MATERIALS SELECTION IN MECHANICAL DESIGN (3-0-0)

Module I **(12 hours)**

Introduction: Materials properties – chemical, physical, mechanical, dimensional; Materials categories; Design process, conceptual design, embodiment design, detail design; Ideology of optimization, materials selection charts.

Performance indices: Performance, objective function, constraints, performance index; Calculational Model, Measure of Performance, Equations for constrained variables; Design-fixed parameters, free parameters.

Optimization of selection without considering shape effects: Recipe for optimization, Applying performance indices to selection charts; Primary constraints; Reality Check; Case studies – mirrors for large telescopes, table legs, structural materials for buildings, flywheels, springs, elastic hinges and couplings, pressure vessels, Vibration effects, stiff and high damping materials; Thermal effects, insulations, solar heating, heat exchangers.

Module II **(14 hours)**

Manufacturing and process selection: Classification of manufacturing processes, review of shaping, joining and finishing processes, Strategy for processes selecting, translation, screening, ranking; Selection charts, process-material matrix, process-shape matrix, mass bar-chart, thickness bar-chart, tolerance and surface-roughness bar-charts; Manufacturing cost; Case studies: forming a fan, fabricating a pressure vessel, economical casting.

Multiple Constraints in Materials Selection – Overconstrained Design: Decision matrices, selection stages, coupling equations, value functions; Multiple Selection Stage Method, Active Constraint Method, Coupling Equation Method; CES Software; Fully determined design; Massively overconstrained designs; Conflicting objectives, penalty functions and exchange constants; Case studies – shipbuilding, con-rods for high-performance engines, windings for high-field magnets, casing for mini-disk player or cell phone, disk-brake caliper.

Module II **(10 hours)**

Optimization of selection considering shape effects: Shape factors, Microscopic or micro-structural shape factors; Limits to shape efficiency, stiffness-limited design, strength-limited design, material indices that include shape, elastic bending of beams and twisting of shafts, failure of beams and shafts, co-selection of material and shape; Case studies – choosing optimal I-beam, spars for man-powered planes, ultra-efficient springs, forks for a racing bicycle.

Designing hybrid materials: Families of configurations of hybrid materials - composites, sandwiches, lattices and segmented; method “A+B+configuration+scale”; Anisotropy; Case studies – metal matrix composites, refrigerator walls, natural materials.

Text book

1. M. F. Ashby, MATERIALS SELECTION IN MECHANICAL DESIGN, Third Edition

Reference books

1. J. E. Gordon, *The New Science of Strong Materials, or Why You Don't Fall Through the Floor*, Princeton University Press, Princeton, NJ.
2. J.E. Gordon, *Structures, or Why Things Don’t Fall Down,* Da Capo Press.
3. M. F. Ashby and D. R. H Jones, *Engineering Materials Parts 1, 2, and 3*, Pergamon Press, Oxford, UK.
4. F. A. A. Crane and J. A. Charles, *Selection &Use of Engineering Materials*, Butterworths, London, UK.