

**Department of Materials Science and Engineering and
Department of Mechanical Engineering
University of Maryland, College Park**

ENMA 300 (ENME 382): Introduction to Engineering Materials

Description: Structure of materials, phase transformations, corrosion and mechanical properties of metals, ceramics, polymers and related materials. **Sustainability-informed materials selection** and manufacturing processes for engineering applications.

Prerequisites: ENES 220 or permission of the department.

Class Schedule: CHE 2108; MWF 10:00-10:50 AM (Lectures)

Textbook: Callister, William D., Jr., Rethwisch, D.G., Fundamentals of Materials Science and Engineering: An Integrated Approach, 4th Ed., John Wiley and Sons, 2012. ISBN # 978-1-1180-6160-2. (Hardcopy and electronic versions are both acceptable.)

Course Objectives: The main objective of this course is to understand the process-structure-property relationships in engineering materials and use this information in materials selection for engineering design. A student completing this course satisfactorily should be able to:

1. Identify features of crystal structures and their relationship to physical, mechanical, thermal, and chemical properties of materials.
2. Understand the similarities and differences in the microstructure of metals, ceramics, polymers, biomaterials and nanomaterials; and how these relate to their critical properties.
3. Interpret features of binary phase diagrams and identify phase transformations
4. Become familiar with common manufacturing processes for metals, ceramics, and polymers; their effects on structure; **and their impact on sustainability**.
5. Identify process-structure-property relationships in engineering materials; and understand how these apply to materials selection in specific engineering problems. **Consider sustainability in materials selection.**
6. Address basic concepts of engineering ethics.

Topics Covered:

0. Engineering ethics: will be covered throughout the course and especially in the topic of material degradation.

I. Introduction - Chapter 1

1. Concept of Process-Structure-Property Relationships
2. Materials Classifications based on Structure and Properties
3. Methodology for Materials Selection
4. **Incorporating Sustainability into Materials Selection**

II. Atomic Structure and Interatomic Bonding - Chapter 2

1. Atomic Structure and the Periodic Table
2. Atomic Bonding in Solids
3. Effects of atomic bonding on Properties: Mechanical, Thermal, Electrical, Chemical, **Sustainability**

III. Structure of Crystalline Solids (metals and ceramics) - Chapter 3

1. Crystal Structures: Unit cells, common structures, lattice parameters, density calculations, crystal systems
2. Polymorphism: Carbon including fullerenes, carbon nanotubes, graphite, and graphene.
3. Crystallographic directions and planes
4. Glasses

IV. Polymer Structures - Chapter 4

1. Polymer molecules - mers, chemistry, common polymers
2. Molecular weight and its effect on properties
3. Molecular structure; Configuration; and Crystallinity
4. Thermoplastics and thermosets
5. **Recyclability, Biodegradability, Availability, and Sustainability**

V. Defects and imperfections in solids (metals and ceramics) - Chapter 5

1. Point Defects
2. Dislocations
3. Grain Boundaries, phase boundaries, surfaces and microstructure

VI. Diffusion (metals and ceramics) - Chapter 6

1. Diffusion mechanisms
2. Steady-State diffusion
3. Factors that influence diffusion

VII. Mechanical Properties - Chapter 7

1. Concepts of stress and strain
2. Elastic and Plastic Deformations
3. Hardness
4. Viscoelasticity

VIII. Deformation and Strengthening Mechanisms - Chapter 8

1. Dislocations, slip planes, slip directions and plastic deformation
2. Strengthening in metals
3. Recovery, recrystallization and grain growth
4. Deformation in ceramics
5. Deformation and strengthening of polymers

VIII. Manufacturing Processes for Materials

1. Metals - Forging, Casting, Drawing, Rolling
2. Ceramics – Slip Casting, Powder Processing
3. Polymers – Injection Molding, Transfer Molding, Fiber Drawing
4. **Impact of Manufacturing Processes on Sustainability (e.g. energy intensiveness, waste streams)**

IX. Failure - Chapter 9

1. Fracture Concepts (e.g. ductility, brittleness, microstructures)
2. Fracture Mechanics
3. Fatigue: the S-N curve
4. Creep
5. Designing for Robustness – safety margins, failure statistics, **sustainability**
6. **Reliability, Accelerated Testing, and Sustainment**

X. Corrosion and Degradation of Materials - Chapt. 16

1. Degradation of Metals (Electrochemical and chemical corrosion and oxidation)
2. Degradation of Polymers (Swelling and dissolution, bond rupture, weathering)

XI. Phase Diagrams and Phase Transformations - Chapters 10 and 11

1. Basic Concepts
2. Equilibrium Phase diagrams (metals and ceramics)
3. The iron-carbon system: microstructure development, effects of alloying elements
4. Phase transformations- basic concepts, kinetics (including TTT and CCT curves), metastable vs. stable transformations including displacive (martensitic) transformations, microstructure development
5. Precipitation and dispersion hardening
6. Glass transition curves and crystallization of polymer and ceramic glasses

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Grading:

Midterm I	20%	Wednesday, October 10, 2012, tentative date
Midterm II	20%	Wednesday, November 14, 2012, tentative date
Final Exam	35%	Wednesday, December 19, 2012, 8:00 AM – 10:00 AM
Homework	15%	(Expect 10 or 11 assignments)
Pop and Lab Quizzes	10%	(Intended to evaluate understanding and reinforce important concept & attendance)

Homework is intended to give students a chance to practice with concepts and critical thinking skills. Students who complete the homework tend to do better on exams and in the course. Not all assigned problems will be graded but detailed solutions will be available. While general concepts may and should be discussed with classmates, students should regard homework as an individual assignment except when team exercises are assigned.

Class attendance is strongly encouraged. Material not in the textbook will be covered and there will be several unannounced quizzes. A lack of attendance and/or class participation will affect grades.

Course Website: <https://bb.eng.umd.edu> (ENMA 300 and ENME 382)

Website Accompanying Textbook: www.wiley.com/college/callister (Web Module M)

CourseEvalUM Fall 2011: Your participation in the evaluation of courses through CourseEvalUM is a responsibility you hold as a student member of our academic community. Your feedback is confidential and important to the improvement of teaching and learning at the University as well as to the tenure and promotion process. CourseEvalUM will be open for you to complete your evaluations for semester courses sometime in December 2011. Please go directly to the website (www.courseevalum.umd.edu) to complete your evaluations. By completing all of your evaluations each semester, you will have the privilege of accessing online, at Testudo, the evaluation reports for the thousands of courses for which 70% or more students submitted their evaluations.

• **Academic Accommodations:** If you have a documented disability, you should contact Disability Support Services 0126 Shoemaker Hall. Each semester students with documented disabilities should apply to DSS for accommodation request forms which you can provide to your professors as proof of your eligibility for accommodations. The rules for eligibility and the types of accommodations a student may request can be reviewed on the DSS web site at http://www.counseling.umd.edu/DSS/receiving_serv.html.

• **Religious Observances:** The University System of Maryland policy provides that students should not be penalized because of observances of their religious beliefs, students shall be given an opportunity, whenever feasible, to make up within a reasonable time any academic assignment that is missed due to individual participation in religious observances. It is the responsibility of the student to inform the instructor of any intended absences for religious observances in advance. Notice should be provided as soon as possible but no later than the end of the schedule adjustment period. Faculty should further remind students that prior notification is especially important in connection with final exams, since failure to reschedule a final exam before the conclusion of the final examination period may result in loss of credits during the semester. The problem is especially likely to arise when final exams are scheduled on Saturdays.

• **Academic integrity:** The University of Maryland has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit <http://www.studenthonorcouncil.umd.edu/whatis.html>

The University of Maryland is one of a small number of universities with a student-administered Honors Code and an Honors Pledge, available on the web at <http://www.jpo.umd.edu/aca/honorpledge.html>. The code prohibits students from cheating on exams, plagiarizing papers, submitting the same paper for credit in two courses without authorization, buying papers, submitting fraudulent documents, and forging signatures. The University Senate encourages instructors to ask students to write the following signed statement on each examination or assignment:

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"I pledge on my honor that I have not given or received any unauthorized assistance on this examination (or assignment)."

Contribution of the course to the professional component: This course is an introductory course in Materials Science and Engineering. It teaches the fundamentals of structure – property relationships in materials, essential in the selection of materials for specific applications, which is important in the development of all engineers.

Relationship of course to program objectives: This course serves as the foundation for the Undergraduate Program in Materials. All other courses build up on the basic concepts introduced in this course. In addition, it serves as a fundamental component of the mechanical engineering curriculum where the students will be called upon to conduct materials evaluations and selections in capstone design courses as well as in their post-graduate employment.

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