MECH 5390/6390: Fracture Mechanics

Class Reference Number: 19316 / 16323


Required Software: PTC MathCAD and Excel

References:

1. R. J. Sanford, Principles of Fracture Mechanics, Prentice Hall

Class/Lab Meeting: Online, T 12:00pm-1:20pm

Class Room: Online

Instructor: Dr. Calvin M. Stewart, Ph.D.
            cmstewart@utep.edu
            Phone: 915-747-6179
            Office Hours: F 9:00am-11:00am, or by appointment

Course Objectives
A review of classical and modern methods of fracture mechanics and the physical process therein. Primary emphasis relates to metallic, polymeric, and ceramic materials. Students will be challenged to develop both analytical and practical skills fracture mechanics.

Goals
1. Review and extend the basics of design against fracture;
2. Learn the microstructural aspects that lead to fracture;
3. Apply advanced mathematical theories to characterize and predict fracture;

Topics Covered
Grades

Your final grade for this course will be based on the following activities

<table>
<thead>
<tr>
<th>Assignments</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Homework</td>
<td>30%</td>
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<tr>
<td>Project(s)</td>
<td>70%</td>
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<tr>
<td>Total</td>
<td>100%</td>
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Grade Scale

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Grade</th>
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<tbody>
<tr>
<td>100-90%</td>
<td>A</td>
</tr>
<tr>
<td>89-80%</td>
<td>B</td>
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<tr>
<td>79-70%</td>
<td>C</td>
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<tr>
<td>69-60%</td>
<td>D</td>
</tr>
<tr>
<td>&lt;60%</td>
<td>F</td>
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The instructor reserves the right to revise this grading plan.

Online Course

Fracture mechanics is an online course. Students will learn by reading the book, attending live-streamed lectures, and completing assignments for each topic in the course. The week can be divided as follows

Weekly Schedule

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
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</thead>
<tbody>
<tr>
<td>• Assigned reading</td>
<td>• Lecture</td>
<td>Assignments/Projects</td>
<td>Assignments/Projects</td>
<td>• Office Hours (9am to 11am) Assignments/Projects</td>
</tr>
</tbody>
</table>

The lectures and reading for each week are listed in the course schedule. Assignments are listed in the lecture notes.

Lectures

Lectures are held live on Microsoft Teams. Students are encouraged to attend the lectures during the assigned course time. The lectures will be recorded and can be viewed later by Students.

Tuesday from 12:00pm to 1:20pm

[Join Microsoft Teams Meeting](#)

Office Hours

Office hours are held on Microsoft Teams. A link to the meeting room is on the first page of the syllabus. If you cannot attend office hours, make an appointment by email for an alternative meeting time. Use the same link to join the meeting room.

Friday from 9:00am to 11:00am

[Join on Microsoft Teams Meeting](#)
Course Content

The syllabus, schedule, lecture videos and notes, and other materials will be posted to the course website.

Bookmark Course Website
Course Schedule and Assigned Reading

1. **Introduction to Fracture** (Anderson Chp 1, Janssen Chp 1, Sanford Chp 1)
   a. Failure of Structures
   b. Definition
   c. Significance
   e. Materials
   f. Methods

2. **Historical Prospective** (Anderson Chp 1, Janssen Chp 1, Sanford Chp 1)

3. **Solid Mechanics** (Anderson A2, Janssen Chp 2, Sanford Chp 2)
   a. Interatomic View of Fracture (Anderson p 31-33)
   b. Linear Elasticity, Equilibrium of Stress, Compatibility Equation of Strain, Airy Stress Functions (Janssen p25-30, Anderson A2)
   c. Stress Concentration Factors (Anderson p33-36)
      i. Circular hole (Sanford Chp 2, tablet notes)
      ii. Elliptical hole (Sanford Chp 2, tablet notes)
   d. Limitations of SCF approach and the need for LEFM

4. **Linear Elastic Fracture Mechanics** (Anderson Chp 2, Janssen Chp 2, Sanford Chp 3)
   a. Crack Tip Singularity (Sanford p51-52)
   b. Williams Solution: Sharp Crack, Complex Functions, Westergaard Stress Function, Westergaard Example: Central Crack Problem (Sanford p51-116, Janssen p 30-37)
   c. Stress Intensity Factors (Janssen p41-59, Anderson p51-67)

5. **Crack Tip Plasticity** (Anderson Chp 2, Janssen Chp 3, Sanford Chp 6)
   a. Irwin, Dugdale (Strip-Yielding), Plastic Zone Shape/Size (Anderson p72-82, Janssen p61-80)
   b. Plane Stress versus Plane Strain (Anderson p82-84)
   c. Effect of Variables on Fracture Toughness (Sanford p221-230, Anderson 84-91)

6. **Energy Methods** (Anderson Chp 2, Janssen, Chp 4, Sanford Chp 7)
   a. Definitions
   b. Griffith Energy Balance (Sanford p237-240)
   c. Relationship between G and K (Sanford p240-243, Janssen90-93)
   d. Compliance (Sanford p243-248, janssen p.93-95)
   e. Resistance R Curve (Sanford p230-233, Janssen p96-105)

7. **LEFM Testing** (Anderson Chp 7-8, Janssen, Chp 5, Sanford Chp 8)
   a. Plane Strain Fracture Toughness (Janssen p107-114, p251-265)
      i. Test Standards
      ii. Test Procedure
   b. Plane Stress Fracture Toughness (Janssen p115-120)
c. K-R Curve Testing (Janssen p120-129)
d. Measuring Crack Length

8. Elastic Plastic Fracture Mechanics (Anderson Chp 3, Janssen, Chp 6, Sanford Chp 11)
   a. Introduction
   b. The J integral concept and examples (Anderson p 122-129, Sanford p338-343, Janssen p 135-149)
      i. Concept
      ii. Examples
      iii. J as a path-independent line Integral
      iv. J as a Stress Intensity Parameter
c. Crack Opening Displacement (Anderson p.138-142, Janssen p.149-154)

9. Microstructural Mechanics & Failure Analysis (Hertzberg, Anderson Chp 5-6, Janssen, Chp 12-13, Sanford Chp 11)

Books