# ME Mechanical Engineering

## Section 1: Engineering Mathematics

Linear Algebra: Matrix algebra, systems of linear equations, eigen values and eigen vectors.

Calculus: Functions of 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, Fourier series; gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, applications of Gauss, Stokes and Green's theorems.

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.

Complex Variables: Analytic functions; Cauchy-Riemann equations; Cauchy's integral theorem and contour integral formula; Taylor and Laurent series.

Probability and Statistics: Definitions of probability, sampling theorems, conditional probability; mean, median, mode and standard deviation; random variables, binomial, Poisson and normal distributions.

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations; integration by trapezoidal and Simpson's rules; single and multi-step methods for ordinary differential equations.

## Section 2: Applied Mechanics and Design

Engineering Mechanics: Free-body diagrams and equilibrium; friction and its applications including rolling resistance, belt-pulley, brakes, clutches, screw jack, wedge, vehicles, etc.; plane trusses and frames; virtual work; kinematics and dynamics of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations.

Mechanics of Materials: Stress and strain, elastic constants and their relationships; stress and strain components transformations in 2D; Mohr's circle for plane stress and plane strain; thin-walled pressure vessels; 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; energy methods; thermal stresses; strain gauges and rosettes; Mechanical properties of materials, toughness, hardness, impact strength.

Theory of Machines: Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope.

Vibrations: Free and forced vibration of linear systems with single and two degrees of freedom, damping estimation and effects; vibration isolation, transmissibility ratio; resonance; critical speeds of shafts; Control system, PID controller, transfer function.

Machine Design: Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; principles and design of machine elements such as bolted, riveted and welded joints; shafts, gears, belt drives, rolling and sliding contact bearings, brakes and clutches, springs.

## Section 3: Fluid Mechanics and Thermal Sciences

Fluid Mechanics: Fluid properties; fluid statics, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; concept of velocity potential; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings; One dimensional high speed compressible fluid flow; flow through converging and converging-diverging nozzles.

Heat Transfer: Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes; boiling and condensation; effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan- Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis.

Thermodynamics: Thermodynamic systems and processes; properties of pure substances, behaviour of ideal and real gases; zeroth, first and second laws of thermodynamics, calculation of work, heat, energy changes and entropy changes in various processes; application of first and second laws for analysis of closed and open systems; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.

Applications: *Power Engineering:* vapour and gas power cycles, concepts of regeneration and reheat; *I.C. Engines:* Air-standard Otto, Diesel and dual cycles; *Basics of Combustion:* Air- Fuel Ratio, Equivalence Ratio; *Refrigeration and air-conditioning:* Vapour and gas refrigeration and heat pump cycles, properties of moist air, psychrometric chart, basic psychrometric processes; *Turbomachinery:* Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines, steam and gas turbines, Air and gas compressors, pumps and pump characteristics.

## Section 4: Materials, Manufacturing and Industrial Engineering

Engineering Materials: Crystal structure of common metals, phase diagrams, heat treatment; Properties and applications of engineering materials - metals and alloys, polymers, composites and ceramics; Engineering and true stress-strain diagrams.

Casting, Forming and Joining Processes: Different types of casting processes; Patterns, moulds and core; Solidification and cooling, riser and gating design, casting defects; Plastic deformation and yield criteria; Hot working and cold working; Principles of bulk forming and sheet forming processes and estimation of load in these processes; Fundamentals of powder metallurgy and its applications; Principles of welding, brazing, soldering; Solid-state welding processes, adhesive bonding; Non-destructive testing methods.

Machining and Machine Tool Operations: Basic machining operations and machine tools; Single-point and multipoint cutting tools; Geometry of single-point turning tools - ASA and ORS systems; Mechanics of machining; Cutting tool materials, tool life and tool wear; Economics of machining; Abrasive machining processes; Principles and applications of non-traditional machining processes; Principles of work holding, jigs and fixtures.

Additive Manufacturing: Principles of different types of additive manufacturing processes for engineering materials; Additively manufactured products – advantages, limitations, and applications.

Metrology and Inspection: Limits, fits and tolerances; Linear and angular measurements; Comparators; Interferometry; Form and finish measurement; Alignment and testing methods; Tolerance analysis in manufacturing and assembly; Principle of coordinate- measuring machine (CMM).

Computer Aided Manufacturing and Automation: Basic concepts of CAD/CAM and their integration tools; NC/CNC machines and CNC programming; Pneumatic, electro-pneumatic, and hydraulic actuators for automation; Programmable logic controllers.

Production Planning and Control: Work study, Productivity, Forecasting models, Aggregate production planning, Scheduling, Materials requirement planning, Six sigma, Lean manufacturing, Inventory Control – deterministic models, safety stock, inventory control systems, Quality and reliability concepts for product lifecycle analysis.

Operations Research: Linear programming, Simplex method, Transportation, Assignment, Network flow models, Simple queuing models, PERT and CPM.