Statistical quality control – process capability analysis, control charts for variables and attributes and acceptance sampling; Six sigma; Total quality management, Just-in-Time inventory management; Quality assurance and certification - ISO 9001:2015, ISO 14001:2015; Integration of sustainable manufacturing with quality management.

Reliability and Maintenance: Reliability, availability and maintainability; Distribution of failure and repair times; Determination of MTBF and MTTR, reliability models; Determination of system reliability; Preventive and predictive maintenance and replacement, total productive maintenance.

Section 6: Industrial Engineering

Product Design and Development: Principles of product design, tolerance design; Quality and cost considerations; Product life cycle; Standardization, simplification, diversification; Value engineering and analysis; Concurrent engineering; Design for “X”.

Work System Design: Taylor's scientific management, Gilbreths' contributions; Productivity – concepts and measurements; Method study, micro-motion study, principles of motion economy; Work measurement – time study, work sampling, standard data, PMTS; Ergonomics; Job evaluation and merit rating.

Facility Design: Facility location factors and evaluation of alternate locations; Types of plant layout and their evaluation; Assembly line balancing; Material handling systems.

Section 7: Operations research and Operations management

Operation Research: Linear programming – problem formulation, simplex method, duality and sensitivity analysis; Transportation and assignment models; Integer programming; Markovian queuing models; Introduction to discrete event simulation.

Engineering Economy and Costing: Elementary cost accounting and methods of depreciation; Break-even analysis; Activity based costing.

Production Control: Forecasting techniques – causal and time series models, moving average, exponential

smoothing, trend and seasonality; Aggregate production planning; Master production scheduling; MRP, MRP-II and ERP; Routing, scheduling and priority dispatching; Push and pull production systems, concepts of lean and agile manufacturing systems; Logistics, distribution, and supply chain management; Inventory – functions, costs, classifications, deterministic inventory models, quantity discount; Perpetual and periodic inventory control systems.

Project Management: CPM, PERT and Gantt chart. Time-cost tradeoff.