

**Syllabus for Materials Science for Engineers (ENGR-1600)
Fall 2009**

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Office Hours: tba

Your Section # _____
Professor _____
Office / Email _____
Office Hours _____

If you have questions about the course, go to your instructor first.

For switching sections, talk to Mrs. Rickert in JEC 3018 (they are all full).

Goal: The goal of the course is to help you achieve a fundamental understanding of the structure and properties of materials (metals, polymers, ceramics, semiconductors). Most of you will use materials to build the products you design, and a strong grasp of the properties of materials and the methods to control those properties will make you a better engineer.

Text: We will use *Fundamentals of Materials Science and Engineering: An Integrated Approach* by Callister. In addition, the package contains a workbook with figures and team problems and a laboratory notebook. You will also have access to online resources for the course on <http://www.wileyplus.com>.

Academic Integrity: The relationship between students and faculty is based upon trust, and the continued maintenance of this trust is necessary for education to be successful. Students need to trust faculty to make appropriate judgments as to the content and structure of the course. Faculty members need to trust that the work turned in by students represents their own effort. Violation of this trust undermines the educational process. In addition, as engineers, you may be designing products (aircraft, the computers that run them, or the runways they land on) that lives depend on. As a result, we will have no tolerance for breach of academic integrity such as cheating, plagiarizing, or inappropriate sharing of lab reports or quizzes.

Anyone caught cheating or plagiarizing for the first time will receive an F in the assignment or test.

Anyone caught cheating or plagiarizing for the second time will receive an F in the course.

Cheating includes sharing answers, stealing answers, and placing text strings on your calculator or other equations not on the crib sheet we hand out. Plagiarism means copying words from someone's work, even if you "change the sentence a bit." If you share your

laboratory report, you are as guilty as the person copying it. If you do use material from an appropriate source, make sure you reference it properly in your report.

You should be aware that we have collected a substantial number of lab reports over time, so that we will be in a position to compare different electronic versions of lab reports, etc.

Reading Assignments: There will be reading assignments associated with each class session. It is very important for you to read the assignment before coming to class.

Teaching Assistant Help: Teaching assistants will have office hours at times and locations to be announced. In addition, your professor will have office hours that will be announced in class.

Class Participation: Class participation is an essential part of this course and worth 5% of your grade as measured primarily by class attendance. The participation portion of your grade will be assessed on the basis of your class attendance, participation in classroom discussions, attendance of laboratories, and by your participation in your team when solving team problems. Proper classroom behavior is also very important, including showing up for class on time. Reading newspapers, listening to music with headphones, reading your email, playing computer games while in the classroom and any similarly rude behavior will not be tolerated. If you do not attend class on the day of a laboratory, you will receive a zero for that laboratory (unless the professor has excused you from the laboratory).

Homework: There will be weekly homework assignments due at the beginning of the Thursday class session. Late homework will not be accepted.

An acceptable homework problem solution must meet the following criteria:

1. Your work must be presented in a neat and orderly fashion.
2. All steps in a calculation must be shown, and the reasoning behind each step must be clearly stated. All units and their cancellations must be shown in numerical problems.
3. Numerical answers must have units and be expressed to an appropriate number of significant figures.
4. Answers to non-mathematical questions require concise paragraphs with complete sentences. Copying from the text book is plagiarism (see academic integrity).

Homework will be graded on a scale of 0 to 2. In order to get a grade of 2, you must have made a serious attempt to do ALL problems, and you must have done half of them correctly.

An essential part of learning from doing homework is to compare your homework to the posted solutions. Homework solutions will be posted every Friday on the course website on the RPI Learning Management System web pages.

Laboratory Sessions: The course includes several laboratories. Please purchase the package at the book store that has the lab manual, lab notebook, and ready notes (workbook). The lab manual has further instructions about the laboratory and writing lab reports.

The essential deliverables for each lab are:

1. A flow chart showing the lab procedure, due at the start of class on the day of the laboratory.
2. Laboratory notes, due at the end of the laboratory class.
3. A laboratory report, due one week after the laboratory is completed.

Quizzes: There will be a **20 minute quiz almost every week** during the Wednesday class period. These weekly quizzes are section-specific and will be worth 20 points each. There will also be **4 cumulative quizzes** (marked cumulative on the syllabus) that will be common to all sections and will be worth 40 points each. The cumulative quizzes are graded individually by the instructors of each section.

All the quizzes together will be 40% of the total grade. Quizzes may include material covered in lecture, team problems, reading, homework, or laboratory. No makeup quizzes will be given. If a student misses a quiz for an unavoidable and compelling reason, the student may be excused from the quiz at the instructor's discretion provided that the student presents a suitable written excuse. The written excuse is required from the Dean, a doctor, or a coach. Cumulative quizzes are written jointly by all the instructors but graded individually for each section.

Final Examination: There will be a comprehensive final examination given during exam week. The examination will not be given early to any student because of previously made travel arrangements. Please do not plan to leave school until the end of exam week. The Final is written and graded jointly by all instructors.

Final Grades: The final grade for the course will be determined as follows:

Homework	10 %
Participation	5 %
Laboratory Reports	15 %
Quizzes	40 %
Final Examination	30 %

Letter grades for this course will be as follows: A, A-, B+, B, B-, C+, C, C-, D+, D, F.

Internet Site: There will be a website for the course. The site will contain homework solutions, instructions for the labs, etc. The URL is <http://rpilms.rpi.edu/>. Log in, go to Fall 09 courses and find Materials Science for Engineers (ENGR-1600).

Class Schedule

Session	Date	Topic	Reading
1	Mon Aug 31	Introduction: Materials Classes	Chapter 1
	Wed, Sept 2	Lecture	
2	Thur, Sept 3	Review of Bonding Structure - Property Relations (CTE, T _m , etc.)	Chapter 2
	Mon, Sept 7	no class	
	Wed, Sept 9	Quiz	
3	Thur, Sept 10	Crystallography - Metal Structures Crystal Structure Tutorial (team problem; nothing needs to be turned in).	Chapter 3, sections 3.1-3.5
4	Mon, Sept.14	Miller Indices - Structure of ionic and covalent crystals	Chapter 3, sections 3.6-3.19
	Wed, Sept 16	Quiz	
5	Thur, Sept 17	Polymerization LAB – Polymer Synthesis	Chapter 4, sections 4.1-4.4, 4.6-4.10
6	Mon, Sept 21	Morphology of Linear Polymers	Chapter 3 and 4, sections 4.5, 4.11-4.12
	Wed, Sept 23	Quiz	
7	Thur, Sept 24	Glasses and the Glass Transition Minilab – Superball Experiment No full report required.	Chapter 3, section 3.8, Chapter 11, 11.15-11.17
8	Mon, Sept 28	Structure Determination Mechanical Properties – Macroscopic	Chapter 3, section 3.20
	Wed, Sept 30	Cumulative Quiz Sessions 1-7	
9	Thur, Oct 1	Mechanical Properties – Macroscopic LAB – Structure Determination by Diffraction	Chapter 7, sections, 7.1-7.9, 7.13, 7.14, 7.19, 7.20
10	Mon, Oct 5	Mechanical Properties – Atomic and molecular behavior, line defects	Chapters 5, 7, 8, sections 5.7, 8.1-8.7, 8.15, 8.17-8.19
	Wed, Oct 7	Quiz	
11	Thur, Oct 8	Brittle and Ductile Fracture LAB – Tensile Testing	Chapter 9, sections 9.1-9.8
12	Tue, Oct 13	Strengthening in metals	Chapter 8, sections 8.9-8.14
	Wed, Oct 14	Quiz	
13	Thur, Oct 15	Polymer Deformation Mechanisms and Strengthening LAB - Brittle Fracture (Strenght of glass)	Chapter 8, sections, 8.17-8.19
14	Mon, Oct 19	Crystal Defects – Point Defects, Solid solutions	Chapter 5, sections 5.1-5.6
	Wed, Oct 21	Cumulative Quiz Session 8-13	

15	Thur, Oct 22	Diffusion LAB – Diffusion Laboratory (H₂ permeation)	Chapter 6, sections, 6.1-6.5
16	Mon, Oct 26	Phase Equilibrium – One Component Phase Equilibrium – Two component	Chapter 10, sections 10.1-10.5
	Wed, Oct 28	Quiz	
17	Thur, Oct 29	Phase Equilibrium – Two component LAB – One Component Phase Diagram	Chapter 10, sections 10.6-10.8, 10.10, 10.12,10.13, 10.17
18	Mon, Nov 2	Phase Equilibrium – Two component Nucleation and Growth	Chapter 11, sections 11.1-11.4
	Wed, Nov. 4	Quiz	
19	Thur, Nov 5	Microstructure Development Demo - Spherulite Growth No full report required	Chapter 10, sections 10.11, 10.18-10.19
20	Mon, Nov 9	Heat Treatment	Chapter 11, sections 11.5-11.12
	Wed, Nov 11	Cumulative Quiz Sessions 14-19	
21	Thur, Nov 12	Special Topics Lecture	
22	Mon, Nov 16	Electrochemistry, Corrosion	Chapter 16, sections 16.1-16.2
	Wed, Nov 18	Quiz	
23	Thur, Nov 19	Corrosion LAB – Corrosion / Degradation of Materials	Chapter 16, sections 16.5-16.13
24	Mon, Nov 23	Electrical Properties of Metals	Chapter 12, sections, 12.1-12.9
	Wed, Nov 25	no class	
25	Thur, Nov 26	no class	
26	Mon, Nov 30	Semiconductors LAB – Electrical Conductivity of Metals	Chapter 12, sections 12.10-12.13
	Wed, Dec 2	Cumulative Quiz Sessions 20 -24	
	Thur, Dec 3	Semiconductors (continued), Dielectric Materials	Chapter 12, sections 12.18-12.23
27	Mon, Dec 7	Microelectronic Devices / Device Fabrication Demo - Single crystal Si ingot, Si wafers	Chapter 12.15
	Wed, Dec 9	Practice Quiz	
28	Thur, Dec 10	Review	

HOMEWORK ASSIGNMENTS: In order to get full credit, you must do the following:

Show all your numerical calculations, including units and their cancellations.

When final answers are given in the book or in these notes, you must show the derivation of those answers, so that we see that you can work through the problems.

When a verbal answer is required, you need to provide it in the form of complete sentences.

When a graph is asked for, it must be drawn nicely (straight axes properly labeled, with even units, accurate data points, etc.)

Homework #1 DUE Thursday, Sept 10: Sessions 1-2

2.9 2.11 2.13

Additional Problem:

Make a plot of bonding energy vs. melting temperature for the metals listed in Table 2.3. From your plot, determine the bonding energy for Cu, which has a melting temperature of 1084°C.

Homework #2 DUE Thursday, Sept 17: Session 3

3.1 3.3 3.7

Homework #3 DUE Thursday, Sept 24: Sessions 4-5

3.12 (also do NiO and NiS) 3.14 3.27 3.28
4.6 4.7

Homework #4 DUE Thursday, Oct 1: Sessions 6-7

4.3 4.5

Additional Problems

1. If a long chain molecule of linear polyethylene were scaled up to the diameter of a piece of spaghetti, how long would it be? Assume a molecular weight of 100,000.
2. If cooling is rapid enough, a glass can be formed from any material. What process are you trying to "beat" by cooling rapidly.
3. Is the glass transition temperature a well-defined temperature? Why, or why not?

Homework #5 DUE Thursday Oct 8: Sessions 8-9

3.47 3.51 7.3 7.4 7.8

Homework #6 DUE Thursday, Oct 15: Sessions 10-11

7.6 8.3 8.6 9.2 9.4

Homework #7 DUE Thursday, Oct 22: Sessions 12-13

8.21 8.22 8.24

Additional problem:

Would you expect the tensile strength of polychlorotrifluoroethylene to be greater than, the same as, or less than that of polytetrafluoroethylene having the same molecular weight and crystallinity? Why?

Homework #8 DUE Thursday, Oct 29: Sessions 14-15

5.2 5.5 6.2 6.4 6.8 6.12

Homework #9 DUE Thursday, Nov 5: Sessions 16-1

10.3 10.4 10.5 10.7 10.12

Homework #10 DUE Thursday, Nov 12: Sessions 18-19

11.5 10.8 10.17 10.18 10.28

Homework #11 DUE Thursday, Nov 19: Sessions 20-21

11.8 11.10 11.13 11.18

Homework #12 DUE Thursday, Dec 3: Sessions 22-23

16.2 16.4

Additional Problems:

1. Briefly describe the phenomenon of passivity. Name two common types of metal alloy that passivate.

2. For a concentration cell, briefly explain why corrosion occurs at the region having the lower concentration.

Homework #13 DUE Thursday, Dec 10: Sessions 24-25

12.5 12.9 12.11 a-c

Additional Problems:

1. At room temperature the electrical conductivity and the electron mobility for Cu are 6.0×10^7 (Ωm)⁻¹ and 0.0030 m²/Vs, respectively.
 - a) Compute the number of free electrons per m³ at room temperature.
 - b) Determine the number of free electrons per Cu atom. The density of Cu is 8.9 g/cm³.
2. What change in temperature increases σ of intrinsic Si by a factor of 2, compared to room temperature (293°K) ?
3. Determine the type of dopant (n or p) in the following situations:
 - a) As in Si
 - b) Ga in Si
 - c) Ge in GaAs

Homework #14 DUE Monday, Dec 14: Sessions 26 & 27

12.29 a-c

Additional Problems:

1. What should the band gap E_g of a material be so that it is transparent in the entire visible wavelength range?
2. Assume that the gate capacitor in an MOS transistor has dimensions $1\mu\text{m} \times 1\mu\text{m}$ and that the gate dielectric is SiO₂ with a thickness of 30nm. What is the capacitance of the gate capacitor? (You may need to look up some data about SiO₂)
3. A typical concentration of dopant atoms in a semiconductor is 10^{16} cm⁻³. What is the dopant concentration in terms of number of dopant atoms / Si atom?
4. What would the consequences be (advantages, disadvantages) of using a material with a relative dielectric constant much higher than that of SiO₂ in an MOS device?