SAMPLE SYLLABUS

ME C225/MSE C212: Deformation, Fracture and Fatigue of Structural Materials

Professor Lisa Pruitt, 5134 EH, lpruitt@me.berkeley.edu, Office hours: Tu-Th 2:30-3:30 or by appointment

Lectures: Tu-Th 9-11, 1165 Etcheverry Hall

Deformation, Fracture and Fatigue of Structural Materials (4 units)

This survey course presents the mechanics and microstructural aspects of deformation, fracture, and fatigue in metals, ceramics, polymers, composites and natural materials. Topics include structure-property relationships, mechanical behavior over different length scales, linear elasticity, non-elasticity, plasticity and time dependent deformation. The historical evolution of fracture mechanics is presented with emphasis on linear and non-linear elastic fracture mechanics and their use in fracture analysis. The physical basis of intrinsic and extrinsic toughening, environmentally-assisted fracture, cyclic fatigue failure, fatigue-crack propagation, stress-strain/life and damage-tolerant design, creep-crack growth, and fracture statistics are reviewed.

I. Deformation behavior

Overview of historic engineering failures
Review of structural materials: metals, ceramics, polymers, composites, and natural materials
Microstructural aspects of deformation and length scale effects
Elastic behavior, multiaxial loading, time-dependent behavior
Yield criteria and permanent deformation
Failure modes and propensity for fracture in different materials

(25%) Project I (Deformation and failure modes)

II: Fracture Mechanics

Historical development of fracture mechanics
Griffith fracture theory and notion of energy release rate
Linear elastic fracture mechanics, crack-tip asymptotic singular fields, and small scale yielding
Non-linear fracture mechanics, J- integral methods, R-curves
Experimental methods for determining fracture toughness
Microstructural effects, intrinsic and extrinsic toughening mechanisms
Environmentally assisted and time-dependent crack growth

(25%) Project II (Fracture Mechanics)

III. Fatigue

Historical perspective
Fatigue characterization: Total life versus defect tolerant philosophy
Cyclic stress fields, notches, and short cracks
Experimental methods for determining fatigue resistance
Micromechanisms of fatigue fracture

(25%) Project III (Fatigue)

IV. Damage tolerance, design considerations and failure analysis

Damage tolerance in materials
Design considerations
Methodologies for failure analysis

(25%) Project IV (Damage tolerance, design considerations, and failure analysis)

******_This course will be taught using an active and cooperative environment. The course grades will be comprised of 4 team projects. Each project will utilize teams and will require both an oral presentation to the class and a technical write-up. Each team member will provide a self-assessment and team assessment. Each project will utilize a different combination of students in the teams._

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Recommended text: Suresh, Fatigue of Materials, Cambridge University Press, 2nd edition, 1998.

Useful references:

1) Mechanical Behavior of Materials:

F. A. McClintock and A. S. Argon: *Mechanical Behavior of Materials* (Addison- Wesley, 1966)

M. A. Meyers and K. K. Chawla: *Mechanical Metallurgy: Principles and Applications* (Prentice-Hall, 1984)

2) Fracture Mechanics:

D. Broek: *Elementary Engineering Fracture Mechanics* (3rd ed., Sijthoff Noordhoff, 1982)

J. F. Knott: *Fundamentals of Fracture Mechanics* (Halstead Press, 1973)

S. T. Rolfe and J. M. Barson: *Fracture and Fatigue Control in Structures* (2nd ed., Prentice-Hall, 1987)

H. L. Ewalds and R. J. Wanhill: *Fracture Mechanics* (Arnold, 1984)

T. L. Anderson: *Fracture Mechanics: Fundamentals and Applications* (2nd ed., CRC Press, 1995)

B. R. Lawn: *Fracture of Brittle Solids* (2nd ed., Cambridge Univ. Press, 1993)

3) Handbooks on *K* and *J* Solutions:

Akram Zahoor: *Ductile Fracture Handbook* (Electric Power Research Inst., 1989)

H. Tada, P. C. Paris, and G. R. Irwin: *Stress Analysis of Cracks Handbook* (Del/Paris Publ., 1985)

3) Fatigue:

S. Suresh: *Fatigue of Materials* (Cambridge, 1998, 2nd ed.)

F. Ellyin: Fatigue Damage, Crack Growth and Life Prediction (Chapman&Hall, 1997)

4) Environmentally-Influenced Failure:

J. C. Scully: *Fundamentals of Corrosion* (Pergamon, 1975, 2nd ed.)

5) Mechanical Testing:

Metals Handbook, 9th ed., vol. 8 (American Society for Metals)

6) Failure Analysis/Fractography:

Metals Handbook, 9th ed., vol. 12 (American Society for Metals)

7) Continuum Mechanics/Elasticity (simple treatments):

E. P. Popov: *Introduction to Mechanics of Solids* (Prentice-Hall, 1968)

S. H. Crandall, N. C. Dahl and T. J. Lardner: *An Introduction to the Mechanics of Solids* (2nd ed., McGraw-Hill, 1978)

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