Mechanical Behavior of Materials Course Notes, 2nd Edition

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THE UNIVERSITY OF ALABAMA ENGINEERING

DEPT. OF METALLURGICAL & MATERIALS ENGINEERING
Spring Semester 2008

MTE 455 – Mechanical Behavior of Materials
MTE 556 – Advanced Mechanical Behavior of Materials I

LECTURES: **Mon, Wed, Fri A027 Bevill from 10:00 to 10:50 PM**

SUPPLEMENTAL GRADUATE LECTURES: **To be determined**

INSTRUCTOR: **Dr. Mark L. Weaver**

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TEXTBOOK: Meyers & Chawla (see p. 8 for details). Additional materials will be provided as necessary.

Preface

These course notes deal with the mechanical response of materials to applied forces or loads. Mechanical properties are amongst the most structure sensitive properties. As such, it is critical that engineering students understand the role of microstructure in determining the final properties of materials.

This set of lecture notes has been prepared to aid in providing you with a complete understanding of the fundamental aspects of deformation as it occurs in materials. Microscopic and macroscopic length scales are addressed. Groups of topics have been separated into modules designed to reinforce the materials that you will read in the required text or in one of the alternate references listed in the Bibliography. The selection of topics does not represent the perfect or ideal way to teach one about mechanical behavior. Rather the topics and order reflect the things that I view as valuable for a balanced engineering student to know.

I have gone to great lengths to prepare these notes to assist you in learning the fundamentals. However, there are bound to be mistakes and/or omissions. I take full responsibility for them and ask that you point them out to me so that they can be corrected.

These notes do contain some copyrighted material. I have attempted to site all of the sources, however, I may have missed a few. Please point them out if you notice them so that I can correct the error.

These notes are not to be distributed for a fee and are provided free for anyone to use.

– M.L. Weaver, December 2007

Spring 2008 Semester

- This set of notes will be used for MTE 455 and MTE 556 this semester.
- Supplemental materials will be provided by the instructor for students enrolled in MTE 556.
- Supplemental lectures will be scheduled for students enrolled in MTE 556. These lectures are required for students enrolled in MTE 556.
- Required supplemental assignments will be given to students enrolled in MTE 556.

Table of Contents

Part I - Mechanics

QUIZ #1 (MODULES 1-7)

Part II - Defects

QUIZ #2 (MODULES 7-14)

Part III - Micromechanics

QUIZ #3 (MODULES 15-22)

Part IV – Fracture & Other topics

QUIZ #4 (MODULES 15-end)

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FINAL EXAM (CUMULATIVE)

Course Grading

(Tentative)

Quizzes 1 - 4	40.0%
Final Exam (cumulative)	30.0%
Homework	20.0%
Lab Experiments	10.0%
TOTAL	100.0%

There will be 4 quizzes. All quizzes shall be written, quantitative, and closed book.

The Final exam will be cumulative and will address all topics covered in this course.

ALL COURSE POLICIES ARE DETAILED IN THE COURSE SYLLABUS.

Partial Bibliography

★ **M.A. Meyers and K.K. Chawla, Mechanical Behavior of Materials, Prentice-Hall (1999).** This text is currently being revised. A new edition will be published in 2008 by Cambridge University Press. The first edition can be acquired from Book Masters, Inc. 30 Amberwood Parkway, Ashland, Ohio 44805 (1-800-247-6553 or http://bookmasters.com for $70).

G.E. Dieter, Mechanical Metallurgy, McGraw-Hill (1986).

R.W. Hertzberg, Deformation & Fracture Mechanics of Engineering Materials, 4th ed., John Wiley & Sons (1996).

T.F. Courtney, Mechanical Behavior of Materials, 2nd ed., Waveland Press (2005).

N.E. Dowling, Mechanical Behavior of Materials, Engineering Methods for Deformation Fracture and Fatigue, 3rd ed., Prentice-Hall (2007)

W.F. Hosford, Mechanical Behavior of Materials, Cambridge (2005).

K. Bowman, Mechanical Behavior of Materials, John Wiley & Sons (2004).

W. Soboyejo, Mechanical Properties of Engineered Materials, Marcel Dekker (2003).

J.F. Nye, Physical Properties of Crystals, Oxford University Press (1985).

D. Hull and D.J. Bacon, Introduction to Dislocations, 4th ed., Butterworth-Heinemann (2001).

R.E. Reed-Hill and R. Abbaschian, Physical Metallurgy Principles, 3rd ed., Thompson Learning (1992).

J. Roesler, H. Harders, M. Baeker, Mechanical Behavior of Engineering Materials, Springer (2007).

A.S. Argon, Strengthening Mechanisms in Crystal Plasticity, Oxford (2008).

G. Gottstein, Physical Foundations of Materials Science, Springer (2004).

★ = text for course

How to learn the most

- Listen to the instructor
  - Not everything is covered in the notes or the book(s).
  - Ask questions or go and see the instructor when you are confused.

- Take notes by hand
  - This will reinforce what you read.
  - This course is less mathematical than many of the others that you have taken. It will require you to think and conceptualize things.

- Look at the lecture materials and read the suggested sections of the book prior to the lectures.

- Actually read the required textbook. When necessary, take a look at other texts on the subject.

- Do the homework and turn it in on time.

Topics

(not necessarily in order)

Chapter(s) In text	Subject	Sections
1	Introduction/Overview of Materials	All
2	Stress & Strain Relations for Elasticity	All
3	Elements of Plasticity	All
6	Plastic Deformation of Single Crystals	6.1, 6.2
4	Dislocations and Point Defects	All
5,6,10**	Strengthening Mechanisms	All Ch.5; 6.3,6.5; All Ch. 10
7	Fracture Mechanics	All
8,9	Fracture	All
14	Fatigue of Engineering Materials	All
13	Creep and Superplasticity	All
15	Composites	All
**	OTHER TOPICS	All as assigned

** Alternate reading materials (i.e., handouts) may be provided

Assigned Homework Problems

From Meyers & Chawla for Spring Semester 2008

Some, but not all, will be assigned

- CHAPTER 1
  - 1.1; 1.2; 1.3; 1.15; 1.16; 1.17; 1.18
- CHAPTER 2
  - 2.1; 2.2; 2.3; 2.4; 2.5; 2.7; 2.9; 2.10; 2.13; 2.16; 2.17; 2.19; 2.24
- CHAPTER 3
  - 3.1; 3.2; 3.3; 3.5; 3.8; 3.11; 3.12; 3.15
- CHAPTER 4
  - 4.7; 4.8; 4.9; 4.10; 4.13; 4.14; 4.15; 4.23; 4.26; 4.27; 4.28
- CHAPTER 5
  - 5.8; 5.26
- CHAPTER 6
  - 6.3; 6.4; 6.9; 6.10; 6.14; 6.15; 6.19
- CHAPTER 7
  - 7.9; 7.10; 7.11; 7.13; 7.30
- CHAPTER 8
  - 8.2; 8.5
- CHAPTER 9
  - 9.1; 9.3; 9.4
- CHAPTER 10
  - 10.7; 10.9; 10.11; 10.12; 10.13; 10.14
- CHAPTER 13
  - 13.1; 13.4; 13.7; 13.13
- CHAPTER 14
  - 14.1; 14.2; 14.3; 14.4; 14.6; 14.7
- CHAPTER 15
  - 15.1; 15.6; 15.7; 15.10
- OTHER TOPICS
  - Handouts

★ Homework problems from alternate sources will be assigned when deemed appropriate by the instructor.

Learning Objectives

To develop a **fundamental understanding of how materials respond to applied loads** in terms of continuum mechanics and micromechanics.

In this course we will tie together many of the mechanisms that you learned about in physical metallurgy to the fundamentals of stress, strain, and fracture that you learned about in engineering mechanics and mechanics of materials.