Mechanical Engineer

Syllabus

I. FLUID MECHANICS & THERMAL SCIENCES

PART A: FLUID MECHANICS

Properties and Fluid statics

Basic concepts and properties of fluids, viscosity, compressibility, fluid statics, pressure variation in static fluids, manometry, hydrostatic forces on submerged surfaces, buoyancy and stability of floating bodies.

Fluid Kinematics and Dynamics

Control volume analysis of mass, momentum and energy, fluid acceleration, differential equations of continuity and momentum, equations of motion, Bernoulli's equation and applications.

Viscous Flow

Viscous flow of incompressible fluids, laminar and turbulent flows, elementary turbulent flow, flow through pipes, major and minor head losses in pipes, bends and fittings.

Boundary Layer and Similarity

Boundary layer concept, thermal and velocity boundary layers, boundary layer separation, dimensional analysis, Buckingham π theorem, model laws and similarity.

PART B: HEAT TRANSFER

Conduction

Modes of heat transfer, one-dimensional steady heat conduction, thermal resistance concept and electrical analogy, composite walls, fins, unsteady heat conduction, lumped parameter system.

Convection

Free and forced convection, thermal boundary layer, dimensionless parameters (Re, Pr, Gr, Nu), heat transfer correlations for flow over flat plates and through pipes, effect of turbulence.

Radiation

Radiative heat transfer, Stefan–Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis, radiation heat transfer coefficient.

Heat Exchangers

Heat exchanger performance analysis, LMTD method, Effectiveness–NTU method.

PART C: THERMODYNAMICS

Basic Thermodynamics

Thermodynamic systems and processes, properties of pure substances, thermodynamic property charts and tables.

Laws of Thermodynamics

Zeroth, First and Second Laws of Thermodynamics, work and heat interactions, control volume analysis.

Entropy, Availability and Irreversibility

Entropy, availability (exergy), irreversibility, thermodynamic relations.

Gases and Gas Mixtures

Ideal and real gases, compressibility factor, gas mixtures.

PART D: THERMAL ENGINEERING APPLICATIONS

Power Engineering

Vapour and gas power cycles, Rankine and Brayton cycles with regeneration and reheat, fuels and their properties, flue gas analysis, boilers, condensers, cooling towers, air ejectors, electrostatic precipitators.

Internal Combustion Engines

Air-standard Otto, Diesel and Dual cycles, SI and CI engines, engine systems and components, performance characteristics and testing, fuels, emissions and emission control.

Refrigeration and Air Conditioning

Vapour and gas refrigeration and heat pump cycles, vapour compression and vapour absorption systems, refrigerants, compressors, condensers, evaporators, expansion devices, properties of moist air, psychrometric chart and processes, other refrigeration systems.

Turbo machinery

Impulse and reaction principles, velocity diagrams, Pelton, Francis and Kaplan turbines, steam and gas turbines, pumps, compressors, air and gas compressors, basics of jet propulsion.

II. MANUFACTURING TECHNOLOGY & MATERIAL SCIENCE

Engineering Materials: Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials.

Metrology: Limits, Fits, Tolerances, plug, ring and snap gauges, surface roughness-basics.
Manufacturing process: Casting: Casting process, sand casting, die casting *(Process steps, advantages, defects)*

Welding: Gas welding – Arc welding- Butt and Lap joints- Heat affected zone*(Principles, application and, defects)*

Metal Forming: Forging (basic concepts) – Wire, rod and tube drawing-Bending – extrusion, Powder Metallurgy.

Machine Tools: Lathe operations (facing, turning, threading), drilling machines (operations), Milling machine (identification and purpose only). Cutting tools: Single point vs Multi point cutting tools, tool materials (HSS, Carbide), cutting parameters (speed, feed, depth of cut).

Heat treatment of materials: Annealing, Normalising, Hardening, Tempering (purpose and effects on properties)

Jigs and Fixtures: Difference between jigs and fixtures, Advantages.

CNC AND PLC: CNC: Basic concepts, Coordinate system, PLC: block diagrams, Ladder logic basics (*Simple Numerical problems*)

Advanced machining processes: Electro chemical Machining (ECM), Electron Discharge Machining (EDM), Laser Beam Machining (LBM).

III. MANAGEMENT

Principles and Functions of Management: Henry Fayol's Administrative Management-Taylor's scientific management, Functions of management.

Forecasting: Simple methods - Numerical problems.

Decision making: Strategic vs Operational. Decision under Certainty, Uncertainty and Risk

Organisation structure: Line, staff and Matrix organisation-Scalar chain, Leadership styles, Managerial skills.

Motivation: Maslow's hierarchy theory of needs, Herzberg's two factor theory, Mc Gregor's theory X and theory Y.

Human Resource Management: Recruitment vs selection, Training vs Development, Performance appraisal, Incentives and wage systems (time rate and piece rate).

Communication management: Oral, written, formal and informal, Barriers to communication

Inventory and Store Management: EOQ model, EPQ model (Assumptions and Numerical problems), stock levels: maximum, minimum and reorder level. Store layout, codification.

Project Management: CPM, PERT, critical path, crashing. (Numerical problems)

Marketing Management: Pricing, Product, Place and Promotion mix (Basic concepts)

Financial Management: Profit and Wealth Maximisation, Types of costs: Fixed. Variable and semi variable costs, Direct and Indirect costs. Budgeting (basics), Cash flow statement (meaning and purpose), Working Capital, Liquidity ratios. Break Even Analysis: Basics (Numerical problems).

Basics of Entrepreneurship and MSME: Role of MSME, small scale industry-advantages.

IV. APPLIED MECHANICS AND DESIGN

Engineering Mechanics: Free-body diagrams and equilibrium, friction and its applications, 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, 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, energy methods, thermal stresses, strain gauges and rosettes, testing of materials with universal testing machine, testing of hardness and 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 single degree of freedom systems, effect of damping, vibration isolation, resonance, critical speeds of shafts.

Machine Design: 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, gears, rolling and sliding contact bearings, brakes and clutches, springs.

V. ENGINEERING MATHEMATICS

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

Calculus: Functions of single variable, limit, continuity and differentiability, double and triple integrals, partial derivatives, total derivative, Taylor series (in one variable), 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.

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 differential equations.
