

MSE 1070: Mechanical Behavior of Materials **Syllabus for 2024 Spring**

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Lecture: 3 Credits, Wednesday, 1:50 pm - 4:25 pm, SCUPI North 210

Office Hours: Wednesday, 9:10 am – 11:55 am, SCUPI North 405

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QQ Group: 809363720

Prerequisites: ENGR 0022, ENGR 0145

Course Description:

This course teaches the fundamental concepts which deals with the behavior and response of metallic materials to applied force, involving mechanical properties of metals or mechanical testing, and the field restricted to the plastic working and shaping of metals as well as more theoretical aspects of the field, which merge with metal physics and physical metallurgy. Also, the basic knowledge on applied mathematics and applied mechanics are also included in this course. This course is divided into mechanical fundamentals, metallurgical fundamentals, applications to materials testing and plastic forming of metals. Mechanical fundamentals present the basic concepts of three-dimensional stress-strain relationship, theories of yielding and plasticity. Regarding metallurgical fundamentals, the concepts of dislocation theory, strengthening mechanisms of metals and fracture mechanics are also introduced and discussed. Applications to materials testing deals with the engineering aspects of the common testing techniques of mechanical failure of metals, including tension, torsion, hardness, fatigue, creep, and impact fracture toughness tests. Additionally, the topics on plastic forming of metals dealing with the common mechanical processes for producing useful metal shapes are illustrated in this course.

Course Objectives:

In this course, students can (i) understand fundamental concepts of stress, strain and stress-strain relationships in engineering materials; (ii) apply theories of elastic and plastic deformation to analyze material response under applied loads; (iii) understand the relationship between dislocation behavior, common strengthening mechanisms, and mechanical properties of metals; (iv) analyze failure modes such as yielding, fracture and fatigue using principles of fracture mechanics; (v) perform common mechanical tests to characterize properties like tensile strength, hardness, fatigue resistance and toughness; (vi) interpret material responses from stress-strain curves obtained in tension, torsion, hardness and other tests; (vii) apply principles of applied mathematics and mechanics to analyze stresses and strains in engineering components and materials; and (viii) synthesize knowledge of mechanical and metallurgical fundamentals to solve materials selection/design problems involving metal works or plastic forming applications.

Applicable ABET Outcomes:

1. An ability to apply knowledge of mathematics, science, and engineering
2. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
3. An ability to function on multi-disciplinary teams
4. An ability to identify, formulate, and solve engineering problems
5. An understanding of professional and ethical responsibility
6. An ability to communicate effectively
7. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Required Resources:

Required textbook:

1. Dieter, G. E. **Mechanical Metallurgy**, 3rd ed., New York: McGraw-Hill, 1986. Print.

Useful supporting materials:

1. Hull, D., and D.J. Bacon. **Introduction to Dislocations**. 5th ed., Amsterdam: Butterworth-Heinemann, 2011. Print.
2. Meyers, M.A., and K.K. Chawla. **Mechanical Behavior of Materials**, 2nd ed., Cambridge: Cambridge University Press, 2009. Print.
3. Courtney, T.H. **Mechanical Behavior of Materials**, 2nd ed., Long Grove, Ill: Waveland Press, 2005. Print.
4. Ashby, M.F., H. Shercliff, and D. Cebon. **Materials: Engineering, Science, Processing and Design**, 4th ed., Kidlington, Oxford, United Kingdom: Butterworth-Heinemann, 2019. Print.
5. Raman, A. **Materials Selection and Applications in Mechanical Engineering**. New York: Industrial Press, 2007. Print.
6. Meyers, M.A., and K.K. Chawla. **Mechanical Metallurgy: Principles and Applications**. Englewood Cliffs, N.J: Prentice-Hall, 1984. Print.
7. Smith, W. F. **Structure and Properties of Engineering Alloys**, 2nd ed., New York: McGraw-Hill, 1993. Print.

Course Content (tentative):

1. Elasticity

Ch 2 Stress and strain relationships for elastic behavior

2. Plasticity, Plastic deformation, and Deformation processing

Ch 3 Elements of the theory of plasticity

Ch 4 Plastic deformation of single crystals

Ch 5 Dislocation theory

Ch 6 Strengthening mechanism

Ch 8 Tension test

Ch 15 Fundamentals of metalworking

Ch 16 Forging

Ch 17 Rolling of metals

Ch 20 Sheet-metal forming

3. Fracture, Fatigue and Creep

Ch 7 Fracture

Ch 11 Fracture mechanics

Ch 14 Brittle fracture and impact testing

Ch 12 Fatigue of metals

Ch 13 Creep and stress rupture

Grading Policies:

Requirements	Corresponding Percentages
Assignments (8)	15%
Term Paper	20%
Midterm Exam	25%
Final Exam	35%
Attendance	5%

Grading Scale:

100% ≥ A ≥ 90%; 90% > A- ≥ 85%; 85% > B+ ≥ 80%; 80% > B ≥ 76%; 76% > B- ≥ 73%; 73% > C+ ≥ 70%; 70% > C ≥ 66%; 66% > C- ≥ 63%; 63% > D ≥ 60%; 60% > F.

Homework:

There will be about eight homework assignments that will be submitted to Blackboard either as Word document or as pdf **before the start of the class (1:50 pm) on the due day**. If you are unable to attend a class, you may attach a note to your homework and submit it in advance. **If homework is submitted late, you would lose 10% per day. You may receive no credit if homework is not submitted within a week from the due day.**

Term Paper:

A term paper on the mechanical properties of certain metallic material should be completed by groups. Each group contains at most four students. The term paper will be submitted on Blackboard either as Word document or as pdf. The document needs to be submitted to Blackboard **before the start of the class (1:50 pm) on the due day (TBA)**. The requirements of the term paper are listed below.

Requirements for the Term Paper

The paper must have a title page, main content, and references. The paper should be single-column, 1-inch margins, 11-point size, single-spaced, and 9-10 pages, excluding the title page, references, and well-marked appendices.

To facilitate the grading of your paper, please follow the suggested organization listed below.

The title page should include:

- (1 point) The title of the paper
- (1 point) Names, email addresses, and student IDs
- (1 point) Course name, and instructor's name
- (1 point) A maximum 350-word abstract
- (1 point) Three to five keywords

The main content should include:

- Introduction
 - (3 points) Summarize the research area of this type of metallic material and explain why this material has been studied.
 - (3 points) Summarize the development of this metallic material (i.e., the development of industrial processing steps or microstructural evolutions).
 - (3 points) Summarize the advantages and issues of the application of this material to industry.
- Content details
 - (6 points) Present the mechanical properties (i.e., tensile, impact toughness, fatigue resistance, creep resistance, weldability, formability, corrosion resistance...) of these materials.
 - (6 points) Explore the relationship between processing, microstructure, and properties of this metallic materials.
- Conclusions
 - (2 points) List concluding remarks.
- References
 - (2 points) List all the citations referenced in your paper. You will lose points for each dangling reference (i.e., the reference not cited in the main text).

Exams:

If no final exam is given (based on students' approval), the exams are not cumulative. An equation sheet might be permitted (information about this will be given a week before the exam). The students need to be present during the exam. In case of an emergency (doctors notice), a make-up exam might be given. The only allowed things during the exams are pens, ruler, water, potentially calculator. Paper and the equation sheet will be provided.

A student found *cheating, attempting to cheat*, having an *unauthorized device/tool* during the exam *independent of the reason* will receive a zero on the exam.

Attendance:

Participation through presence but also answering questions, asking questions, contributing to activities is very important to improve active learning for each student. Therefore, your participation will be graded during each lecture starting with the second week.