

**MAT505 Mechanical Properties of Materials**  
**by Burç Mısırlıoğlu**

**Office: FENS G046**

**Office Hours: N/A yet (E-mail before wanting to contact me for questions and discussion)**

Course description: This course is intended to bridge the introductory materials science knowledge to mechanical behavior of various material systems. 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 explain the fundamentals laws of elasticity followed by plastic behavior and deformation. In the meantime, 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 will be described. The content includes and is not limited 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, viscoelastic behavior and case studies that span a variety of phenomena including fatigue in alloys.

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

1. Stress, strain and deformation (2-3 weeks)

Definition of stress and strain, engineering and true stress/strain  
Stress-strain curves  
Generalized Hooke's law, relations in elasticity, tensor representations  
Principal and shear stresses on an arbitrary plane, Mohr's circle

2. Line and planar defects in crystalline inorganic materials and plastic deformation (2 weeks)

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

3. Basic strengthening mechanisms of alloys (1-2 weeks)

Phase transformations: Why do we need them?  
Solid solutions, ordering and precipitates  
Conditions for stabilization of a desired precipitate in a matrix  
Work hardening  
Grain-boundary strengthening  
Precipitation hardening, solid solution hardening  
Dispersion hardening  
Comparison of ferrous alloy strengthening vs. non-ferrous alloys

4. Fracture: Brittle fracture and ductile fracture (2 weeks)

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

5. Creep and high temperature deformation (1-2 weeks)

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

6. Time dependent behavior, viscoelasticity (2 weeks)

Maxwell model, Kelvin-Voigt model, standard linear solid model and combinations thereof to represent time dependent deformation of materials, specifically polymers.

7. Some special materials, materials selection and case studies (depending on available time)

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

A number of documents from online resources and compiled by the lecturer will be shared with the class.