Course number and name

MTSE 3050 - Mechanical Properties of Materials

Credits and contact hours

3 Credits. MW 5:30pm - 6:50pm

Instructor’s or course coordinator’s name

Instructor: Dr. Rajiv Mishra

Text book, title, author, and year

Draft of a new textbook (Mechanical Behavior of Materials: Deformation and Design, Rajiv Mishra, Indrajit Charit, Paperback ISBN: 9780128045541, Imprint: Butterworth-Heinemann, Publication Date: 2018) will be posted on Blackboard as pdf files. Lecture notes will be provided in addition to the copies of lecture slides.

   a. Other supplemental materials - Lecture slides – this will be a major source.
   b. The book listed below is for reference and for structured self-reading:

Specific Course Information

a. Brief description of the content of the course (catalog description)
   Macroscopic mechanical response of ceramics, metals, polymers and composite materials, with an introduction to the underlying microstructural processes during deformation and fracture.

b. Prerequisites or co-requisites
   ENGR 3450

c. Indicate whether a required, elective, or selected elective course in the program
   Required

Specific goals for the course

a. Specific outcomes of instruction
   • Students will learn about correlations between microstructure and mechanical properties, e.g. influence of grain size on strength and/or fracture toughness
   • Students will be given a recurring homework where they answer the same broad question with greater detail as the semester progresses. The answers will be measured against a mechanism evaluation matrix.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other
outcomes are addressed by the course.

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<tr>
<th>Specific Course Learning Outcome</th>
<th>Student/ABET Outcome</th>
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<tr>
<td>1. Students will learn about correlations between microstructure and mechanical properties</td>
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**GRADING**

Homework and Quizzes......................... 30% + 10% for recurring six-grain homework
First exam.............................................. 20%
Second exam......................................... 20%
Final...................................................... 20%

Note
Homework must be turned in during the class. If you intend on missing a class, the homework should be submitted BEFORE the due date.
The total numbers of points possible is 100, and grades will be assigned as follows:

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<th>Points</th>
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<td>&gt;76</td>
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<td>&gt;66</td>
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**Brief list of topics to be covered**

**Topic 1. Introduction to mechanical response of materials (2 lectures)**

1.1 Mechanical response of materials – Introduction
1.2 Broad categories of engineering materials (Brief Survey)
   1.2.1 Metals and Alloys
   1.2.2 Ceramics
   1.2.3 Polymeric materials
   1.2.4 Composites
1.3 Engineering Systems and Materials
   1.3.1 Automobile
   1.3.2 Advanced Aircraft
   1.3.3 Power Plant
1.3.4 Miscellaneous examples of engineering systems (where mechanical property requirement may not be easily recognizable such as microelectronics)

**Topic 2. Framework of five basic design approaches for structural components (1 lecture)**

2.1 Ashby’s basic mechanical design framework

**Topic 3. Introduction to systems approach to materials (1 lecture)**

3.1 Olson’s systems approach to materials by microstructural design
   3.1.2 Specific examples of the success of the approach
3.2 Importance of microstructure-properties correlations

**Topic 4. A brief survey of microstructural elements in engineering structural materials (1 lecture)**

4.1 Metallic materials
4.2 Non-metallic materials

**Topic 5. Simple mechanical tests and complexities (2 lectures)**

5.1 Testing methods for mechanical properties
5.2 Hardness testing
5.3 Tensile testing
5.4 Fatigue testing
5.5 Fracture modes and testing (fracture toughness)
5.6 Creep testing
5.7 Examples of Linkage between mechanics and dislocation-based plasticity theory

**Chapter 6. Elastic response of materials: stiffness limiting design (2 lectures)**

6.1 Need for discussion of elastic response of materials
6.2 Development of elastic theory
   6.2.1 Simple Hooke’s law (various moduli – Young’s modulus, Shear modulus and bulk modulus; and Poisson’s ratio)
   6.2.2 Generalized form and their implication
   6.2.3 Elastic strain energy and resilience
6.3 Design of high stiffness composite materials

**Chapter 7. Yielding and work hardening: strength limiting design (4 lectures)**

7.1 Dislocation based plasticity in crystalline materials
   7.1.1 Theoretical strength of materials
   7.1.2 Crystal plasticity and Schmid factor
7.2 Various strengthening mechanisms in engineering materials
   7.2.1 Grain size (Hall-Petch) Strengthening
   7.2.2 Solid Solution Strengthening
7.2.3 Fine particle strengthening
7.2.4 Composite strengthening
7.2.5 Texture strengthening
7.3 Large-scale plasticity – dislocation generation, storage and arrangement
7.4. Failure mechanisms
7.5. Microstructural distribution and consequent effects
    7.5.1 Grain size distribution effects
    7.5.2 Precipitate size distribution effects
7.6. Effect of multiaxial loading on yielding
    7.6.1 von Mises criterion
    7.6.2 Tresca criterion
7.7 Principles and examples of strength limiting design

Chapter 8. Toughness of materials: Toughness limiting design (2 lectures)

8.1 Various definition of toughness of materials
    8.1.1 Tensile toughness
    8.1.2 Impact toughness
    8.1.3 Fracture toughness
8.2 Details of fracture toughness testing
    8.2.1 Brittle materials
    8.2.2 Ductile materials – plastic zone
8.3 Stress intensity and role of mechanics
8.4 Damage tolerant design approach based on assumption of flaws
8.5 Unintended role of constituent particles and inclusions
8.6 Fracture mechanisms and crack growth rate
    8.6.1 Cleavage
    8.6.2 Shear

Chapter 9. Fatigue behavior of materials: Fatigue limiting design (3 lectures)

9.1 Constant stress and strain amplitude testing
    9.1.1 S-N curve and endurance limit
    9.1.2 Bauschinger effect and cyclic stress-strain response
9.2 Fatigue deformation and role of microstructure
    9.2.1 Origin of scatter: is microstructural distribution important?
9.3 Fatigue life prediction and example
    9.3.1 Probabilistic life modeling
9.4 Fatigue crack growth – related models
9.5 Fatigue fracture characteristics – SEM fractography

10. High temperature deformation of materials: Creep limiting design (2 lectures)

10.1 Effect of temperature on dislocation-obstacle interactions
10.1.1 Effect on strengthening mechanisms
10.2 Role of diffusion
10.3 High temperature deformation constitutive relationships (Norton's equation, Bird-Mukherjee-Dorn equation)
   10.3.1 Dislocation creep
   10.3.2 Diffusion creep
   10.3.3 Grain boundary sliding and superplasticity
   10.3.4 Creep deformation mechanism maps
10.4 Creep fracture mechanisms
   10.4.1 Creep fracture mechanism maps
   10.4.2 Creep life related equations (Larson-Miller, Monkman-Grant, Sherby-Dorn parameter etc.)
10.5 Other aspects of high temperature deformation

Chapter 11. Intersection of dislocation based plasticity and mechanics (2 lectures)

11.1 Microscale stress concentration
   11.1.1 Constituent particles
   11.1.2 Gray cast iron vs. Ductile cast iron
   11.1.3 Cracking based on grain boundary character distribution
1. **Academic Integrity Standards & Sanctions for Violation**

   Students caught cheating or plagiarizing will [instructors should insert consequences, insert sanction, such as course failure]. Additionally, the incident will be reported to the Dean of Students, who may impose further penalty. According to the UNT policy, the term "cheating" includes, but is not limited to:

   a. use of any unauthorized assistance in taking quizzes, tests, or examinations; 
   b. dependence upon the aid of sources beyond those authorized by the instructor in writing papers, preparing reports, solving problems, or carrying out other assignments; 
   c. the acquisition, without permission, of tests or other academic material belonging to a faculty or staff member of the university; 
   d. dual submission of a paper or project, or resubmission of a paper or project to a different class without express permission from the instructor(s); or 
   e. any other act designed to give a student an unfair advantage. The term "plagiarism" includes, but is not limited to:

   a. the knowing or negligent use by paraphrase or direct quotation of the published or unpublished work of another person without full and clear acknowledgment; and
   b. the knowing or negligent unacknowledged use of materials prepared by another person or agency engaged in the selling of term papers or other academic materials.

2. **ADA Statement**

   The University of North Texas makes reasonable academic accommodation for students with disabilities. Students seeking accommodation must first register with the Office of Disability Accommodation (ODA) to verify their eligibility. If a disability is verified, the ODA will provide you with an accommodation letter to be delivered to faculty to begin a private discussion regarding your specific needs in a course. You may request accommodations at any time, however, ODA notices of accommodation should be provided as early as possible in the semester to avoid any delay in implementation. Note that students must obtain a new letter of accommodation for every semester and must meet with each faculty member prior to implementation in each class. For additional information see the Office of Disability Accommodation website at disability.unt.edu

3. **Emergency Notification & Procedures**

   UNT uses a system called Eagle Alert to quickly notify you with critical information in the event of an emergency (i.e., severe weather, campus closing, and health and public safety emergencies like chemical spills, fires, or violence). The system sends voice messages (and text messages upon permission) to the phones of all active faculty staff, and students. Please make certain to update your phone numbers at my.unt.edu. Some helpful emergency preparedness actions include: 1) know the evacuation routes and severe weather shelter areas in the buildings where your classes are held, 2) determine how you will contact family and friends if phones are temporarily unavailable, and 3) identify where you will go if you need to evacuate the Denton area suddenly. In the event of a university closure, please refer to Blackboard for contingency plans for covering course materials.