Syllabus for ME 378D and ME 386Q17: Failure Analysis
Spring 2023

Instructor Information

Name: Desiderio Kovar
Office: ETC 9.146
Office hours: T 11 am – noon in person and via zoom (https://utexas.zoom.us/j/92525183370) and F 1 - 2 pm in person or via zoom (https://utexas.zoom.us/j/99773379413).
Phone: 471-5185
E-mail: dekovar@austin.utexas.edu.
We will be using Canvas to communicate and to post class notes, assignments, solutions, etc.

Course Information

Unique numbers: 19130 (ME 378D) and 19320 (ME 386Q17)

Prerequisites: It is strongly suggested that before you take this class, you have taken the following: ME 311, and 111L: Introduction to Materials Engineering w/ lab and that you received a grade of C or higher, ME 378K: Mechanical Behavior of Materials, EM 319: Mechanics of Solids, or you have graduate standing

Lectures: Mondays, Wednesdays, and Fridays 11:00-12:00. Attendance and participation in the lectures is the only way to learn the material.

Course Goals: This course is an introduction to methodology of analyzing failures of engineering parts and devices. Although we will cover a broad range of analysis, the focus will be on understanding fractography and relating this back to material and mechanics relevant to failure to determine the likely root cause(s). Lectures will primarily be based on case studies and will be supplemented by two group class projects.

Required Text

You are not required to purchase a textbook for this course.

Useful References

Failure Analysis of Materials

- Charlie R. Brooks and Ashok Choudhury, *Failure Analysis of Engineering Materials*, McGraw-Hill, 2002. Available for free electronically: https://search.lib.utexas.edu/permalink/01UTAU_INST/9e1640/alma991047482439706011

Case Studies

- *Failure analysis case studies: a sourcebook of case studies selected from the pages of Engineering failure analysis 1994-1996*, edited by D.R.H. Jones. Amsterdam; New York: Elsevier, 1998. https://search.lib.utexas.edu/permalink/01UTAU_INST/be14ds/alma991035753079706011
- *Failure analysis case studies II: a sourcebook of case studies selected from the pages of Engineering failure analysis 1997-1999*, edited by D.R.H. Jones. Amsterdam; New York: Pergamon, 2001. https://search.lib.utexas.edu/permalink/01UTAU_INST/9e1640/alma991058176735406011
- *Handbook of Materials Failure Analysis with Case Studies from the Oil and Gas Industry*, edited by Abdel Salam Hamdy Makhlouf and Mahmood Aliofkhazraei, Amsterdam: Elsevier, 2016. https://search.lib.utexas.edu/permalink/01UTAU_INST/9e1640/alma991058011681606011
- *Handbook of materials failure analysis with case studies from the aerospace and automotive industries,* edited by Abdel Salam Hamdy Makhlouf, Mahmood Aliofkhazraei. Oxford, UK: Elsevier, 2015. http://ezproxy.lib.utexas.edu/login?url=http://www.sciencedirect.com/science/book/9780128009505
- *Handbook of materials failure analysis with case studies from the chemicals, concrete and power industries,* edited by Abdel Salam Hamdy Makhlouf, Mahmood Aliofkazraei. Kidlington, Oxford, UK: Elsevier, 2015. http://ezproxy.lib.utexas.edu/login?url=http://www.sciencedirect.com/science/book/9780081001165

Materials Data, methods, techniques, etc.

- ASM Handbook vol. 1-23: https://dl-asminternational-org.ezproxy.lib.utexas.edu/handbooks/pages/Handbooks_by_Volume

More information on Specific Topics/Materials

- T.H. Courtney, Mechanical Behavior of Materials. 2nd ed. (McGraw-Hill, NY, 2000). Available for free temporarily until the Engineering Library reopens at https://catalog.hathitrust.org/Record/002446138? After that, will be available in the Course Materials section in the Engineering Library. TA 405 C859 2000
- R.W. Hertzberg, Deformation Fracture Mechanics of Engineering Materials. 5th ed. (John Wiley and Sons, NJ, 2012) Available for free electronically: https://search.lib.utexas.edu/permalink/01UTAU_INST/9e1640/alma991058176735806011
- G.E. Dieter, Mechanical Metallurgy. 3rd ed. (McGraw-Hill, NY, 1986). Available for free temporarily until the Engineering Library reopens at https://catalog.hathitrust.org/Record/000384843? After that, will be available in the Course Materials section in the Engineering Library. TA 405 D53 1986
- N.G. McCrum, C.P. Buckley, and C.B. Bucknall, Principles of Polymer Engineering. (Oxford University Press, Oxfordshire, Great Britain, 1988)* (1st ed. in engineering library, 2nd ed. in Chemistry Library) https://search.lib.utexas.edu/permalink/01UTAU_INST/be14ds/alma991024029619706011. Will be available in the Course Materials section in the Engineering Library after January 31. TA 455 P58 M334 1997
- D.J. Green, An Introduction to the Mechanical Properties of Ceramics. (Cambridge University Press, 1998). Available for free electronically: https://search.lib.utexas.edu/permalink/01UTAU_INST/be14ds/alma991028744059706011

Exemplars and Fractography

- G.D. Quinn, NIST Recommended Practice Guide: Fractography of Ceramics and Glasses, September 26, 2006, Available for download for free (!!!) at http://dx.doi.org/10.6028/NIST.SP.960-16e2
- ASM Handbook, Vol. 11: https://doi-org.ezproxy.lib.utexas.edu/10.31399/asm.hb.v11.9781627081801
- ASM Handbook, Vol. 12: https://doi-org.ezproxy.lib.utexas.edu/10.31399/asm.hb.v12.9781627081818
- J.L. González-Velázquez, Fractography and Failure Analysis, Springer International Publishing AG, 2018: https://search.lib.utexas.edu/permalink/01UTAU_INST/9e1640/alma991057929482006011

This is a partial list; there are many other references in books, book chapters, and journal articles and you are encouraged to seek those references out for the specific materials and failure mechanisms that are of interest to you.

Grading System

Homework (approximately every other week) = 15%
Exam #1= 20%
Exam #2 =25%
Project #1 = 15%
Final Project= 25%
There is no final exam in this class.

Two in-class exams will be announced during lecture approximately two weeks before the exam date. The dates listed in the course schedule are approximate.

The projects will be performed in groups of 3-4. Project #1 will consist of a critical analysis of a documented failure analysis. This analysis can be one that your group selects from the literature. The goal will be to identify areas where the analysis can be improved by reviewing the analysis, performing additional calculations, suggesting additional testing that could be performed, and estimating the time and cost for the additional testing/analysis.

The final report will be a failure analysis that your group performs on a part that you select. You will be responsible for identifying the material and heat treatment condition of the material from which the part is made, how the part was made, estimating relevant properties for the material and part, performing calculations and determining the likely cause of failure of the part. You will have access to laboratory facilities for conducting your analysis for the final report.

Part of the grades for both reports will consist of intermediate and final peer evaluations. You will submit written reports limited to 10 pages including figures using a 12-point, double-spaced font. The final report will also consist of a final presentation. Final presentations will be 20 minutes long and will take place the last week of class. Additional details will be available when the projects are formally assigned.

Final grades will be determined based on the following scales:

Undergraduate Section		Graduate Section	
Overall Score	**Course Grade Range**	**Overall Score**	**Course Grade Range**
88% - 100%	A- to A	90% - 100%	A- to A
78% - 87%	B- to B+	80% - 89%	B- to B+
68% - 77%	C- to C+	70% - 79%	C- to C+
58% - 67%	D	60% - 69%	D
< 58%	F	< 60%	F

I reserve the right to modify this scale **to the benefit of students** (i.e., to reduce the percentage required for an A, B, etc.).

The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-4321, TTD 471-4241 or the College of Engineering Director of Students with Disabilities at 471-4321.

Information about Lectures

Over the years I have tried various lecturing methods including 1) Traditional lecturing from the whiteboard and 2) Providing PowerPoint slides of my lecture notes via Canvas. I have not been happy with either approach. I have therefore adopted the following approach: I will provide you with PowerPoint slides that contain all the figures and equations and most of the text that I lecture from. On many slides, critical bits of information will be missing. I will fill in that information during lecture and provide additional topical (and hopefully fun) information and examples orally that are not in the notes. My intent is that you follow along in the notes during lecture, that we work through the notes together during lecture, and that this provides you with an opportunity to *think* about the content and ask questions that you may have.

Attendance Policy

Regular and timely attendance is required at all lecture and laboratory meetings. You are responsible for obtaining any information that was discussed in lectures during an absence; since lectures will be recorded, this should not be difficult. A student who is absent from a class or examination for the observance of a religious holy day may complete the work missed within a reasonable time after the absence, if proper notice of the planned absences has been given. Notice must be given before the absence and no later than the fifteenth class day of the semester. A student who fails to complete missed work within the time allowed will be subject to the normal academic penalties. Requests for excused absences from exams for other reasons will be granted only in special circumstances (serious illness on the part of the student, death in the immediate family, etc.) and must be made in writing with appropriate documentation provided. When academic conflicts arise, a written notice must be given to the instructor at least two weeks *in advance* in order to schedule an alternative due date for assignments. In case of personal emergency, the instructor should be notified as soon as is convenient to discuss what arrangements can be made. Unexcused absences from an exam will result in a grade of zero.

Accessibility

I am truly committed to creating an accessible and inclusive learning environment. Please let me know if you experience any barriers to learning so I can work with you to ensure you have equal opportunity to participate fully in this course. If you are a student with a diverse learning style, a disability, or think you may have a disability, and need accommodations please contact Services for Students with Disabilities (SSD). Please refer

to SSD's website for contact and more information: http://diversity.utexas.edu/disability/. If you are already registered with SSD, please deliver your Accommodation Letter to me as early as possible in the semester so we can discuss your approved accommodations and needs in this course.

Scholastic Dishonesty Policy

Scholastic dishonesty will not be tolerated in any form and will be prosecuted to the fullest extent. You are expected to have read and understood the current issue of the General Information Catalog, published by the Registrar's Office, for information about procedures and about what constitutes scholastic dishonesty (e.g,. copying homework from another student, cheating on an exam, etc.). Specific information relevant to the scholastic dishonesty policy can be found in the Student Affairs Handbook, in Appendix C, Chapter 11 of the General Information Catalog, and on the Student Judicial Services web page.

Use of Class Materials

The materials used in this class, including exams, quizzes, homework assignments, and homework solutions are copyright protected works owned exclusively by Desiderio Kovar. Unauthorized copying of the class materials is a violation of federal law and may result in disciplinary actions being taken against you. Additionally, the sharing of class materials without my specific, express approval is a violation of the University's Student Honor Code and an act of academic dishonesty, which could result in further disciplinary action. Examples of such sharing include, uploading class materials to commercial websites (e.g., Course Hero, ScibD, Notehall, Koofers, CampuBuddy etc.).

Honor Codes

You are expected to be familiar with and to abide by the University of Texas at Austin's honor code and the Department of Mechanical Engineering's honor Code:

UT Honor Code

"The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the university is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community."

Mechanical Engineering Honor Code

The purpose of this honor code is to:
-to instill trust and respect amongst students, faculty, and staff.
-to foster an environment of academic integrity.
-to uphold ethical standards of the engineering profession.
-to maintain the reputation of the department, college, and university.

Student Pledge:
1) Academic Integrity
You will only take credit for work that is your own.
-It is the responsibility of the instructor to inform students of what he or she deems acceptable student conduct.
-It is the responsibility of the student to know and understand the guidelines of each individual instructor and those of the university.

2) Trust and Respect
You will treat your fellow classmates and your instructors in such a way as to promote a learning environment of mutual trust and respect.

3) Engineering Code of Ethics or Engineer's Creed
You will uphold the principles set forth in the engineer's creed in your academic and future professional career.

4) Reputation
You will conduct yourself in a manner that reflects well upon the department, college, and university.

Conclusion:
You will uphold and abide by the principles set forth in this honor code with the understanding that any infraction may be referred to the university disciplinary board.

Relationship of the Course to ME Student Outcomes:

√	ME Student Outcomes	ABET a-k
√	**1.** Knowledge of and ability to apply engineering and science fundamentals to real problems.	**a**
√	**2**. Ability to formulate and solve open-ended problems.	**e**
√	**3.** Ability to design mechanical components, systems and processes.	**c**
√	**4.** Ability to set up and conduct experiments, and to present the results in a professional manner**.**	**b**
√	**5.** Ability to use modern computer tools in mechanical engineering.	**k**
√	**6.** Ability to communicate in written, oral and graphical forms.	**g**
√	**7.** Ability to work in teams and apply interpersonal skills in engineering contexts.	**d**
	8. Ability and desire to lay a foundation for continued learning beyond the baccalaureate degree.	**i**
√	**9.** Awareness of professional issues in engineering practice, including ethical responsibility, safety, the creative enterprise, and loyalty and commitment to the profession.	**f**
√	**10.** Awareness of contemporary issues in engineering practice, including economic, social, political, and environmental issues and global impact.	**h, j**

ABET Criterion 9: Program Criteria for Mechanical Engineering Curriculum:

MECHANICAL ENGINEERING PROGRAM CRITERIA

√	These program criteria will apply to all engineering programs that include "mechanical" or similar modifiers in their titles.
	1. Curriculum: The curriculum must require students to apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations); to model, analyze, design, and realize physical systems, components or processes; and prepare students to work professionally in either thermal or mechanical systems while requiring topics in each area.
	2. Faculty: The program must demonstrate that faculty members responsible for the upper-level professional program are maintaining currency in their specialty area.

Class and Reading Schedule (Note that this schedule is approximate)

Week	Material
1	Introduction; general definitions of Failure
2	Conducting a Failure Analysis;
3	Analytical Tools for Fractographic Analyses
4	Macroscopic Failure Modes; Elastic Deformation, Yielding
5	Ductile Fracture; Brittle Fracture; Fatigue;
6	Fatigue; Exam I
7	Microscopic Mechanisms; plasticity; ductile fracture
8	Microscopic Mechanisms; brittle fracture; fatigue
9	Fracture Modes
10	Fracture in Polymers and Ceramics
11	High Temperature Creep and Fracture
12	Environmental Degradation
13	Environmental Degradation cont.; Exam II
14	Environmental Degradation cont.
15	Presentations