UNIVERSITY OF CALIFORNIA, DAVIS
Department of Materials Science and Engineering

Professor Gibeling **EMS-249** **Fall 2018**

COURSE INFORMATION

Course Title:	Mechanisms of Fatigue
Instructor:	Prof. Jeffery C. Gibeling Office: 2019 Kemper Phone: (530) 752-7037 FAX: (530) 752-9554 E-mail: jcgibeling@ucdavis.edu Office Hours: MW 10:00-11:00AM (and by arrangement)
Course Meetings:	MWF 9:00-9:50 in 201 Wellman. Additional time will be arranged for one laboratory exercise during the quarter.
Textbook:	S. Suresh, Fatigue of Materials, Second Edition, Cambridge University Press, Cambridge, 1998.
Grading Basis:	Homework (4-5 assignments) 20% Term Paper (due Monday, Dec. 3) 30% Final Exam 50%
References:	Please see separate list.

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COURSE OUTLINE AND READING ASSIGNMENTS

Date	Lecture Topic	Assignment*	
		Chap.	Pages
Sept. 26	Introduction: Historical Overview	1	1-11
Sept. 28	Introduction: Fatigue Methodology	1	11-18
Oct. 1	Cyclic Deformation: Experimental Studies & Bauschinger Effect	3	97-104
Oct. 3	Cyclic Deformation: Cyclic Stress-Strain Curve	3	86-97
Oct. 5	Cyclic Deformation: Fatigue Life Rules	7	221-231 235-237
Oct. 8	Cyclic Deformation: Fatigue Life Rules	8	256-262
Oct. 10	Cyclic Deformation: Dislocation Mechanisms	2	39-52
Oct. 12	Cyclic Deformation: Dislocation Mechanisms	-	------
Oct. 15	Cyclic Deformation: Alloying Effects	-	------
Oct. 17	Cyclic Deformation: Persistent Slip Bands	2	52-69
Oct. 19	Cyclic Deformation: Persistent Slip Bands	-	------
Oct. 22	Cyclic Deformation: Microstructural Effects	2	69-84
Oct. 24	Cyclic Deformation: Brittle Materials	5	165-191
Oct. 26	Nucleation: Stage I Growth	4	132-137
Oct. 29	Crack Nucleation: Intrusions and Extrusions	4	137-147
Oct. 31	Crack Nucleation: Intrusions and Extrusions	-	--------
Nov. 2	Crack Nucleation: Microstructural Effects	4	147-162
Nov. 5	Crack Propagation: Stage I to Stage II Transition	-	---------
Nov. 7	Crack Propagation: Experimental Studies	-	---------
Nov. 9	Crack Propagation: Mechanics of Growth	9	283-307
Nov. 12	VETERAN'S DAY HOLIDAY	**	*******
Nov. 14	Crack Propagation: Mechanics of Growth	10	331-368
Nov. 16	Crack Propagation: Single Crystal Results	-	---------
Nov. 19	Crack Propagation: Polycrystalline Results	-	---------
Nov. 21	Crack Propagation: Crack Closure Mechanisms	14	483-507
Nov. 23	THANKSGIVING HOLIDAY	**	*******
Nov. 26	Crack Propagation: Crack Closure Mechanics	14	507-537
Nov. 28	Crack Propagation: Small and Short Cracks	15	541-568
Nov. 30	Crack Propagation: Mechanistic Models of Crack Growth	-	---------
Dec. 3	Crack Propagation: Brittle Materials	11	383-399
Dec. 5	Crack Propagation: Brittle Materials	-	---------
Dec. 7	Crack Propagation: Bone	-	---------

FINAL EXAMINATION: Thursday, December 13, 2018, 3:30-5:30 PM

* All reading assignments are from the text by Suresh, Second Edition

COURSE OUTLINE

I. INTRODUCTION TO FATIGUE
- A. Historical Overview
- B. Examples of Fatigue in Engineering Structures
- C. Physical Mechanisms of Fatigue

II. CYCLIC DEFORMATION
- A. Phenomenological Description of Cyclic Deformation
  1. Experimental methods
  2. Hysteresis loops and saturation
  3. Cyclic hardening and softening
  4. The Bauschinger effect
  5. Cyclic stress-strain curves
  6. Fatigue life rules
     - a. stress-based rules
     - b. strain-based rules
     - c. effect of mean stress
- B. Dislocation Processes in Cyclic Deformation
  1. Studies of single crystals
  2. Dislocation structure and persistent slip bands (PSB's)
  3. Models of cyclic deformation and PSB formation
     - a. Brown
     - b. Essmann, Gösele and Mughrabi
  4. Mechanisms of strain localization
     - a. Planar slip and wavy slip
     - b. Precipitate shearing
     - c. Grain size effects
     - d. Precipitate free zones
- C. Low Cycle Fatigue of Ceramics and Bone

III. FATIGUE CRACK NUCLEATION AND STAGE I GROWTH
- A. Extrusions and Intrusions
- B. Models of Extrusion/Intrusion Formation and Crack Nucleation
  1. Wood
  2. Cottrell and Hull
  3. Neumann
  4. Laird
  5. Brown
  6. Mughrabi
- B. Crack Nucleation in Polycrystalline Materials
- C. Stage I Crack Growth
  1. Environmental effects
  2. Microstructural effects

IV. STAGE II FATIGUE CRACK GROWTH
- A. Stage I to Stage II Transition
- B. Fracture Mechanics Description of Stage II Growth
- C. Experimental Measurements

D. Mechanics of Stage II Growth
    1. Use of ΔK as a characterizing parameter
    2. Paris (power) law
    3. Threshold behavior
E. Microstructural Observations of Stage II Growth
    1. Effect of crystal orientation
    2. Environmental effects
    3. Frequency effects
F. Near Threshold Growth
    1. Environmental effects
    2. Microstructural effects
    3. Crack closure
    4. History effects
    5. Small cracks and short cracks
G. Models of Stage II Growth
    1. Laird and Smith
    2. Neumann
H. Fatigue Crack Growth in Ceramics and Bone
    1. Microstructure effects
    2. Engineering crack growth resistance