Materials Science & Engineering Program course offering

Mechanical Behavior of Materials
by Burç Mısırlıoğlu

Office: FENS G046
Office Hours: N/A yet (Feel free to stop by as long as I am available)

Course description: This course is intended as a bridge between introductory-to-intermediate materials science knowledge and mechanical behavior of various crystalline and amorphous systems (Junior or senior year students could find it beneficial). It covers the influence of microstructure on the mechanical behavior of materials including metallic alloys, polymers and ceramics. The main objective of the course is to describe the ways in which microstructure and defects are exploited to fabricate high-performance materials that are applied to today's technologies ranging from aerospace to toughened ceramics. The content includes and is not limitied to stress-strain relations, elastic and plastic deformation, dislocations, dislocation interactions, work hardening, vacancies, interaction of precipitates with defects, glass transition in polymers, creep in materials, brittle fracture and ductile fracture, case studies that span a wide variety of phenomena including fatigue in alloys.

The outline of the course can be summarized under the following titles:

1. Atomic bonding: An overview

   Types of atomic bonds in metals, ceramics and polymers
   Structure of engineering materials
   Structures of alloys, ceramics and polymers

2. Stress, strain and deformation

   Definition of stress and strain, engineering and true stress/strain
   Stress-strain curves
   Generalized Hooke's law, relations of elasticity, tensor representations
   Elastic deformation
   Normal strains and shear strain
   Principal and shear stresses on an arbitrary plane, Mohr's circle
   Overview on mechanical testing methods

3. Line and planar defects in crystalline inorganic materials and plastic deformation

   A general overview on commonly observed defects in crystalline solids
   Stress-strain curves: The plastic part in alloys
   Dislocation types and their characteristics
   Slip and shear
   Interaction of grain boundaries with dislocations
   Dislocation reactions

4. An overview of phase transformations, solid solutions

   Phase tranformations: Why do we need them?

Solid solutions, ordering and precipitates
Conditions for stabilization of a desired precipitate in a matrix

5. <u>Basic strengthening mechanisms of alloys</u>

   Work hardening
   Grain-boundary strengthening
   Precipitation hardening, solid solution hardening
   Dispersion hardening
   Comparison of ferrous alloy strengthening vs. non-ferrous alloys

6. <u>Fracture: Brittle fracture and ductile fracture</u>

   Formation of a crack in a crystal
   Fracture of metals and alloys
   Fracture of ceramics
   Modes of fracture
   Failure types of alloys
   Failure of polymer materials

7. <u>Creep and high temperature deformation</u>

   Vacancies at high temperatures and dislocation activation energy.
   Diffusion of vacancies under stress
   Polycrystalline creep vs. single crystal creep
   Creep embrittlement
   Dynamic annealing
   Creep resistant alloy design

8. <u>Some special materials, materials selection and case studies</u>

Reference Books (at the moment):

- Mechanical Metallurgy, George E. Dieter.
- Mechanical Behavior of Materials, Thomas H. Courtney.
- Physical Metallurgy Principles, Hill and Abbaschian
- Phase Transformations in Metals and Alloys, Porter and Easterling
- Principles of Polymer Engineering, McCrum, Buckley, Bucknall