

MFPC3002 MATERIAL DEFORMATION PROCESSES (3-0-0)

Course Objectives:

This course explores material deformation mechanisms, covering elastic/plastic behavior, dislocation theory, and strengthening methods. Students will analyze yield criteria, work hardening, fracture mechanisms (ductile/brittle), and high-temperature deformation. Emphasis is placed on constitutive models, stress-strain relationships, and applications in composites and polycrystalline materials.

Module-I: (08 Hours)

Introduction: Scope of the subject, elastic, plastic, and anelastic deformation. Constitutive equations in elasticity for isotropic and anisotropic materials, strain energy, elastic stiffness and compliance tensor, crystal structure and elastic constants. Plastic response of materials - different types of uniaxial stress-strain curves. Equivalent stress and strain.

Module-II: (06 Hours)

Levy-Mises and Prandtl-Reuss equations. Deformation theory of plasticity. Yield surface, Isotropic and kinematic hardening- Bauschinger effect. Elements of dislocation theory- crystallography, elastic properties, dislocations and their interactions in different crystal structures, origin and multiplication of dislocations, thermally activated dislocation motion.

Module-III: (05 Hours)

Critical resolved shear stress in single crystals. Work hardening in single and polycrystals. Strengthening mechanisms in polycrystals – role of grain boundaries, solid solution, precipitates and dispersoids, order-disorder transformation.

Module-IV: (05 Hours)

Mechanical properties of composites. Elevated temperature deformation mechanisms– cross slip, climb and grain boundary sliding. Deformation mechanism maps.

Module-V (06 Hours)

Fracture mechanisms of ductile and brittle fracture; fracture in creep and stress corrosion conditions; fractography. Griffith theory of brittle fracture. Concepts of stress concentrations and stress intensity factors, crack tip plastic zone. J and CTOD parameters. Ductile to brittle transition behavior.

Course Outcomes:

- CO1: Remembering (Knowledge): Define elastic/plastic deformation, yield surfaces, and dislocation properties in crystals.
- CO2: Understanding (Comprehension): Explain Levy-Mises equations, Bauschinger effect, and Griffith's brittle fracture theory.
- CO3: Applying (Application): Calculate equivalent stress/strain and analyze strengthening mechanisms (grain boundaries, precipitates).
- CO4: Analyzing (Analysis): Evaluate fracture modes (creep, stress corrosion) and deformation maps for elevated temperatures.
- CO5: Creating (Synthesis): Predict material behavior by integrating dislocation dynamics, hardening models, and fracture mechanics.

Text Books:

1. M. A. Meyers and K. K. Chawla, Mechanical Behavior of Materials, Second Edition, Cambridge, 2003.
2. Mechanical Metallurgy: By- Dieter, Mc Graw Hill Book Co.
3. D. Hull and DC Bacon, Introduction to dislocations, Elsevier Butterworth-Heinemann, 2009, ISBN: 978-81-312-2105-1.
4. R. Balasubramaniam, Callister's Materials Science and Engineering, Wiley-India, 2010.
5. Engineering Plasticity: BY- Johson & Mellor, Van Nostrand.