

**MME 3407/5308/MASE6390 - MECHANICAL BEHAVIOR OF MATERIALS
(SPRING SEMESTER 2023)**

INSTRUCTOR: Dr. S. K. Varma (E-Mail: skvarma@utep.edu)
OFFICE: 201F Engineering Science Complex
TEXTBOOK: "Mechanical Behavior of Materials"
 Marc A Meyers and Krishan Chawla
 Cambridge University Press, 2009
 ISBN 978-0-521-86675-0

CLASS TIMES:

Lecture	TR	1030 – 11:50	CBRL 205
Lab	T	1:30 – 4:20	CBRL 205
	R	1:30 – 4:20	CBRL 205

COURSE SYLLABUS

NO.	CHAPTER	DATE	TOPIC
1	1	Jan 17	Materials Structure, Properties, and Performance
2	1	Jan 19	Materials Structure, Properties, and Performance
3	1	Jan 24	Materials Structure, Properties, and Performance
4	3	Jan 26	Plasticity
5	3	Jan 31	Plasticity
6	3	Feb 2	Plasticity
7	4	Feb 7	Imperfections: Point and Line Defects
8	4	Feb 9	Imperfections: Point and Line Defects
9	X	Feb 14	EXAMINATION NO.1
10	4/5	Feb 16	Imperfections: Point and Line Defects
11	4/5	Feb 21	Imperfections: Point and Line Defects/Interfacial and Volumetric
12	6	Feb 23	Geometry of Deformation
13	6	Feb 28	Geometry of Deformation
14	6	Mar 2	Geometry of Deformation
15	10	Mar 7	Solid Solutions, Precipitation and Dispersion Strengthening
16	10	Mar 9	Solid Solutions, Precipitation and Dispersion Strengthening
X	X	Mar 14	SPRING BREAK
X	X	Mar 16	SPRING BREAK
17	10	Mar 21	No Class - Solid Solutions, Precipitation and Dispersion Strengthening
18	X	Mar 23	EXAMINATION NO.2
19	13	Mar 28	Creep and Superplasticity
20	13	Mar 30	Creep and Superplasticity
21	13	Apr 4	Creep and Superplasticity
22	13	Apr 6	Creep and Superplasticity
23	X	Apr 11	EXAMINATION NO.3
24	14	Apr 13	Fatigue
25	14	Apr 18	Fatigue
26	14	Apr 20	Fatigue
27	14	Apr 25	Fatigue
28	21	Apr 27	Ductile Fracture
29	21	May 2	Ductile Fracture
30	X	May 4	EXAMINATION NO.4
X	X	May 11	FINAL EXAMINATION THURSDAY 10:00 – 12:45

GRADING POLICY:

Homework	15%
Project	20%
Four Exams	55%
Final Examination	10%

NOTES:

1. Homework will be sent electronically and will also be posted on blackboard (bb).
2. **Please do not copy homework from others** and if caught, both (or more) sets of homework will be given a grade of zero and may be subject to disciplinary action.
Also remember the penalty involved for plagiarism. Very serious consequences may evolve in such a situation.
3. Questions will be asked from the students at random from the material already covered in the lectures. You must come prepared to the class for this type of discussion.
4. Absence from the class must be explained in writing (signed) otherwise it will be considered as unexcused absence.
Students will be dropped from the class after 4 unexcused absences.
5. **The grades on homework and exams can only be discussed within one week after returning them in the class.**
It is your responsibility for collecting these immediately after my handing it out to class. The days of absence are included in this one-week period.
6. Instructions on project details will be provided to you later.

DETAILS OF COURSE OUTLINE

CHAPTER 1 (Materials: Structure, Properties, and Performance)

1.1 Introduction

1.3 Structure of Materials

1.3.1 *Crystal Structures*

1.3.2 *Metals*

1.3.3 *Ceramics*

1.3.4 *Glasses*

1.3.5 *Polymers*

Chemical Structure

Types of Polymers

Thermosetting Polymers and Thermoplastics

Degree of Crystallinity

Molecular Weight and Distribution

CHAPTER 3 (Plasticity)

3.1 Introduction

3.2 Plastic Deformation in Tension

3.2.1 *Tensile Curve Parameters*

3.2.2 *Necking*

3.2.3 *Strain Rate Effects*

3.3 Plastic Deformation in Compression Testing

3.4 The Bauschinger Effect

3.5 Plastic Deformation of Polymers

3.5.1 *Stress-Strain Curves*

3.5.2 *Glassy Polymers*

3.5.3 *Semicrystalline Polymers*

3.5.4 *Viscous Flow*

3.5.5 *Adiabatic Heating*

3.6 Plastic Deformation of Glasses

3.6.1 *Microscopic Deformation Mechanism*

3.6.2 *Temperature Dependence and Viscosity*

3.8 Hardness

3.8.1 *Macroindentation Tests*

Brinell Hardness Tests

Rockwell Hardness Test

Vickers (or Diamond Pyramid) Hardness Tests

3.8.2 *Microindentation Test*

3.8.3 *Nanindentation*

3.9 Formability: Important Parameters

3.9.1 *Plastic Anisotropy*

CHAPTER 4 (Imperfections: Point and Line Defects)

4.1 Introduction

4.2 Theoretical Shear Strength

4.3 Atomic or Electronic Point Defects

4.3.1 *Equilibrium of Point Defects*

4.3.2 *Production of Point Defects*

4.3.3 *Effect of point Defects on Mechanical Properties*

4.4 Line Defects

4.4.1 *Experimental Observation of Dislocations*

- 4.4.2 *Behavior of Dislocations*
 - Dislocation Loops*
 - Movement of Dislocations*
- 4.4.3 *Stress Field Around Dislocations*
- 4.4.4 *Energy of Dislocations*
- 4.4.5 *Force Required to Bow a Dislocation*
- 4.4.6 *Dislocations in Various Structures*
 - Dislocations in Face Centered Cubic Crystals*
 - Dislocations in Body Centered Cubic Crystals*
- 4.4.7 *Dislocations in Ceramics*
- 4.4.8 *Sources of Dislocations*
- 4.4.9 *Dislocation Pileups*
- 4.4.10 *Intersection of Dislocations*
- 4.4.11 *Deformation Produced by Motion of Dislocations (Orowan's Equations)*
- 4.4.12 *Peierls-Nabarro Stress*
- 4.4.13 *The Movement of Dislocations: Temperature and Strain Rate Effects*

CHAPTER 5 (Imperfections: Interfacial and Volumetric Defects)

- 5.1 Introduction**
- 5.2 Grain Boundaries**
 - 5.2.1 *Tilt and Twist Boundaries*
 - 5.2.2 *Energy of Grain Boundary*
 - 5.2.3 *Variation of Grain Boundary Energy with Orientation*
 - 5.2.5 *Grain Boundary Triple Points*
 - 5.2.6 *Grain Boundary Dislocations and Ledges*
- 5.3 Twinning and Twin Boundaries**
 - 5.3.1 *Crystallography and Morphology*
 - 5.3.2 *Mechanical Effects*
- 5.4 Grain Boundaries in Plastic Deformation (Grain Size Strengthening)**
 - 5.4.1 *Hall-Petch Theory*
- 5.6 Nanocrystalline Materials**

CHAPTER 6 (Geometry of Deformation and Work Hardening)

- 6.1 Introduction**
- 6.2 Geometry of Deformation**
 - 6.2.2 *Stress Required for Slip*
 - 6.2.3 *Shear Deformation*
 - 6.2.4 *Slip Systems*
 - 6.2.5 *Independent Slip Systems in Polycrystals*
- 6.3 Work Hardening**
 - 6.3.1 *Taylor's Theory*
 - 6.3.2 *Seeger's Theory*
 - 6.3.3 *Kuhlman-Wilsdorf's Theory*
- 6.4 Softening Mechanisms**

CHAPTER 7

- 7.1 Introduction**
- 7.2 Theoretical Tensile Strength**

CHAPTER 10 (Solid Solutions, Precipitation, and Dispersion Strengthening)

- 10.1 Introduction**

10.2 Solid Solution Strengthening

10.2.1 Elastic Interactions

10.2.1 Other Interactions

10.3 Mechanical Effects Associated With Solid Solutions

10.3.1 Well-Defined Yield Point in the Stress-Strain Curves

10.3.2 Plateau in the Stress-Strain Curve and Luders Band

10.3.3 Strain Aging

10.3.4 Serrated Stress-strain Curve

10.3.5 Snoek Effect

10.3.6 Blue Brittleness

10.4 Precipitation and Dispersion Hardening

10.5 Dislocation-Precipitation Interaction

The precipitate particles are impenetrable to the dislocations

The precipitate particles are penetrable to dislocations

10.6 Precipitation in Microalloyed Steels

CHAPTER 13 (Creep and Superplasticity)

13.1 Introduction

13.2 Correlation and Extrapolation Methods

13.3 Fundamental Mechanisms Responsible for Creep

13.4 Diffusion Creep

13.5 Dislocation Creep

13.6 Dislocation Glide

13.7 Grain Boundary Sliding

13.8 Deformation –Mechanism (Weertman-Ashby) Maps

13.9 Creep Introduced Fracture

13.10 Heat Resistant Materials

13.11 Creep in Polymers

13.13 Superplasticity

CHAPTER 14 (Fatigue)

14.1 Introduction

14.2 Fatigue Parameters and S-N Curves

14.3 Fatigue Strength or Fatigue Life

14.4 Effect of Mean Stress on Fatigue Life

14.5 Effects of Frequency

14.6 Cumulative Damage and Life Prediction

14.7 Mechanisms of Fatigue

14.7.1 Fatigue Crack Nucleation

14.7.2 Fatigue Crack Propagation

14.8 Linear Fracture Mechanics Applied to Fatigue

14.9 Hysteric Heating in Fatigue

CHAPTER 15 (Composite Materials)

15.1 Introduction

15.2 Types of Composites

15.3 Important Reinforcements and Matrix Materials

15.3.1 Microstructural Aspects and Importance of the Matrix

15.4 Interfaces in Composites

15.4.1 Crystallographic Nature of the Fiber/Matrix Interface

15.4.2 Interfacial Bonding in Composites

- 15.4.3 Interfacial Interactions*
- 15.5 Properties of Composites**
 - 15.5.1 Density and Heat Capacity*
 - 15.5.2 Elastic Moduli*
 - 15.5.3 Strength*
 - 15.5.4 Anisotropic Nature of Fiber Reinforced Composites*
 - 15.5.5 Aging Response of Matrix in MMCs*
 - 15.5.6 Toughness*
- 15.6 Load Transfer from Matrix to Fiber**
 - 15.6.1 Fiber and Matrix Elastic*
 - 15.6.2 Fiber Elastic and Matrix Plastic*
- 15.7 Fracture in Composites**
 - 15.7.1 Single and Multiple Fracture*
 - 15.7.2 Failure Modes in Composites*