UNIVERSITY OF MARYLAND BALTIMORE COUNTY, (UMBC)

Department of Mechanical Engineering

ENME678
Engineering Fracture Mechanics **Spring 2015**

Instructor: Panos G. Charalambides
Office: 209 Engineering Building
Tel. No.: 410-455-3346

Course Summary

In light of the current technological needs for high toughness high performance composites, Engineering Fracture mechanics is currently enjoying a renewed interest within the research and design communities. Toughness and strength are material characteristics often obtained from competing microstructural failure processes. To optimize and control the above quantities it is necessary to understand fracture at the microstructural level and in particular fracture in the presence of a major material flaw, or macrocrack.

In this course, a rigorous mathematical approach is used to study the stress/strain fields around the tip of a sharp flaw for the three basic fracture modes: the opening, mode I, in-plane shear, mode II and antiplane shear, mode II. The energetics associated with the presence and growth of a major crack will be examined and various fracture criteria will be established. Various analytical techniques in extracting the stress intensities for a given geometry and applied loading will be presented. Crack kinking and crack stability will be addressed. Correction to the near-tip stress fields due to plasticity and aspects of bimaterial fracture pertinent to thin film decohesion, fiber debonding and delamination in composites will also be presented. Throughout the course, special emphasis will be placed on aspects related to engineering design and fracture mechanics.

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OUTLINE OF TOPICS

Preliminaries

- Indicial Notation
- Basic Vector and Tensor Operations
- Elasticity Field Equations
- *Engineering Applications*

Linear Elastic Analysis

- Crack-tip Stress and Deformation Fields in Linear Elastic Solids
- Energy Changes with Crack Size
- Compliance Methods for Determining K
- Weight Function Analysis
- J - integral
- *Engineering Applications*

Fracture Criteria for Elastic Brittle Fracture

- Theoretical Strength
- Griffith
- Cohesive Zone Models
- Mode II Criteria
- Estimate of Plastic Zone based on K
- Fracture Toughness Testing and Thickness Effects
- *Engineering Applications*

Elastic Plastic Fracture

- Slip Lines and Limit Analysis
- Asymptotic Results for Crack-tip Stress Fields
- J - integral Analysis
- Stable Growth
- *Engineering Applications*

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ADDITIONAL TOPICS IN FRACTURE MECHANICS

Singular Elasticity Solutions in Two Dimensions

- Dislocation and Point Force Solutions
- Cracks as Continuous Dislocation Distributions
- Hilbert Arc Problems
- Analytic Function Techniques
- *Engineering Applications*

Physical Mechanisms of Fracture

- Cleavage Fracture
- Ductile hole growth
- Stress Corrosion
- Fatigue
- *Engineering Applications*

Dynamic Fracture

- Crack-tip Stress Fields
- Energy Flux to Crack-tip
- *Engineering Applications*

Special Topics

- Steady State Energy Release Rates in Fracture Mechanics
- Crack Paths (Thin Film Decohesion)
- Bimaterial Fracture at Interfaces

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Lectures: MW 2:30 – 3:45 p.m. (University Center 115)
Instructor: **Panos G. Charalambides**, (Engineering 209, x5-3346)
Office Hours: MW 4:00 p.m. - 5:00 p.m. and by appointment

Textbook: T. L. Anderson: Fracture Mechanics: Fundamentals and Applications
Second Editions, CRC Press Inc., 1991: **Recommended**.

Grading Policy

Mid-Term Exam	30%
Homework	30%
Final Exam	40%

List of books for complementary reading.

Fracture Mechanics

Broek, D.	Elementary Engineering Fracture Mechanics. (Leyden, Noordhoff International), 1974.
Broek, D.	The Practical Use of Fracture Mechanics. (Kluwer Academic Publishers), 1989.
Lawn, B. R. & T. R. Wilshaw	Fracture of Brittle Solids (Cambridge University Press), 1975.
Knott, J. F.	Fundamentals of Fracture Mechanics (Halsted Press), 1975.
Parker, A.P..	The Mechanics of Fracture and Fatigue. (E. & F.N. Spon Ltd.), 1981.
Ewalds, H.L.. & Wanhill, R.J.H.	Fracture Mechanics. (Edward Arnold (Australia) Pty Ltd.), 1984.
M. F. Kanninen and C. H. Popelar	Advance Fracture Mechanics (Oxford Press), 1986.
Liebowitz, H. (Editor)	Fracture: An Advance Treatise, Vol I, II, & III (Academic Press)
Hutchinson J. W.	Nonlinear Fracture Mechanics (Solid Mechanics, The Technical University of Denmark), 1979.

Continuum Mechanics

Malvern L. E.	Introduction to the Mechanics of a Continuous Medium (Prentice-Hall), 1969.

Elasticity

Sokolnikoff I. S.	Mathematical Theory of Elasticity, 2nd Edition, (McGraw-Hill), 1956.
Timoshenko S. & Goodier J. N.	Theory of Elasticity, 2nd Edition, (McGraw-Hill), 1951.
Love A. E. H.	The Mathematical Theory of Elasticity, 4th Edition, (Cambridge University Press), 1927; (reprinted by Dover), 1944.
Muskhelishvili N. I.	Some Basic Problems of the Mathematical Theory of Elasticity, translated by J. R. M. Radok, (P. Noordhoff Ltd.),1963.

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Weekly Time Schedule

Time	Monday	Tuesday	Wednesday	Thursday	Friday
8:00-9:00					
9:00-10:00					
10:00-11:00					
11:00-12:00					
12:00-1:00					
1:00-2:00					
2:00-3:00					
3:00-4:00					
4:00-5:00					
5:00-6:00					
6:00-7:00					
6:00-7:00					
8:00-9:00					

Please indicate conflict hours on the above time schedule and return to me as soon as possible for conflict meeting arrangements.