

MAE160

Mechanical Behavior of Materials

Designation: Required Course for ME

Catalog Data:

MAE 160 Mechanical Behavior of Materials (4)

Elasticity and anelasticity, dislocations and plasticity of crystals, creep, and strengthening mechanisms. Mechanical behavior of ceramics, composites, and polymers. Fracture: mechanical and microstructural aspects. Fatigue. Laboratory demonstrations of selected topics.

Prerequisites: grades of C- or better in MAE 20, MAE 130A or SE 101A, and MAE 131A.

Textbooks, Required Materials:

1. R. W. Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, 4th ed, Wiley 2006 or
2. M. A. Meyers and K. K. Chawla, Mechanical Behavior of Materials, Atlas Books, 2008

Prerequisites by Topic: Inorganic chemistry and physics, introductory materials science and engineering.

Class/Laboratory Schedule: 3 lecture hours and 1 discussion hour per week

Course Topics:

1. Elastic constants; anisotropy and symmetries.
2. Yield and Failure Criteria
3. Dislocations and Slip
4. Twinning
5. Strengthening Mechanisms
6. High Temperature Response: Creep
7. Deformation Response of Plastics
8. Fracture :Mechanical Aspects
9. Fracture: Microstructural Aspects
10. Fatigue Crack Propagation
11. Fatigue Life Predictions
12. Mechanical Response of Ceramics; Weibull statistics
13. Mechanical Behavior of Composites
14. Constitutive Equations for Different Classes of Materials

Course Objectives:

(Numbers in parentheses refer to MAE Program Outcomes)

Objective 1: To teach students the deformation behavior of engineering materials as a function of various external factors, such as temperature, strain rate, stress state, and internal microstructural features such as anisotropy and plasticity (1a, 3c, 5e, ME12).

Objective 2: To teach students the micromechanisms of deformation and the various methods of strengthening materials. (1a, 3c, 5e, ME12).

Objective 3: To teach students the constitutive behavior of materials and its role in material modeling. (1a,5e, ME12)

Objective 4: To teach students the concept of linear elastic fracture mechanics, its limitation and application in real engineering situations. (1a, 3c, 5e).

Objective 5: To teach students the role of microstructure and test conditions on the fracture behavior of materials. (1a, 3c, 5e)

Objective 6: To teach students the concept of fatigue fractures, and methods of predicting fatigue lifetimes of components (5e,1a, 3c).

Methods of Evaluation:

1. Homework will be regularly collected and graded.
2. Exams

Performance Criteria:

(Numbers in parentheses refer to the methods of evaluation used to assess student performance.)

Objective 1

1.1 Students will demonstrate an understanding of the structure-deformation behavior correlation in engineering materials. (1,2).

Objective 2

2.1 Students will demonstrate the ability to identify the deformation mechanisms operative in various engineering materials. (1,2).

2.2 Students will demonstrate an ability to qualitatively predict the mechanical properties of materials using a variety of strengthening theories. (1,2).

Objective 3

3.1 Students will demonstrate an understanding of the dependency of the yield strength and flow stress of materials on both test temperature and strain rate. (1,2)

3.2 Students will demonstrate an understanding of several material models, their limitations, and applications (1,2).

Objective 4

4.1 Students will demonstrate the ability to determine stress intensity factors for a variety of flawed component configurations.(1, 2)

4.2 Students will demonstrate the ability to design using a fracture mechanics approach. (1, 2)

Objective 5

5.1 Students will demonstrate knowledge of temperature transition effects in engineering materials and how various microstructures influence the fracture behavior. (1,2)

Objective 6

6.1 Students will demonstrate knowledge of fatigue crack growth and its correlation using fracture mechanics theory. (1,2)

6.2 Students will demonstrate an understanding of designing for fatigue applications, and for predicting fatigue lifetimes of engineering components using fracture mechanics. (1,2)

Contribution of Course to Professional Component:

Engineering Science

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Revised: Joanna McKittrick, Marc A. Meyers, April 2008 via Teaching Work Group Meeting