

Schedule: MWF 11:00am-11:50am in 1304 Siebel Center for Computer Science

Course websites:

- Class schedule, announcements, lecture videos, lecture notes, gradebook, and homework deposit:
canvas.illinois.edu
- Class announcements and online discussion forums:
campuswire.com

Scope: This course provides an advanced treatment of mechanical behavior of materials, drawing from solid mechanics, defects theory, thermodynamic and kinetic principles. Fundamentals of elastic and plastic deformation are reviewed to provide a basis for more advanced topics including creep, fracture and fatigue. These deformation mechanisms are connected with underlying microstructural features, loading conditions and service conditions in the context of engineering design.

Objectives: Students will be able to explain macroscopic mechanical behavior of materials in the context of microscopic mechanisms and apply this understanding to calculate mechanical behavior of known and developing engineering systems. Students will be able to evaluate mechanical failure modes to identify causes and solutions and will be able to design experiments that evaluate specific failure mechanisms.

Prerequisites: MSE 406 (Mechanical Behavior of Materials)

Instructor: Pascal Bellon (bellon@illinois.edu; 312d MSEB)

Office hours: Tu 4:00pm-6:00pm or by appointment.

Reference Texts:

Mechanical Behavior of Materials, Thomas H. Courtney, 2nd ed. (Waveland Press, 2013); *Statics & Mechanical Behavior of Materials*, Marc Meyer & Krishan Chawla, 2nd ed. (Cambridge, 2009); *Deformation and Fracture Mechanics of Engineering Materials*, Richard W. Hertzberg, 4th ed. (John Wiley & Sons, 1996); *Mechanical Metallurgy*, George Dieter, SI Metric ed., (McGraw-Hill,1988); *Engineering Materials 1*, Michael Ashby and David Jones, 3rd ed. (Butterworth-Heinemann, 2005); *Mechanical Behavior of Materials*, Williams F. Hosford, 1st ed. (Cambridge, 2005); *Fracture Mechanics*, Ted L. Anderson, 3rd ed. (CRC Press, 2005); *Fatigue of Materials*, S. Suresh, 2nd ed. (Cambridge University Press, 1998); Available at Engineering Reserves in Grainger.

Special accommodations: To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact their lecturer and the Disability Resources and Educational Services (DRES, disability.illinois.edu) as soon as possible, and no later than Sept. 1.

Course evaluation:

$$4\% \times (\text{Participation}) + 18\% \times (\text{Homework}) + 18\% \times (\text{Written assignments and Final Project}) + 35\% \times (\text{Quizzes}) + 25\% \times (\text{Final Exam}) = \text{Total}$$

Participation (4%): Participation is qualitatively based on participation in class discussion and activities and will be quantitatively measured by completion of a daily *exit ticket* at the end of each regular lecture or completed online for virtual lectures. These exit tickets will not be graded for accuracy but will count towards attendance. Students may skip up to four exit tickets before the participation grade is impacted; after that 1% will be deducted from the participation grade for each one missed.

Attendance is mandatory, but for the health and safety of all students please do not attend class

if you're ill or feeling unwell. Students may miss up to four lectures *for any reason* before the participation grade is impacted; after that 1% will be deducted from the participation grade for each one missed. For anticipated absences, see below.

Homework (18%): Homework is assigned and collected weekly on Wednesdays at the beginning of class (11AM) and returned by the following Wednesday. Some computational assignments may have a later submission time, be sure to review the posted assignment on CANVAS carefully. No late homework will be accepted, but the two lowest homework scores will be dropped. Completed homework assignments must be submitted through the CANVAS website.

Final Project (18%): Over the course of the semester, students will explore a materials application with relevance to the course material as determined by the instructor in *teams of two*, selected by the students. This will culminate in a final presentation held during the class period on either Monday, December 4 or Wednesday, December 6. The final project must

- demonstrate familiarity with the common failure modes of the system,
- identify how concepts discussed in class are related or are synergistic
- identify where the field is going and novel techniques or models that may change the conventional teaching in MSE440 in the future and
- include an experiment or model designed by the team that could evaluate one of the outstanding challenges for the materials system, including detailed description of how the experiment or model was inspired by the literature or working with other students.

There will be 4 major milestones over the course of the semester:

1. Critical reading assignment #1: A 1 page individual report will be submitted demonstrating basic familiarity with the selected system and with relevant failure modes, and will include a comprehensive bibliography (not included in the 1 page limit).
2. Design project working day #2: An in-class working day to reflect on critical reading #1, team formation and brainstorming for experiment or model design.
3. Design proposal #3: A two-page team report giving (a) an overall perspective of the field relevant to your system (based on the previously identified sources), predominant failure mechanisms, connections to class and an outlook on the direction of the field; and (b) proposing experiments or model design to address a specific and important issue in your selected system.
4. Final Poster Presentation: A digital copy of the presentation must be submitted via CANVAS. In addition to specifically addressing the 4 points outline above, the poster will also be evaluated on the basis of clarity & presentation style.

Quizzes (35%): Quizzes will be administered in a written format. During weeks with quizzes, the first 25 minutes of the class period will be dedicated to the quiz. Students arriving late will not be allotted extra time and any student arriving more than 10 minutes late will not be allowed to take the quiz. In the case of illness or other emergency, quizzes may be rescheduled at the instructors discretion. See the excused absences section below for more details.

Each quiz will center around a predefined scenario or case study that will be provided one week in advance. This scenario will also include targeted study topics and relevant formulas. Students will be asked a short series of questions related to the scenario. This type of exam structure leverages your knowledge of the targeted scientific fundamentals with problem solving. You are welcome to have notes available but the time will be very short and you may not have sufficient time to reference your notes extensively. Any notes must be in a hard copy—no electronic devices will be allowed during the quizzes.

Only the 5 best quiz scores will be included in your final grade calculation.

Final Exam (25%): A comprehensive written final exam will be held on Wednesday, December 13 between 8:00-11:00 AM.

Grade Reporting: All assessment scores are stored on the CANVAS website. Any errors in grade reporting appearing on CANVAS must be reported within 2 weeks of the due date of the assessment item or by the last day of class, whichever is earlier.

Expectations: To succeed in this class, you will need to

- Review the suggested reading material before coming to class, and formulate questions;
- participate in the in-class discussions;
- make sure you understand the homework problems and solutions;
- seek out help when you have trouble.

Obtaining help: The main two ways to obtain help are online at Piazza or during office hours. You can also speak with your professor briefly after lecture. Please do not send email directly to the professor for routine help or absences. In cases of emergencies related to exams (e.g., illness) you should email your professor at the earliest possible opportunity.

Online Forum (Campuswire): This class uses Campuswire for all communication between the instructor and students. Please visit campuswire.com to register with your @illinois.edu email address. If you desire, you can post anonymously on Campuswire or make a private post just to the instructors (this should be done rather than emailing the professor directly). You can also use the chat rooms feature on Campuswire study groups etc. *Note that Campuswire should be used to communicate with your instructors, rather than email.*

Absences: Excused Absence Request Form: illinois.edu/fb/sec/4107592

1. Regular attendance is very important for your progress and success in this course. Excuses from assessments will be considered in the following circumstances:
 - (a) Illness.
 - (b) Personal crisis (e.g., car accident, required court appearance, death of a close relative).
 - (c) Religious observance.
 - (d) Required attendance at an official UIUC activity (e.g., varsity athletics, band concert).
2. In all cases you must complete the online Excused Absence Request Form and upload a scan of the official written documentation explaining your absence. This form helps to organize all request to ensure that nothing is overlooked or lost via email or more informal communications.
3. In cases (a) or (b) please provide some form of documentation via the online form within 2 weeks of the due date of the missed assessment, but no later than reading day (December 9). In cases of extended or unusual illness, late submission of excuse documentation will be considered. See [Student Assistance Center](#).
4. In case (c) please notify the instructor by completing an Excused Absence Request form at least one week prior to the due date of the missed assessment.
5. In case (d) an official letter from the designated university official must be submitted via the online form at least one week prior to the due date of the missed assessment.
6. If you will not be able to take a quiz due to illness or any other reason, you must send email to your professor at the earliest possible opportunity. Quizzes may be rescheduled at the discretion of the instructor but may involve a new scenario.
7. Notwithstanding the above, at the professor's discretion you may be required to make up any excused work or attend substitute instruction or assessment.

Academic Integrity, Harassment, and Discrimination: You are bound by the [University Honor Code](#) in this course. Any violation of the Honor Code will result in disciplinary action. In

addition, harassment or discrimination of any kind will not be tolerated. Please report any concerns immediately to your professor.

Community of Care: As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regards to their well-being or yours, we encourage you to refer this behavior to the [Student Assistance Center](#) (217-333-0050). Based on your report, the staff in the Student Assistance Center reaches out to students to make sure they have the support they need to be healthy and safe.

Further, we understand the impact that struggles with mental health can have on your experience at Illinois. Significant stress, strained relationships, anxiety, excessive worry, alcohol/drug problems, a loss of motivation, or problems with eating and/or sleeping can all interfere with optimal academic performance. We encourage all students to reach out to talk with someone, and we want to make sure you are aware that you can access mental health support at the [Counseling Center](#) or [McKinley Health Center](#). For mental health emergencies, you can call 911 or walk in to the Counseling Center, no appointment needed.

Changes to syllabus: may occur as deemed necessary by the professor; they will be announced.

Week	Day	Date	Lecture Topic	Reading Assignment		Evaluation		
				Book	Ch	Homework	Quizzes	Design Project
1	M	21-Aug	Course goals & Elasticity Review (1)	MC	2.1-2.9			
	W	23-Aug	Elasticity & dislocations (2)	C	3	HW1 - Pretest		
	F	25-Aug	Dislocations (3)	C	3			
2	M	28-Aug	Plastic deformation (4)	C	4.1-4.6			
	W	30-Aug	Plastic deformation (5)			HW2 - Elasticity & dislocations		
	F	1-Sep	Strengthening (6)	C	5.1-5.9			
3	M	4-Sep	No class - Labor day					
	W	6-Sep	Plasticity & strain rate sensitivity (7)	MC	3.2, 3.7, 3.9	HW3 - Dislocations, Plasticity & Strengthening		
	F	8-Sep	Creep - intro (8)	C	7.1-2		Quiz 1 - Elasticity & dislocations	
4	M	11-Sep	Creep - diff. based mechanisms (9)	C	7.3A-C			
	W	13-Sep	Creep - combining mechanisms (10)	C	7.3D-7.4	HW4 - CM #1: Strain rate sensitivity		
	F	15-Sep	Creep - combining mechanisms					Critical Reading #1
5	M	18-Sep	Creep - Experimental methods & Intro to superplasticity (11)	H	5.6			
	W	20-Sep	Fracture - Case studies	C	7.7-9	HW5 - Creep #1		
	F	22-Sep	Quiz only				Quiz 2 - Plasticity & strengthening	
6	M	25-Sep	Fracture - Intro (12) (recorded)	A	2.1;1.3.1-2			
	W	27-Sep	Fracture - Geometry (13)	A	2.2-2.6	HW6 - Creep #2		
	F	29-Sep	Fracture - Brittle fracture (14)	MC	7.1			
7	M	2-Oct	Fracture - Brittle fracture (15)	MC	7.10			
	W	4-Oct	Fracture - Brittle fracture (15 cnt'd)	A	6.2	HW7 - Intro to fracture		
	F	6-Oct	Quiz only	A	5.2		Quiz 3 - Creep	
8	M	9-Oct	Fracture - Cleavage (16)	A	5.2			
	W	11-Oct	Fracture - DBTT (17)	A	5.3	HW 8 - CM #2: Thermally induced fracture		
	F	13-Oct	Design Project Working Day					Design Project working day #2
9	M	16-Oct	Fracture - Ductile fracture (18)	A	5.1-2			
	W	18-Oct	Fracture - Ductile fracture (18 cnt'd)	A	5.1-2	HW9 - Toughening		
	F	20-Oct	Fracture - Ductile fracture (19)	A	3.1,2,5; 7.4		Quiz 4 - Toughening	
10	M	23-Oct	Fracture - Testing (20)	H	9.1-2			
	W	25-Oct	Fatigue - Case studies (21)			HW10 - Cleavage & ductile fracture		
	F	27-Oct	Fatigue - Fractography & terminology (22)	H	12.1			

11 M	30-Oct	Fatigue - Experiments (23)	H	12.2-2.2	
W	1-Nov	Fatigue - Intro to mechanisms (24)	MC	14.7	HW 11 - Fracture testing & composites
F	3-Nov	Quiz only			Quiz 5 - Cleavage & ductile fracture, fracture testing
12 M	6-Nov	Fatigue - Mechanisms & crack growth (25)	MC	14.7	
W	8-Nov	Fatigue - Short crack fatigue and advanced topics (26)	H	12.6	No HW
F	10-Nov	Guest lecture by Prof. Stinville			
13 M	13-Nov	Embrittlement - Intro & Stress corrosion cracking (27)	C	& 13.3A-B	
W	15-Nov	Embrittlement - Radiation (28)	C	13.4-6	HW 12 - Fatigue
F	17-Nov	Quiz only			Quiz 6 - Fracture: Composites & Hi-T
14 M	20-Nov	Thanksgiving break			
W	22-Nov	Thanksgiving break			
F	24-Nov	Thanksgiving break			
15 M	27-Nov	Embrittlement - Metal Embrittlement & Hydrogen (29)	C	13.4-5	
W	29-Nov	No class			HW13 - Fatigue & Embrittlement
F	1-Dec	Design Project Poster Session (In-Class)			Design Proposal & Poster Preparation
16 M	4-Dec	Poster presentations (1/2)			Poster Presentation
W	6-Dec	Poster presentations (2/2)			Poster Presentation
17 W	13-Dec	Final Exam: 8-11AM			