EML 5233 – FAILURE OF MATERIALS IN MECHANICAL DESIGN
Spring 2021

Textbook: *Failure of Materials in Mechanical Design*
Jack. A. Collins, Second Edition, Wiley-Interscience Publication

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Classroom **ONLINE**, Tuesday 5-6 (11:45-1:40), Thursday 6, (12:50-1:40)

Course Website **On CANVAS**

Office Hours TR (2:00-3:00) (**On Zoom)**

References: **Ref 1:** *Metal Fatigue in Engineering, 2nd edition, Ralph Stephens, Ali Fatemi, Robert Stephens, Henry Fuchs*
Ref 2: *Materials Selection in Mechanical Design by Michael Ashby, Elsevier*

Goals: This course addresses methods for defining and evaluating failure of structural materials and components subjected to steady and time dependent multi-axial (3D) stresses/strains, with applications to aerospace and mechanical structural design. Applications of failure analysis to design machine elements such as gears, rotors, compressor and turbine discs, blades, and other structural components subjected to monotonic and fatigue stresses will be emphasized. Emphasis is on structural metallic materials/alloys. Fatigue design using the stress-life approach, local strain-life approach, and fracture mechanics approach will be studied in detail, for both High Cycle Fatigue (HCF) and Low Cycle Fatigue (LCF) conditions. Components subjected to complex spectrum loading will be analyzed using cumulative fatigue damage theories and rain flow counting methods. Damage tolerant life prediction methods will be presented.

Topics:

1. Modes of Mechanical Failure
2. Strength and deformation of engineering metals, Dislocation theory, Peierls stress, Elastic properties of dislocations, Plastic deformation and slip
3. Review of State of Stress at a Point, Principal Stresses, etc.
4. Relationships between Stress and Strain, Plastic Stress-Strain Relationships
5. Combined Stress Theories of Failure and their Use in Design.
6. High-Cycle Fatigue, Multiaxial Fatigue Stresses, Goodman Diagram
7. Concepts of cumulative fatigue damage, Spectrum loading, Rain flow Counting Techniques.
8. Low-Cycle Fatigue.
9. Stress Concentration, Local Strain-Life Approach, and Neubers rule
10. Introduction to Linear Elastic Fracture Mechanics, Theoretical cohesive strength, Griffith crack theory, Strain energy release rate, Energy release rate and stress field approaches, Fracture toughness of engineering alloys, Crack tip plasticity effects, Use of Fracture Mechanics principles for design.
11. Fatigue crack growth properties, Applications to life analysis and design, Damage Tolerance and Fracture Control Applications in Design
12. High Temperature Effects (Creep, Thermo Mechanical Fatigue)

Homework: Homework assignments on component analysis and design will require the use of software such as MATLAB.
The dates for the first 2 tests are FIXED

Grading Policy:

Homework	= 15%
Test 1	= 25% (**February 25, Thu**)
Test 2	= 25% (**March 23, Tue**)
Test 3	= 35%

TA: Gabriel Sajjan Jacob <skoilparambilgab@ufl.edu>

Attendance Policy, Class Expectations, and Make-Up Policy
Late homework will receive a 10% penalty per day it is late. No cell phone/laptop use is allowed in class (except consent of instructor). These rules apply unless advance written request has been submitted to the instructor and approved. Illegible homework is subject to being rejected by the instructor. Make-up Exam/Late Assignment Policy: Do not miss an exam. Make-up exams will only be given if prior approval is granted by the instructor and the student must make a reasonable attempt to take the exam before the scheduled exam date. Exams can be reviewed at any time in the instructor's office but will not be returned to keep. The instructor will discuss any exam or homework within one week (excluding holidays) after return. After this time, grades are final.

Excused absences are consistent with university policies in the undergraduate catalog (http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance) and require appropriate documentation.

Course Outline

We have 41 lectures between January 11th and April 21st. There is NO spring break this semester. However, Feb 24 and March 25 are off days for class. The dates for the two tests are **FIXED**. I will try to follow the outline below as closely as possible.

Chapters 1, 2 and 3: Reading Assignment

Lecture #	Date	Topic and Book Section
1	Jan 12	Introduction
2,3	Jan 12, 14	Intro to Ch. 4: State of stress. This is fundamental material from your
4-6	Jan 19,21	undergraduate mechanics of materials class. A brief review of state of stress at a point and principal stresses will be covered.
7-8	Jan 26	Ch. 5: Sections 5.1-5.5
9-12	Jan 28, Feb 2,4	Ch. 6: Sections 6.1, 6.3, 6.6-6.10
13-20	Feb 9,11,16,18	Ch. 7: HCF, Haigh diagram from Ref. 1
	Feb 23	
	Test # 1, February 25, Thu	
21-24	March 2,4,9	Ch. 11: LCF, Sections 11.1-11.4, Section 8.5, Material from Ref. 1
25-27	March 11,16	Cumulative fatigue damage, Sections 8.1-8.3, 11.5, Material from Ref. 1
28-29	Mar 18	Ch. 12: Stress concentration, Intro to fracture mechanics, Sections 12.1-12.6, Sections 3.7-3.9, 8.5-8.7, 12.7, Material from Ref. 1
	Test # 2, March 23, Tue	
34-41	Mar 30, Apr 6,8,13	Ch. 13: Creep, stress rupture and fatigue
	Apr 15,20	
	April 21st (Wed) Last Day of Class	
	Test # 3 (Final)	

Academic Honesty: As is understood by the vast majority of students, our basic relationship is based on trust; we have rarely encountered problems in this area. Following the request of the Provost we include the following statement.

All students admitted to the University of Florida have signed a statement of academic honesty committing themselves

to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action.

This statement is a reminder to uphold your obligation as a student at the University of Florida and to be honest in all work submitted and exams taken in this class and all others. All students should review the University's honor code policy - you will be held to it.

Grading Policy

Percent	**Grade**	**Grade Points**
90.0 - 100.0	A	4.00
87.0 - 89.9	A-	3.67
84.0 - 86.9	B+	3.33
81.0 – 83.9	B	3.00
78.0 - 80.9	B-	2.67
75.0 - 79.9	C+	2.33
72.0 – 74.9	C	2.00
69.0 - 71.9	C-	1.67
66.0 - 68.9	D+	1.33
63.0 - 65.9	D	1.00
60.0 - 62.9	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:
http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades