22.296 Mechanical Behavior of Materials
Fall 2013 Schedule *(updated 08/30/2013)*

Professor Emmanuelle Reynaud (Perry 326) Emmanuelle_Reynaud@uml.edu
Professor Christopher Hansen (Perry 223A) Christopher_Hansen@uml.edu

Date	Lecture	Due	Associated Reading
9/4	**Lecture 1A**: Introduction to Materials (CH)		Ch. 1
9/6	**Lecture 1B:** Safety and lab report writing (CH)		Pr. Avitabile's handouts
9/9	**Lecture 2**: Stress, Strain (ER)		6.1-6.2
9/9-9/12	**Lab A: Tensile Test** (ER)		
9/13	**Lecture 3**: Tensile Behavior (ER)		6.3,6.5-6.6
9/16	**Lecture 4:** Steel, phase diagrams (CH)		9.1-9.13
9/16-9/19	**Lab B**: **Information Retrieval** (CH)	**Lab Report A** (Full, Group)	
9/20	**Lecture 5**: Steel and Heat Treatment (CH)		11.1-11.3 11.7-11.8
9/23	**Lecture 6**: Strain Measurement (ER)		http://www.vishaypg.com /docs/11055/tn505.pdf http://www.astm.org
9/23-9/26	**Lab C**: **Strain Gages** (ER)	**Lab Report B** (Memo, Group)	
9/27	**Lecture 7**: Steel and Heat Treatment (ER)		
9/30	**Lecture 8**: Hardness Measurements (CH)		6.10
9/30-10/3	**Lab D: Heat Treatment and Hardness (CH)**	**Lab Report C** (Memo, Group)	
10/4	**Lecture 9**: Strengthening Mechanisms (ER)		10.5-10.9

10/7	**Review (CH)**		
10/7-10/10	**Visit the Service-Learning Community Partners**	**Lab Report D** (Full, Group)	
10/12	**Mid-Term Exam (ER, CH)**		
10/16 (Monday schedule)	**Lecture 10**: Polymers (ER)		15.1-15.5, 15.9-15.17 15.22-15.23
10/14-10/17	**No lab (due to Columbus Day)**		
10/18	**Lecture 11**: Composites (ER)		16.1-16.3,16.8-16.15
10/21	**Lecture 12**: Flexure (CH)		12.9 Handout
10/21-10/24	**Lab E: Flexure (CH)**	**Lab A Redo** (Full, Group)	
10/25	**Lecture 13**: Flexure (CH)		
10/28	**Lecture 14**: Ceramics & Fracture Mechanics (ER)		8.1-8.6 12.8 13.1-13.12
10/28-01/31	**Lab F: Mechanics (ER)**	**Lab Report E** (Full, Individual)	
11/1	**Lecture 15**: Fracture Mechanics (ER)		
11/4	**Lecture 16**: Thermal Properties (CH)		
11/4-11/7	**Practice Project Presentation**	**Lab Report F** (Memo, Group)	
11/8	**Lecture 17:** Thermal Properties (CH)		
11/11	**No Class** (Veterans Day)		
11/11-11/14	**No Lab**		
11/15	Mid-Term Exam Review (ER)		

11/18	**Lecture 18**: Oxidation and Corrosion (ER)		17.1,2,5,7-10
11/19-11/22	**Lab G: Oxidation and Corrosion**		
11/23	**Lecture 19**: Oxidation and Corrosion (ER)		
11/25	Presentation to Partners		
11/25-11/28	**No Lab (Thanksgiving week)**		
11/29	**No Class (Thanksgiving Holiday)**		
12/2	**Lecture 20**: Materials Selection (CH)		22.1-22.3, Supplemental reading from Ashby
12/2-12/5	**No Lab**	**Lab G Report** (Group, Full)	
12/6	**Lecture 21**: Materials Selection (CH)		
12/9	**Review** (CH)		

22.296 MECHANICAL BEHAVIOR OF MATERIALS – FALL 2013

CATALOG DESCRIPTION:
The behavior of engineering materials is studied with an emphasis on factors affecting materials selection and an understanding of material properties and materials characterization techniques. Laboratory and lecture topics include: Tension, compression, elastic modulus, strain, flexure, hardness, abrasion and wear, and corrosion. In addition, the relationships between processing, microstructure, and material properties are discussed.

TEXTBOOK:
- Materials Science and Engineering: An Introduction, 8th ed (2010), 7th ed (2006) or 6th ed (2003) W.D. Callister, Jr., Wiley. (On reserve at Lydon Library)

INSTRUCTORS:
- Emmanuelle Reynaud, Perry 326, 978.934.2961
- Christopher Hansen, Perry 223A, 978.934.2932

LABORATORY MANAGER:
- Glen Bousquet, Ball 120, 978.934.2983

LAB ASSISTANTS (TAs, Lab helper): The lab helpers are responsible for coordinating the lab sessions and answer questions related to the lab content. The lab helpers for Fall 2013 are:
- Siqi Wei Siqi_Wei@student.uml.edu
- Siddarth Dev Siddarth_Dev@student.uml.edu
- Joshua Fortin-Smith Joshua_FortinSmith@student.uml.edu
- Katherine Cain Katherine_Cain@student.uml.edu

There are Graders who are responsible for a majority of the lab report grading. Please contact them in case of issues of grading. The graders for Fall 2013 are:
- Erik Christiansen Erik_Christiansen@student.uml.edu
- Eric Blake Eric_Blake@student.uml.edu
- Meredith Roberts Meredith_Roberts@student.uml.edu
- Patrick Logan Patrick_Logan@student.uml.edu

The Lab helpers and Graders will have office hours to discuss lab report writing and lab report grading. These hours will be posted at the beginning of the semester.

REFERENCES:
- Microsoft Office software guides (Excel, Word, Powerpoint)
- Mechanics of Materials, Hibbeler, Prentice-Hall (or other similar text)
- ASTM Standards and Materials Handbooks (available online or in library reference section)

COURSE SCHEDULE:

Lecture:

22.296.201	MF	12:00-12:50 pm
22.296.202	MF	1:00-1:50 pm

Lab Sections:

- Section 801: W 2:00- 3:50 pm
- Section 802: R 12:30- 2:20 pm
- Section 803: R 2:30- 4:20 pm
- Section 805: W 4:00- 5:50 pm
- Section 806: M 3:00- 4:50 pm
- Section 807: R 10:30 am - 12:20 pm
- Section 808: T 1:30- 3:20 pm
- Section 809: T 3:30- 5:20 pm

OFFICE HOURS:
A total of 6 office hours per week are available to meet with either Prof. Reynaud or Prof. Hansen. If you are unable to meet the instructor during these times, you will need to request an appointment via e-mail or phone, **with a 24-hour notice**.

Office Hours for Prof. Reynaud:

- M: 2 pm – 3 pm
- W: 1 pm – 2 pm
- F: 11 am – 12 pm
- Also by appointment (with a 24-hour notice)

Office Hours for Prof. Hansen:

- M: 2 pm – 3 pm
- W: 11 am – 12 pm
- F: 11 am – 12 pm
- Also by appointment (with a 24-hour notice)

COURSE STRUCTURE:
In general, the following structure will be observed:

- Monday Introduction to a topic
- Mid-week Associated labs are conducted **(pre-labs mandatory for lab access)**
- Friday Discussion of labs and topic (previous week's lab report due)

STUDENT RESPONSIBILITIES

Schedule: It is the student's responsibility to read and understand the syllabus. Special circumstances may require modifications in the syllabus and in the class schedule. In case this occurs, advance notice will be given in class and through email and these changes will be updated in the online syllabus.

Attendance: Your presence in the lab is mandatory. An unjustified absence results in a 0 for the corresponding lab report. Excused absences for religious holidays and other events must be cleared with one of the instructors in advance of the laboratory. Lectures are not mandatory, but attending and paying attention to the majority of the lectures is the only way to ensure a good grade.

Academic integrity: All homework, exams, and projects are to represent students' own original work. Using other people word's without giving them credit is called plagiarism and is one form of academic dishonesty. Students are prohibited from infractions of academic integrity, which includes cheating, fabrication, plagiarism, or facilitating dishonesty. **Infractions will not be tolerated.** The first case of plagiarism will result in an automatic **zero** for the offending assignment (in the case of a group report, each group member gets a zero). In the event of a second case of plagiarism, **it will be reported to the department chair to initiate a formal process,** which includes notification of the Provost's office and associated administrative sanctions. For more information, the university policy on academic integrity is available at: http://www.uml.edu/catalog/undergraduate/policies/academic_dishonesty.htm

Academic or external problems: If you experience problems with the coursework or your classmates or if there are external factors affecting your performance, it is your responsibility to inform the instructor **ASAP**. We are willing to help and happy to listen, but we can only assist if given sufficient time to do so. Similarly, late lab reports will only be graded in case of medical reasons or family emergencies (with a written documentation for justification).

Classroom etiquette: Emailing, text messaging, cell phones ringing, conversation, and late arrivals are very distracting to the class as a group: those behaviors are strictly forbidden in the classroom. Students that cannot refrain to chat or text message during class will be asked to leave.

GRADE DISTRIBUTION

Components	**Amount of total grade**
Class Participation (in-class quizzes*)	10 %
Lab Reports and Lab Notebook**	25%
Team Project	15%
Mid-Term Exam	15%
Take-home Exam – Flexure Lab report	10%
Final Exam	25%

* The two worst grades of in-class quizzes are eliminated.
** The worst grade of all the lab reports and lab notebook is eliminated

The final numerical grade will be calculated according to the above distribution. The letter grade will be attributed with respect to the whole class average grade (AVERAGE) and the standard deviation around that average (STD). A student having a numerical grade equal to the class average will be granted a B-.

OBJECTIVES:

The overall objectives of this course are:

1. To become familiar with the *properties* of various engineering materials.
2. To obtain hands-on experience with the *behavior and testing* of various engineering materials.
3. To obtain hands-on experience that will *apply to theory* discussed in later courses (22.212, 22.311).
4. To understand what questions to ask when *selecting materials* for an engineering design.
5. To understand what questions to ask about a particular *experiment or test setup*.
6. To become proficient at *data analysis and presentation* using computer software such as spreadsheets.
7. To improve *technical report writing and oral presentation* skills.
8. To become familiar with the *resources* available for finding information on materials.

PREREQUISITES

- Chemistry – atomic bonding, atomic structure
- Calculus – simple derivatives and integration
- Physics – static force

BLACKBOARD VISTA 4 ENHANCED CLASS:

This class has a web-enhanced component to it. Each student is required to check the course website on a regular basis. Instructors can be emailed through the BlackBoard Vista internal email system, which places no size limit on attachments.

Clickers: Short-answer quizzes will be randomly assigned during class and use NXT clickers. The two worst grades of in-class quizzes are eliminated. Therefore, attendance is REQUIRED for the class participation grade. **Students who fail to bring their clicker to a lecture will receive a score of zero for the questions presented during that lecture and will be marked as absent unless they approach the instructor before leaving the classroom to indicate they were present**. **NO EXCEPTIONS**. Clicker malfunctions must be brought to the attention of the instructor as soon as possible so that the source of the malfunction can be promptly identified and corrected. Failure to abide by these rules may result in loss of participation and attendance points.

REPORTS:

- There are two types of reports:
  - the MEMO report is a simple report of the activities done during the lab; it consists in filling in a lab report template.
  - the FULL report is a formal report; it should be similar to a project report (see detailed handout on report writing).
- Full reports may be written as a group, but each member must be responsible for the majority of at least 2 of the reports (this person should be indicated as “lead engineer” on the report). Credit will be given according to degree of contribution if there is a large discrepancy in effort (Let the instructor know about that early in the semester so that any group conflict can be avoided). Otherwise, all members of the group will receive the same grade.
- Each completed report will be submitted as a **soft copy** to the Blackboard website – hard copies and emailed copies will **NOT** be accepted. The completed report is due **by the beginning of lab session**, 8 days after the lab has occurred (unless otherwise specified); Blackboard will mark all submissions after the time deadline as late. Each report is graded out of **100 points**. **10 points** will be deducted from any report turned in late, with an additional 10 points deducted for every working day that passes until the report is turned in. The maximum points for delay that can be taken out is 50.
- **All assignments** will be checked by Blackboard “SafeAssign” for signs of plagiarism. Students will be allowed to submit a draft to see if their report contains plagiarized material prior to the final submission. Please see the section above on academic integrity for consequences of plagiarism.
- **Lab report A may be rewritten and resubmitted**. Please report to the schedule for the due date of the redo report. The better of the two grades will be kept.

SERVICE-LEARNING PROJECT WITH A COMMUNITY PARTNER:

We define Service-learning as a project in which students use the technical knowledge acquired in class (and for which they receive credits) to fulfill the need of a non-profit community partner.

This semester, we will be working with a community partners, the Tsongas Industrial History Center. We will make a site visit to our community partners mid-semester.

The lab group will be divided into teams of 2 to 4 students. Each team will work on a project related to the materials used in looms and/or the Lowell textile mills. Each group is responsible for creating and giving a 10-minute long Powerpoint presentation on their project, which will be formally held in front of the group mid-semester (see schedule). On top of the presentation, the group is expected to take an active role in asking questions to the other presenting teams in their lab session. Their participation in the Q & A session accounts for 10% of the final grade. The best presentations will be selected and presented in front of representatives of the community partners later in the semester.

Brief Description of Labs

A. Tensile Testing (Full Report, Group Work)
This lab consists in testing thin films of various materials on a manual tensile tester. Each group tests three materials among aluminum, copper, steel and Nylon. The load and deflection are recorded manually.

B. Information Retrieval (Memo Report, Group Work)
This laboratory will take place in one of the computer lab of the Lydon library. A librarian will introduce the students to the resources on materials section available through the UMass Lowell library website. In particular, the Knovel database, the ASTM standard and the use of meta-engine such as Science Direct will be covered, along with an introduction to the reference software RefWorks.

C. Strain Gages (Memo Report, Group Work)
Each group will mount and test a 1-D strain gage on one side of a polymer flexure specimen to be used later in the **Flexure Lab**. Initial tests on strain gages conducted using the Measurement Instruments portable strain indicator and multimeter (for resistance check).

D. Heat Treatment, Hardness (Full Report, Group Work)
Each group will heat steel blocks. Samples will then be quenched in either water or oil. Cooled samples will be prepped for hardness testing (surfaces will be cleaned of any oxide layer, etc.). **Hardness testing** will be performed on aluminum, polymer, steel (heat treated and not heat treated) blocks using the ME Lab Rockwell Testers. Each group must take 3 measurements on each material using both testers.

E. Flexure, also Take-home Exam (Full Report, Individual Work)
The polymer flexure specimens prepared in Lab B are subjected to three-point bend tests on the manual tensile tester. Load, displacement, and strain data recorded manually.

F. Fracture Investigation (Memo Report, Group Work)
A composite sample will be tested under impact. Each group will analyze their impact data, observe the fracture face and determine what features was likely the fracture origin.

G. Corrosion and oxidation (Full Report, Group Work)
(1) Observation of rate of corrosion on various materials and geometries (e.g., nuts, bolts, paper clip, razor blade) using pre-mixed chemical solution. (2) Observation of by-products from steel and stainless steel shim materials placed in flame and quickly dunked in cold water. (3) Measurement of change in weight (oxidation) of steel and stainless steel shim material placed in flame (using Composites Lab scale). Each group rotates to each station during the lab period.

Specific objectives associated with each laboratory and associated lectures are listed below. At the end of this course, a required evaluation must be filled out by each student to assist us in assessing how well each of the following objectives were met.

Specific Objectives: A student will be able to…

LAB A: TENSILE BEHAVIOR

- Describe a standard method for determining tensile stress-strain behavior and tensile strength.
- Give an approximate value for the tensile modulus of steel, aluminum, and nylon.
- Describe what is meant by stress, strain, and true stress vs. engineering stress.
- Describe the difference between compressive and tensile behavior.
- Calculate the expected loads and deflections given stress and strain values and vice versa.
- Calculate Young's Modulus from stress-strain data.
- Identify key values in a stress-strain diagram.
- Give an approximate value for E of steel, aluminum, and nylon.

LAB B: INFORMATION RETRIEVAL

- Be knowledgeable of the width of technical information
- Develop critical thinking with respect to the information sources
- Know where to start a research on a particular material issue
- Know how to retrieve and find a particular standard
- Be knowledgeable of proper referencing practises

LAB C: STRAIN GAGES

- Describe various techniques for measuring strain, including their advantages and disadvantages.
- Describe what parameters must be considered in selection of a strain gage and explain their importance.
- Calculate strain from strain gage data.
- Describe what is meant by a material's Poisson's ratio
- Describe what is meant by a constitutive relation and Hooke's Law.
- Write the expression relating Young's Modulus, Shear Modulus, and Poisson's Ratio.

LAB D: HEAT TREATMENT and HARDNESS

- Describe the difference between various hardness tests – Brinell, Rockwell, Vickers, Knoop.
- Describe what the Rockwell tests measure, what parameters must be selected, and what factors affect the measurements.
- Give an approximate value for hardness of steel, aluminum, and a polymer.
- Describe the relationship between hardness and other material properties such as strength.
- Explain what methods can be used to increase hardness.
- Explain what effect heat treatment (including quenching and annealing) has on properties and microstructure
- Describe various wear mechanisms – adhesive, abrasive, surface fatigue, corrosive.
- Describe how each of the following parameters can affect wear – e.g., applied load, material properties, material dimensions, surface conditions, energy input (velocity, mass), temperature, angle of contact.
- Describe several methods of reducing wear (e.g., lubrication, surface coatings) and how they work.

LAB E: BEAM BENDING (FLEXURE)

- Describe the differences between flexural tests and axial tests.
- Calculate load-deflection response, stress-strain response, and Young's modulus from a flexure test and strain gage data.
- Describe the difference between material stiffness and structural stiffness.
- Calculate the effect of various parameters in an equation on the dependent variable.
- Explain the assumptions made in the derivation of the beam equations.

LAB F: FRACTURE INVESTIGATION

- Describe differences in microstructure between metals, ceramics, polymers, and composites.
- Describe materials features linked to failure.
- Describe several techniques for microstructure characterization.
- Evaluate the potential of fracture of a structure in use.
- Recreate a scenario leading to fracture based on observations and calculations.

LAB G: CORROSION & OXIDATION

- Describe the different liquid-solid reactions – e.g., electrochemical corrosion, direct dissolution.
- Explain the importance of ranking in the galvanic series.
- Describe what effect various parameters have on corrosion – e.g., temperature, surface area, material combinations.
- Describe methods to reduce corrosion.
- Describe various forms of oxidation.

OTHER TOPICS:

- Generate plots from given data sets.
- Determine the trendline equations (and the correlation factors) for those graphs.
- Describe the various plots and analyze them.
- Gather all the information in a report following the proper format.
- Describe the basic differences between major material classes (e.g., metals, polymers, ceramics, etc..)
- Give examples of some newer areas in materials – e.g., composites, semiconductors, nanomaterials, biomaterials
- Conduct a proper experiment
- Write a clear and logical lab report
- Give a technical oral presentation