Department of
MECHANICAL ENGINEERING
THE UNIVERSITY OF UTAH

ME EN 7530, Fracture and Fatigue, Spring 2021
Professor Jacob Hochhalter

This is an IVC course, meaning that class meetings are live on zoom, but also recorded and posted to Canvas. There are three links that we will use throughout the semester (hyperlinks here):

zoom (passcode: 4e334y)	canvas	gradescope

Class meetings: M, W from 3:00-4:20 PM on zoom
Textbook: Fracture Mechanics: An Introduction, 2^{nd} edition, by E.E. Gdoutos
Instructor: Jacob Hochhalter, email via canvas
office hours are M and W from 4:30-5:30 pm on zoom
TA: Kiffer Creveling, email via canvas
office hours are F from 4:30-5:30 pm on zoom

Prerequisites: ME EN 6300, ME EN 6500, or instructor consent

Course summary

Theory and application of fracture mechanics to design against catastrophic failures in structures. Mechanisms of fracture, stress-intensity factors, elastic and elasto-plastic design criteria, fracture toughness, crack propagation, and fatigue.

Course objectives

The overarching goal of this course is to expose students to the mechanisms of fatigue and fracture, by which many structures and materials fail. By the end of this course, students will:

1. Have a fundamental understanding of linear elastic fracture mechanics (LEFM) and the conditions under which LEFM is valid;
2. Have a fundamental understanding of generalized (nonlinear) fracture mechanics;
3. Have a fundamental understanding of various regimes of fatigue crack growth;
4. Have a working understanding of different analytical, numerical, and experimental methods to assess the integrity and/or life of structural components.

Grading

Homework	30%
Canvas quizzes	10%
Exams	30%
Final Project	30%

≥ 93	< 93 ≥ 90	< 90 ≥ 87	< 87 ≥ 83	< 83 ≥ 80	< 80 ≥ 77	< 77 ≥ 73	< 73 ≥ 70	< 70 ≥ 67	< 67 ≥ 63	< 63 ≥ 60	< 60
A	A-	B+	B	B-	C+	C	C-	D+	D	D-	E

Homework: See next subsection.
Quizzes: Quizzes will be completed on canvas periodically on lecture days to evaluate attendance and assigned reading.
Exams: Two exams will be given for this course and will be on topics discussed during lecture or lab sessions. All exams are **closed book**, **closed notes** (equations will be provided). There will be no make-up exams unless arranged in advance.
Final Project: There will be no final exam for this course. Instead, a final project will be graded with the same weight as a final exam. The topic of the project is up to each student and will build upon the material from the labs. Details regarding the project will be provided after Exam 1.

Homework Assignments

- Homework assignments are meant to test and affirm your understanding of the theoretical background provided during lecture. Some of these assignments will be completed using a programming language of your choice (e.g. MATLAB or Python) or finite element software of your choice (ABAQUS or ANSYS).
- The TAs will grade the assignment directly in gradescope, and feedback will be provided immediately upon completion.

This is a graduate-level course; therefore, it is expected that assignments will be presented in a professional manner. Specifically, the assignments should:

- Clearly define and articulate the problem statement using words and figures.
- Clearly describe the solution method or approach, including explicit mention of any assumptions that are made.
- Clearly state the final solution, including units (if applicable) and a statement about the reasonableness and possible implications of the findings.

Some problems will be assigned directly from the course textbook; while others will be more open-ended and require creativity and critical thinking. Specific instructions will be provided for each assignment.

Late HW Policy

Late homework will be accepted, but with a penalty of 20% reduction per day i.e.

$$\text{HW}_{\text{Score}} = \text{HW}_{(\text{Your Score})} \cdot (1 - 0.2 \cdot \#_{\text{Days}}) \quad \forall (0 \leq \#_{\text{Days}} < 5)$$

Lecture Materials

The course syllabus, lecture slides, assignments, any supplementary materials, and class announcements will be posted in canvas. While the lecture slides contain important concepts that we will cover in class, I will go into more depth during lecture, which includes working through example problems on the screen. Therefore, it is imperative that the lectures are attended or recorded videos are watched.

Assignment Submission

All assignment submissions will be due by 11:59 pm on the due-date specified. All assignments must be submitted on gradescope All students enrolled in the course prior to the first day of school, will automatically be added to gradescope. If you have not yet used gradescope a step-by-step tutorial is provided here.

Academic Integrity

From the Universitys Code of Student Rights and Responsibilities:
Academic misconduct includes, but is not limited to, cheating, misrepresenting one's work, inappropriately collaborating, plagiarism, and fabrication or falsification of information (see here for more details). It also includes facilitating academic misconduct by intentionally helping or attempting to help another to commit an act of academic misconduct.
You are allowed, expected, and encouraged to collaborate on homework by sharing ideas, verbally. Copying written work or code will not be tolerated. Shared work will receive a shared grade, meaning that the assignment score will be divided by the number of students submitting identical work. Cheating on an exam will result in failure of the class. Also, submitted work copied from others will be considered academic misconduct and will be reported to the appropriate University entities.

Students with Disabilities

The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building, 581-5020 (V/TDD). CDS will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in alternative format with prior notification to the Center for Disability Services.

College of Engineering (COE) Guidelines

Please familiarize yourself with the COE guidelines.

Tentative Course Schedule

Week	Date	Lecture Topic	Reading
1		MLK Day	
	1/20/2021	Course Overview	1.1-1.4
2	1/25/2020	Energy balance and release rate, G	4.1-4.4, Handout
	1/27/2021	Stress fields and stress intensity factor, K	2.1-2.5
3	2/1/2020	Relating K and G; Crack tip displacements	3.1-3.3, 4.5
	2/3/2021	Fracture toughness testing	4.6, 5.5, Handout
4	2/8/2020	Crack stability, R-curves	4.7, 5.6
	2/10/2021	Overview of computational fracture mechanics	
5	2/15/2020	President's Day	
	2/17/2021	Computing K and G with finite elements	Handout
6	2/22/2020	Mixed-mode crack growth	Handout
	2/24/2021	Uncertainty propagation (Leser)	7.1-7.7
7	3/1/2021	Exam 1	
	3/3/2021	Cracking in AM metals (Emery)	
8	3/8/2021	Sandia Fracture Challenge, Final projects intro	
	3/10/2021	Intro to nonlinear fracture mechanics, J-integral	6.1-6.5
9	3/15/2021	J-integral, experiment	6.6-6.7
	3/17/2021	J-integral, finite element	
10	3/22/2021	Crack tip opening, traction-separation models	6.8
	3/24/2021	Intro to fatigue and design philosophies	9.1
11	3/29/2021	Strain life and LEFM-based models	9.2-9.3
	3/31/2021	Fatigue crack growth testing (Newman)	Handout
12	4/5/2021	University non-instructional day	
	4/7/2021	Fatigue cracking growth predictions	
13	4/12/2021	Exam 2	
	4/14/2021	Environmentally-assisted Cracking (Harris)	
14	4/19/2021	Micromechanics of fatigue	
	4/21/2021	Fractography, Course Review	
15	4/26/2021	Project Presentations	
	4/28/2021	Project Presentations	
Final	-	No Final	-