

MSE-227 Mechanical Behavior of Materials

Credit Hours: 3-0

Pre-requisites: Nil

Course Objectives

This course builds on the knowledge students already have about the mechanical behavior of engineering materials. Here, the emphasis will be on the elastic and plastic behaviors of different materials as well as on their fracture mechanics. The students will study in detail the mechanisms of elastic and plastic deformation. Additionally, students will learn how different materials may perform in a given situation. As a result, they will be able to select the best material for a particular application.

Course Contents

- A review of the structure of materials and crystalline imperfections. Elasticity (review of stress and strain concepts, Hooke's law, Elastic strain energy); Plasticity (Analysis of Stress-strain behavior, Yielding criteria of Metals and Hardness); Notches (Stress concentration factor, Neuber's rule, Tensile testing of notched specimens). Fracture Mechanics (Fracture modes; Linear elastic fracture mechanics: stress intensity factor and fracture toughness); Theoretical cohesive strength and Griffith criteria; Plain strain toughness testing; crack tip opening displacement (CTOD).
- Plastic deformation and role of Dislocations; types of dislocations; Slip systems; Critical resolved shear stress; Taylor factor; Dislocation interaction; Thermally activated processes; Intersection of dislocations. Ductile-brittle transition. Strengthening Mechanisms. Severe plastic deformation. Fracture behavior of metallic materials (ductile, brittle fractures); different types of embrittlements; Stress-corrosion cracking. Fatigue and creep deformation and fracture (Structural changes; theories and mechanism of crack initiation and propagation; Materials' selection).
- Mechanical behavior of thin films and coatings; Mechanical behavior of Polymers, Ceramics, glasses and composites; Weibull Modulus

Course Outcomes

By the end of this course, students shall have:

1. Explain types and theories of different types of mechanical behaviors: reversible (elastic) and irreversible (plastic) deformations.
2. Describe theory of dislocations and its types and mechanisms of fracture in materials.

3. Differentiate fatigue & creep behaviors and demonstrate mechanical behavior of thin films/coatings.
4. Investigate mechanical design problems and metallurgical failures using knowledge of deformation and fracture of materials and formulate solutions.

Weekly Plan

Week	Topics
1	A review of the structure of materials and crystalline imperfections
2	Elasticity (review of stress and strain concepts, Hooke's law, Elastic strain energy); Plasticity (Analysis of Stress-strain behavior, Yielding criteria of Metals and Hardness);
3	
4	Notches (Stress concentration factor, Neuber's rule, Tensile testing of notched specimens)
5	Fracture Mechanics (Fracture modes; Linear elastic fracture mechanics: stress intensity factor and fracture toughness); Theoretical cohesive strength and Griffith criteria; Plain strain toughness testing; crack tip opening displacement (CTOD).
6	
7	
8	Plastic deformation and role of Dislocations; types of dislocations; Slip systems
9	Mid-Semester Exams
10	Critical resolved shear stress; Taylor factor; Dislocation interaction; Thermally activated processes; Intersection of dislocations. Ductile-brittle transition
11	
12	Strengthening Mechanisms. Severe plastic deformation. Fracture behavior of metallic materials (ductile, brittle fractures); different types of embrittlements; Stress-corrosion cracking
13	
14	Fatigue and creep deformation and fracture (Structural changes; theories and mechanism of crack initiation and propagation; Materials' selection), Mechanical behavior of thin films and coatings; Mechanical behavior of Polymers.
15	
16	Mechanical behavior of Ceramics, glasses and composites; Weibull Modulus
17-18	End Semester Exams

Suggested Books

1. Mechanical Behavior of Material, N. E. Dowling, S. L. Kampe, M. V. Kral, 5th ed. Pearson (2019)

2. Mechanical Behaviour of Engineering Materials: Metals, Ceramics, Polymers by J. Roesler, H. Harders, M. Baeker. 1st ed. Springer (2007)
3. Mechanical Metallurgy by G. E. Dieter. SI Metric ed. McGraw Hill Inc. (2002)
4. Deformation and Fracture Mechanics of Engineering Materials by R. W. Hertzberg, R. P. Vinci, J. L. Hertzberg. 6th ed. Wiley (2021).
5. Introduction to Dislocations by D. Hull, D. J. Bacon. 5th ed. Butterworth Heinemann (2011).