

# ENGR 240 – Science of Materials Laboratory

Spring 2001 – Dana 212

## OVERVIEW

In this laboratory, you will study the effects that material structure, composition, processing, and testing conditions have on material properties. A variety of laboratory equipment will be used for material processing, property measurements, and characterization.

## ORGANIZATION

Students will be divided into small groups. Each group will work as a team and submit a single report for each experiment. In general, each group in a given lab period will be working on a separate experiment.

Work in the laboratory will be limited to the allotted two hour time period. It is therefore vital that all members of the group arrive on time, and are prepared to begin the experiment as quickly as possible. This will require some advance preparation – all students should be familiar with the purpose of the experiment and should have a rough idea of the experimental procedure that will be used before entering the laboratory.

## ATTENDANCE

Perfect attendance is mandatory. You must attend the laboratory section for which you are registered; any exception requires prior approval from Professor Stolk (jstolk@bucknell.edu) or Professor Csernica (csernica@bucknell.edu). If you have a valid reason for missing a particular meeting of your laboratory section (an emergency situation), you must notify your instructor in advance if possible, and a temporary assignment to another laboratory section may be arranged for you. If the emergency situation prevents you from notifying your instructor in advance, you must notify your instructor as soon as possible after your scheduled lab period.

## GRADING

Your laboratory grade will be comprised of your laboratory report grades plus grades for any other in-lab assignments. Deductions to your laboratory grade may result from lack of effort to conduct yourself and your experiments safely or from lack of advanced preparation for the experiments. Recall that your laboratory grade makes up 30% of your overall ENGR 240 grade.

Unexcused absences from the lab will result in a grade of zero for that particular experiment/assignment. Late lab reports will be penalized **10 percent per day late**. Tardiness will result in a grade penalty to be determined by your lab instructor.

## LABORATORY REPORTS

Format, Length and Content - Unless otherwise noted, the laboratory report should be in the form of a short memo addressed to the professor. An example report is given on pages 5-6 of this handout.

The *maximum* length of the memo is two pages of double spaced text (data, tables, graphs, etc. should be attached after the text, and do not count toward this length). This short format will force you to consider what

details to omit and how the important points of your experiment can be conveyed succinctly. Traditionally, high grades are given to reports that clearly present information in a concise fashion.

Here are some rules to follow when writing memorandum reports for ENGR 240 laboratories (see attached example of text from a memorandum report):

1. Memos must be done on a computer.
2. Tables and Figures (including graphs):
  - Unless they are very small (3-5 lines of text), tables and figures should not be included within the text, but should be attached at the end of the report.
  - Each table or figure must have a *descriptive* title so that they can be understood without referring to the text.
  - Tables and Figures must be numbered sequentially—traditionally, tables are numbered using Roman numerals and figures using Arabic numerals, but Arabic numerals for both is acceptable.
  - All graphs, figures, and tables must be referred to explicitly in the text (ex: "As shown in Figure 2..."). Note capitalization of word "Figure".
  - Typically, identical information should not be included in both a table and a figure. If you wish to include your original data sheet in addition to a plot of your data, the data sheet should be included not as a formal table of the report, but in a separate appendix.
3. Suggestions for text organization (see example):
  - The first paragraph (it may be as short as one sentence) should act as an introduction to acquaint the reader immediately with the purpose of the laboratory and what was done.
  - The middle section should briefly summarize the procedure followed in the laboratory—what kind of data was collected (if any), and how was it obtained? Also, what kind of samples were used in the experiment? You need not describe small details of standard procedures (e.g., if you use a hardness testing machine, you can simply say that it was used, and do not have to describe how to load the sample, etc.).
  - The last section should summarize the results of your work. Here, you will likely refer to tables or figures to aid your discussion. This section may include answers to questions like: What calculations were performed? What conclusions can be made? How do your findings compare to what is expected? Is there any supporting information or theory that explains your results? What have you learned from the laboratory? If appropriate, a key result (numerical or other) can be included in the text in this section, even if it also appears in an attached table—if your goal was to obtain a particular numerical result, that result is too important to leave hidden in the attachments to your report!
  - Be sure your text addresses any specific questions that are contained in the lab handout.
4. Significant Figures:

All experiments will inherently contain some degree of uncertainty resulting from factors such as the precision to which you can make a measurement or random fluctuations between measurements. The number of significant figures to which a result is reported should reflect the degree of uncertainty in an experimental result. This is of the utmost importance whenever you present results and conclusions to others! So that you learn to take this practice seriously, five points will automatically be deducted from a lab report grade if a result is presented that contains an excessive number of significant figures. An example of "excessive": you measure the diameter of a circle with a ruler to be 5.2 cm, and you conclude that the circle's circumference is  $\pi(5.2) = 16.34$  cm. You may want to review the "Working with Significant Figures" section of your ENGR 100 notebook.
5. Academic Honesty:

Because each group will cycle independently through a set of experiments, it is likely that your classmates will have in their possession graded reports for an experiment that your group is

currently working on. Each group is expected to work independently on their lab reports. Copies of returned reports are kept on file (including those from previous years) to monitor possible cases of plagiarism. While this warning should be unnecessary for the vast majority of students, I'm sorry to say that cases of academic dishonesty in EG240 Lab have arisen in the past. Avoid the temptation - it's not worth it.

## LABORATORY NOTEBOOK

Each group will be responsible for providing a laboratory notebook that will contain all experimental data. The instructor may collect the laboratory notebooks at the end of the semester and may make periodic checks of the laboratory notebooks during the semester. Each group is responsible for the distribution of all necessary experimental data to all members of the group.

## SAFETY

Some of the equipment used in the laboratory is potentially dangerous. Be aware of what you are doing, what others are doing, and where others are standing. Make yourselves aware of the locations of emergency equipment and facilities (fire extinguisher, shower, eye wash, fire alarm).

Safety glasses or other form of eye protection (prescription glasses with plastic lenses will be OK for most experiments) are to be worn at all times in the laboratory. A small collection of safety glasses is available in the laboratory. Repeated violations of this rule will result in a reduction in your laboratory grade. You will be advised if additional safety equipment is required for a certain experiment (goggles, gloves, etc.).

ASK the laboratory instructor or TA if you need assistance during an experiment or are unsure of a laboratory procedure.

Other laboratory regulations to be followed are outlined in the document *Safety Regulations for the Chemical Engineering Laboratory*, of which you will receive a copy.

## ENGR 240 EXPERIMENT TOPICS

Lab	Topic
C	Electronic Conduction
K	Superconductivity
D	Ionic Conduction
SEM	Scanning Electron Microscopy
J	Tensile Testing of Polymers
T	Mechanical Properties of a Crosslinked Polymer
A	Transition Temperatures of Materials
H	Cold Work and Annealing of Brass

## ENGR 240 EXPERIMENT SCHEDULE

Week	Group 1	Group 2	Group 3	Group 4
1/15	No Lab			
1/22	Lab Introduction & Graphing Exercise			
1/29	C*	K	D	SEM
2/5	SEM	C*	K	D
2/12	D	SEM	C*	K
2/19	K	D	SEM	C*
2/26	* Report Review Conference			
3/5	No Lab			
3/12	No Lab (Spring Recess)			
3/19	J	T	A	H
3/26	H	J	T	A
4/2	A	H	J	T
4/9	T	A	H	J
4/16	To be announced			
4/23	To be announced			
4/30	No lab			

\* Once this semester, you will have a chance to receive feedback on a lab report, then revise it before it is formally graded. This will occur with the report for Lab C. For most groups, you will hand in your report as normal (1 week after the lab's completion). This should be a complete report, but will be considered a draft for grading purposes. Group 4 will have to submit this report 1 day early, in the lecture period before your scheduled lab meeting. For your lab period the week of 2/26, each group will report to Professor Csernica's office (Dana 334) for discussion of the lab and feedback on the report, according to the schedule below. The final report will be due by 1 pm on the Friday before spring break (3/9/01).

Group	Meeting Time
1	First 30 minutes of lab period
2	Second 30 minutes of lab period
3	Third 30 minutes of lab period
4	Fourth 30 minutes of lab period

*(example)*

## MEMORANDUM

DATE: August 29, 2000  
FROM: Julia DiCorleto, Michael Barrera, Mark Allen  
TO: Professor Burns  
SUBJECT: Laboratory–Mechanical Properties of Plastics

Two mechanical properties that may be important when selecting a material for a given application are *tensile strength*, which is a measure of how much stress the material can support before it breaks, and *impact energy*, which is related to the brittleness of the material. In this experiment, our lab group measured and compared the tensile strength and impact energy of two types of plastics, polycarbonate and polystyrene.

Our lab group was provided with special samples of each plastic for testing. These had been cut in the machine shop from 1/8th inch sheet into special geometries that corresponded to ASTM standard test specimen dimensions.

For tensile strength determination, we used a universal testing machine, which pulled (at a rate of 0.2 in/min) on a sample in tension until it fractured. The maximum force applied during the test was recorded. This value, divided by the sample's cross sectional area of 0.0312 inches, is the material's tensile strength. Tensile strengths were converted into units of MPa (see attached calculations page). Four identical tests were conducted for each plastic type. We noted that the polycarbonate samples exhibited a good deal of visible extension or stretching before fracture occurred, while the polystyrene samples snapped without showing much, if any, elongation. Maximum force data, calculated tensile strengths, and averages from the four trials for each plastic are contained in Table I.

Impact energies were obtained using an Izod impact test machine. This device strikes the impact specimen with a weighted pendulum, and records the amount of energy (in J) that caused the material to fracture. Again, four identical tests for each plastic type were conducted. One of the polycarbonate samples did not fracture during the test. We believe that this sample was not properly secured in the testing device,

and this particular data point was discarded. Impact energies for each test, and averages for each plastic type appear in Table II.

From the results in Table I, the tensile strength of the polystyrene material is seen to be about 50% higher than that of the polycarbonate—74 MPa for the polystyrene vs. 50 MPa for the polycarbonate. The polystyrene is therefore stronger, and a part made from polystyrene could support a greater load in service than a corresponding polycarbonate item.

On the other hand, the polystyrene is seen to be quite brittle compared to the polycarbonate. The polycarbonate exhibited an average impact energy of 2.8 J, while the impact energy for polystyrene was only 0.30 J (Table II). If resistance to impact is important to a final application (e.g., a part that is expected to withstand being struck sharply or bumped) the polycarbonate would be the better choice between the two plastics because it is less brittle.

In this experiment we have seen simple standard test methods that can be used to evaluate some important properties of plastics, namely tensile strength and impact energy. These properties can be helpful in selecting the proper material for a particular use. We have also seen how a material which is superior in one mechanical property, such as tensile strength, may not offer the best characteristics in another area, like impact energy. This demonstrates the importance of identifying all properties important to a particular application, so that an optimum material can be chosen.