MTSE 3050: Mechanical Properties of Materials
Spring 2024 Syllabus

Credits & Classroom
Lectures M/W 4:00 pm to 5:20 pm for 3 credits
Classroom DP B157

Instructor
Name Dr. Dwight Burford
Faculty Page
Office Location DP G215g
Office Hours By appointment via email (face-to-face or via Zoom/Teams)
Email dwight.burford@unt.edu

Note: Depending upon the scope and complexity of the communication, most emails are expected to be answered within 48 hours.

Textbook
Mechanical Behavior of Materials: Deformation and Design, (Draft) by Rajiv S. Mishra, Indrajit Charit, & Ravi Sankar Haridas

- https://shop.elsevier.com/books/mechanical-behavior-of-materials/mishra/978-0-12-804554-1

Textbook chapters will be posted on Canvas as pdf files along with lecture slides.

- Other supplemental materials include lecture slides, which will be a major source for course information.

General Course Information
- Course Content (catalog description): Macroscopic mechanical response of ceramics, metals, polymers and composite materials, with an introduction to the underlying microstructural processes during deformation and fracture.
- Prerequisites or co-requisites: ENGR 3450 (required)

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

Student Outcomes Listed in ABET Criterion 3 and Other Outcomes Addressed in Course

<table>
<thead>
<tr>
<th>Specific Course Learning Outcome</th>
<th>Student/ABET Outcome*</th>
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<tr>
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*ABET Accreditation: [https://materials.engineering.unt.edu/accreditation](https://materials.engineering.unt.edu/accreditation)

Grading

• Homework and Quizzes .........30%
• “Six Grain” Homework ..........10%
• First exam .........................20%
• Second exam .......................20%
• Final .............................20%

An “A-F” grading scale will be used. The point percentages used to calculate the final grade are:

A >= 86; B = 75-85; C = 60-74; D = 50-59; F = < 50

Notes

• Homework must be turned in by the beginning of the assigned class period. If you intend to miss a class, the homework is to be submitted BEFORE the due date via Canvas.
• Exam grades are expected to be posted within 2 weeks after an exam is administered. Assignments and projects are expected to be submitted as assigned, e.g. in class or via Canvas. Students are expected to participate in class discussions related to course assignments as specified in class or in the rubric posted to Canvas.

Assignments

The instructions for assignments and their due dates will be posted on Canvas. You must upload your answers in PDF files on Canvas.

Note that the University is committed to providing reliable online course systems to all users. However, in the event of any unexpected server outage or any unusual technical difficulty which prevents students from completing a time sensitive assessment activity, the instructor will extend the time windows and provide an appropriate accommodation based on the situation. Students
should immediately report any problems to the instructor and contact the UNT Student Help Desk: helpdesk@unt.edu or 940.565.2324 and obtain a ticket number. The instructor and the UNT Student Help Desk will work with the student to resolve any issues at the earliest possible time.

Course Topics

Topic 1. Introduction to mechanical response of materials

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

2.1 Ashby’s basic mechanical design framework

Topic 3. Introduction to systems approach to materials

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. Brief survey of microstructural elements in engineering structural materials

4.1 Metallic materials

4.2 Non-metallic materials

Topic 5. Simple mechanical tests and complexities

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


6.1 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 its implication
   - 6.2.3 Elastic strain energy and resilience
6.3 Design of high-stiffness composite materials

**Topic 7. Yielding and work hardening: strength limiting design**

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

**Topic 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

**Topic 9. Fatigue behavior of materials: Fatigue limiting design**

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

**Topic 10. High temperature deformation of materials: Creep limiting design**
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

Course Policies

1. Academic Integrity Standards & Sanctions for Violation

   Students caught cheating or plagiarizing will be reported to the Dean of Students. 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
Eagle Alert and @UNTEagleAlert for contingency plans for covering course materials.