

MatSE 406: Thermal and Mechanical Behavior of Materials

Fall 2023

Schedule

TR 11:00–12:20pm in DCL 1320

Quizzes via Computerized-Based Testing Facility (CBTF)

Course content:

- Canvas space
- PDF syllabus
- Class discussion space campuswire.com
- Online homework prairielearn.org
- Weekly written report upload gradescope.com
- Recorded lectures: follow link provided on canvas's homepage
- Textbook: Mechanical Behavior of Materials, Thomas H. Courtney, 2nd ed. (Waveland, 2005), **preferred**
- Alt. text: Mechanical Behavior of Materials, Mark Meyers & Krishan Chawla, 2nd ed. (Cambridge, 2009).
- Scope
- Fundamentals of elastic, viscoelastic and plastic deformation of materials
- Composite behavior
- Elementary theory of dislocations
- Strengthening mechanisms
- Failure: creep, fracture, and toughening
- Fundamentals of thermal behavior (heat capacity, thermal expansion, conductivity, and the effects of thermal stresses).
- Connecting underlying microscopic mechanisms to macroscopic material behavior, with the goal of controlling or coping with that behavior.

Objectives

Students will be able to

- (a) explain how fundamental microscopic physical mechanisms produce macroscopic mechanical and thermal behavior of materials;
- (b) calculate mechanical and thermal behavior for a variety of realistic problems;
- (c) apply empirical and theoretical models to novel engineering questions.
- (d) work together with their colleagues in a professional, scientific manner.

Prerequisites

- Math 225 (Linear Algebra)
- TAM 206 (Statics and Mechanics of Materials)
- MSE 201 (Phases and Phase Relations)
- as well as their prerequisites, e.g., Math 241 (Calculus III), Physics 211 (Mechanics).

If you have not passed a prerequisite course, please see the instructor before continuing.

Instructor

Marie A. Charpagne (mcharp@illinois.edu; 408A MSEB, west stairwell).

- Assistant Professor in Materials Science and Engineering (joined Univ. Illinois in 2021)
- Research area: alloy design for additive manufacturing

Teaching assistants

- Jackson Nie (yuhengn2@illinois.edu)
- Christopher Bean (cmbean2@illinois.edu)

Discussion sections

All in Natural Sciences Building:

- AD1, F 11:00-11:50am
- AD2, F 12:00–12:50pm
- AD3, F 1:00–1:50pm

You may only attend your registered section

Course evaluation

10% x (Online Homework) + 4% x (Participation) + 8% x (Discussion Worksheets) + 8% x (Written Reports) + 70% x (Quizzes)

Numerical total score corresponds to the following final grades:

A+ (98–100) A (94–97) A– (91–93)
 B+ (88–90) B (84–87) B– (81–83)
 C+ (78–80) C (74–77) C– (71–73)
 D+ (68–70) D (64–67) D– (61–63)
 F (0–60)

Online Homework (10%)

Assignments on *PrairieLearn*.

- Online homework assignments are due on *Tuesdays at 6:00 pm*. Late submissions will not be accepted. You can rework completed items after the due date. This work will not be saved and will not affect your grades.
- You will receive a grade for ALL assigned online homework problems. Your HW score will also appear in the grade book.
- The online homework problems give explicit values and units to the relevant lengths, material properties, forces, etc., and therefore you should give your final answer with a numerical value. Nevertheless, when solving a homework problem you should assign symbols to all the relevant lengths, forces, material properties, etc., and then solve the problem symbolically to ensure you follow the math. Finally, substitute the value and units of each of the symbols in the symbolic formula.
- You are encouraged to print out each homework problem and derive your symbolic solution on this print out. Store these solutions for your future reference.
- The “zeroth” online homework is due on Tuesday August 31. It contains multiple choice questions regarding the syllabus. You will only have one attempt for each multiple choice item. Your complete submission will earn you 0.5 extra points added to your final grade.
- The first online homework is due on Tuesday Sept. 7 and covers the material of the first three lectures.

Participation (4%)

During lecture time, we will use *i>clickers* to help check your understanding of the material, and give you practice working some problems.

Discussion worksheets (8%)

Prompt and regular attendance at your discussion section is required. You must attend only the discussion section in which you are enrolled.

Most discussion sessions will consist of a group worksheet exercise, which is a high-energy and efficient 50-minute learning experience. For each session, students will work with their group of three to four people. Each student must submit a completed worksheet, but only one randomly chosen worksheet will be scored from each group, and every student in that group will be given that score. If you are more than 5 minutes late to a discussion session, then you will not be permitted to complete the worksheet.

There are two main goals for the discussion worksheets:

- Gain experience in team-work. This skill is critical in all engineering disciplines, from large-scale industrial projects to academic research. To work productively in teams is a skill that must be learned just like math or physics, and regular practice is essential. Often you will have to work with people who you do not especially like, or who you find it difficult to work with. It is important to learn how to manage these situations so that the important work is still accomplished.
- Apply engineering concepts to real-world problems. Each worksheet focuses on a real world problem that you will have to use your engineering skills to solve, including the material from class and also knowledge from previous engineering, math, and science classes. You will also have to think like an engineer and understand when to make approximations, how to judge the appropriateness of different models, and which mathematics and physics is most useful for a given engineering problem.

We also hope that these discussion worksheets will help you to meet your classmates, and we encourage you to get together outside of lectures and discussions to work collaboratively on homeworks and exam study.

Discussion sections start Friday August 27. In addition, you will receive an email from CATME with a private survey message for you. Your information will be used to construct your teams for the recitations throughout the semester; you must complete the survey by Sept. 1. You should work with your team to study outside of the class, and you will work together on computational reports (see below). For Aug. 27, you will work in random teams in recitation, but starting Sept. 3, you will work in your assigned team for the rest of the semester.

Written Reports (8%)

Each week a report must be submitted, consisting of a full write-up of a problem related to the group worksheet that was assigned in that week's discussion section. The report will be posted after the discussions on Friday and must be submitted (via GradeScope) the following Thursday at 11:59pm. The TAs will grade the report.

Written reports are assigned to practice the communication of engineering concepts in writing. They will be graded based on presentation, neatness, correct use of symbols, quality of drawings and diagrams, and clarity of explanation (80%). Reports should be neat and organized, hand-written or typed. Tables and graphical representations of results should be generated using some

software program such as Excel, TecPlot, MatLab, etc., rather than being hand-drawn. Correct interpretation of the problem and correct final answers are important but not the focus (20%). Late written reports will not be accepted. The first reports will be assigned Friday August 27 during your discussion section, and due Thursday Sept. 2. Point breakdown for the written report:

- 1: Correct interpretation of the problem
- 1: Correct final answer
- 2: Presentation quality
- 1: Clarity of explanation
- 2: Clear drawings and diagrams
- 2: Use of symbolic work
- 1: Use of units on numerical answers

Computational reports

Computational material science and engineering is a field with increasing importance in research and industry; to give you experience in applying the tools of computational modeling to materials science and engineering, there will be computational reports that are assigned throughout the semester. Additional information will accompany these assignments, and you will be able to take advantage of additional support from a teaching assistant on these assignments. In addition, you can work as a group on the computational reports, and turn in a single report for the computational modeling. All other reports are to be done individually.

Quizzes (70%)

Dates and policies: There are regular 50 minutes quizzes roughly every two weeks.

The seven quizzes are scheduled for Sept. 1-Sept. 5, Sept. 17-20, Oct. 1-4, Oct. 15-18, Oct. 29-Nov. 1, Nov. 12-15, Dec. 3-6. The final exam will take place during exam week.

This course uses the College of Engineering Computer-Based Testing Facility (CBTF) for its quizzes and exams: cbtf.engr.illinois.edu.

The policies of the CBTF are the policies of this course, and academic integrity infractions related to the CBTF are infractions in this course. If you have accommodations identified by the Division of Rehabilitation-Education Services (DRES) for exams, please take your Letter of Accommodation (LOA) to the CBTF proctors in person before you make your first exam reservation. The proctors will advise you as to whether the CBTF provides your accommodations or whether you will need to make other arrangements with your instructor. Any problem with testing in the CBTF must be reported to CBTF staff at the time the problem occurs. If you do not inform a proctor of a problem during the test then you forfeit all rights to redress.

Quiz Content

The quizzes last fifty minutes, and will give you an immediate assessment and feedback on your understanding of the material since the previous quiz. The first quiz is a prerequisite quiz, which covers a review of topics from prerequisites for the class, while the other quizzes are roughly paired around the topics of elasticity, plasticity, creep and failure. The final exam is optional. It is cumulative over the entire course, and lasts three hours.

Total score

Your total score of 70% is calculated from your seven quizzes using a weighted sum.

First, we sort your quiz scores from highest (score S_1) to lowest (score S_7). We sum them up as

$16S_1 + 14S_2 + 12S_3 + 10S_4 + 8S_5 + 6S_6 + 4S_7 = 70S$, where S is your combined quiz score. If you take the final exam and your score exceeds your lowest quiz score, the exam score will replace the lowest quiz in the total calculation; if your score exceeds your lowest two quiz scores, the exam score will replace your two lowest quizzes in the total calculation.

Expectations

To succeed in this class, you will need to

- do your reading and homework on-time, which contains pre-lecture problems to keep you
- involved in lecture;
- participate in the class, be a strong contributor and leader in discussion sections;
- 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 *CampusWire* or in person at *office hours*. Please do not send email directly to TAs or professors for routine help, because our email inboxes are flooded; CampusWire is much better for this. In cases of emergencies related to quizzes (e.g., illness) you should email message Prof. Charpagne at the earliest possible opportunity; note that due to the ability to (re)schedule via the CBTF, you will be able to take care of this yourself in most cases.

Online forum (CampusWire)

This class uses CampusWire for all communication between the instructor, TAs, and students. You will receive an email to register with CampusWire soon. Official class announcements will be sent via CampusWire, so you must register with an email address that you regularly check, or check CampusWire regularly. If you desire, you can post anonymously on CampusWire to the entire class, or post a private question just to the instructors (this should be done rather than emailing the professor directly). TAs are checking CampusWire on a daily basis during the week. Note that *CampusWire should be used to communicate with your instructors, rather than email*.

Office hours

Office hours will be held Mondays (time TBD) and Wednesday time TBD). The first hour will be a time to meet up with fellow MSE406 students to work on homework and written reports together, and the second hour will be staffed by a TA. Office hours will start Aug. 30). Do not ask TAs to work the homework problems before they are due; it is fine to ask specific questions on the details of your attempted solutions, or to work out problems that are similar to homework problems; you can also ask about homework problems or quiz questions once the due dates are passed.

Absences

See ODOS Absence Letters.

- Excuses from assessments will only be given in the following circumstances:
 - Illness.
 - Personal crisis (e.g., car accident, required court appearance, death of a close relative).
 - Required attendance at an official UIUC activity (e.g., varsity athletics, band concert).
- The first two cases follow the student code regarding absences. This includes absence due to
- exposure to COVID-19, and a letter is requested from ODOS.

- In case of the latter 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.
- Please send letters to mcharp@illinois.edu .

Formal and Informal Accommodations

I am committed to assisting students requiring special accommodations for circumstances that are registered with the DRES Student Services Department. These formal accommodations should be discussed with me as early as possible in the semester or as soon after DRES approval as possible. If you are not formally registered with DRES and have anxiety, depression, learning disabilities, or other issues that affect your ability to fully participate and learn in this class, you are encouraged to check-in with the instructor so we can determine together the kind of support you need to thrive in this class. If this is the case, please set up a meeting with me via email.

Inclusion and Diversity

I value all students regardless of their background, race, religion (creed), ethnicity, gender, gender expression, age, country of origin, disability status, marital status, sexual orientation, or military status, etc., and am committed to providing a climate of excellence and inclusiveness within all aspects of the course. If there are aspects of your culture or identity that you would like to share with me as they relate to your success in this class, I am happy to meet to discuss. Likewise, if you have any concerns in this area of facing any special issues or challenges, you are encouraged to discuss the matter with me (set up a meeting via email) with an assurance of full confidentiality (only exception being mandatory reporting of academic integrity / code violation and sexual harassment).

Harassment or discrimination of any kind will not be tolerated.

Anti-Racism and Inclusivity Statement

The intent is to raise student and instructor awareness of the ongoing threat of bias and racism and of the need to take personal responsibility in creating an inclusive learning environment.

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

Learning Environment

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, microaggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Office of the Vice Chancellor for Diversity, Equity and Inclusion (OVCDEI). Based on your report,

OVCDEI members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at ODOS to request appropriate accommodations. This should be done in the first two weeks of classes.

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options. A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/confidentiality.

Other information about resources and reporting is available here: wecare.illinois.edu.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See FERPA info for more information on FERPA.

Academic Integrity

You are bound by the University Honor Code in this course. Any violation of the Honor Code will result in disciplinary action. Students are responsible for producing their own work. Collaborative interaction is encouraged, but each student must do their own individual homework and written reports (except as noted), and contribute their own work to the group. Plagiarism and cheating will not be tolerated, and verified incidents will result in all parties receiving a zero and formal academic sanctions.

Students are responsible for familiarizing themselves with the definition of and penalties for plagiarism in Section I-401 of the UIUC Student Code. Note that plagiarism includes "copying another student's paper or working with another person when both submit similar papers without authorization to satisfy an individual assignment."

COVID-19

Following University policy, all students are required to engage in appropriate behavior to protect the health and safety of the community. Students are also required to follow the campus COVID-19 protocols. Students who feel ill must not come to class. In addition, students who test positive for COVID-19 or have had an exposure that requires testing and/or quarantine must not attend class. The University will provide information to the instructor, in a manner that complies with

privacy laws, about students in these latter categories. These students are judged to have excused absences for the class period and should contact the instructor via email about making up the work. Students who fail to abide by these rules will first be asked to comply; if they refuse, they will be required to leave the classroom immediately. If a student is asked to leave the classroom, the non-compliant student will be judged to have an unexcused absence and reported to the Office for Student Conflict Resolution for disciplinary action. Accumulation of non-compliance complaints against a student may result in dismissal from the University.

Face-covering and building access

All students, faculty, staff, and visitors are encouraged to wear face coverings in classrooms and university spaces. This is in accordance with CDC guidance and University policy and expected in this class.

Please refer to the University of Illinois Urbana-Champaign's COVID-19 website for further information on face coverings. Thank you for respecting all of our well-being so we can learn and interact together productively.

In order to implement COVID-19-related guidelines and policies affecting university operations, instructional faculty members may ask students in the classroom to show their Building Access Status in the Safer Illinois app or the Boarding Pass. Staff members may ask students in university offices to show their Building Access Status in the Safer Illinois app or the Boarding Pass. If the Building Access Status says "Granted," that means the individual is compliant with the university's COVID-19 policies—either with a university-approved COVID-19 vaccine or with the on-campus COVID-19 testing program for unvaccinated students.

Changes to syllabus

May occur as deemed necessary by the professor; they will be announced and the updated syllabus posted on the course website.

Calendar

Day	Assignments	Lecture (Courtney Chapter)
T Aug 22		1. Review of mechanical response (1)
R Aug 24	Posted: HW0	2. Elastic behavior (2.1-2.4)
F Aug 25		Worksheet 0
T Aug 29	Due: HW0, Posted: HW1	3. Anisotropic elastic behavior (2.5)
W Aug 30	CBTF Quiz 0	
R Aug 31		4. Rubber, viscous flow (2.6, 8)
F Sep 01	Posted: WR1	Worksheet 1
T Sep 05	Due: HW1, Posted: HW2	5. Polymer deformation, damping (2.7-2.8, 8)
R Sep 07	Due: WR1	This is a holiday
F Sep 08	Posted: WR2	Worksheet 2
T Sep 12	Due: HW2, Posted: HW3	6. Composites intro (6.1, 6.2, 6.4)
R Sep 14	Due: WR2	7. Composite fiber effects (6.5, 6.6)
F Sep 15	CBTF Quiz 1	No recitation
T Sep 19		8. Composite statistics (6.7, 9.7)
R Sep 21		Review
F Sep 22	Posted: CR3	Worksheet 3
T Sep 26	Due: HW3, Posted: HW4	9. Dislocations intro (3.1-3.4)
R Sep 28	Due: CR4	9. More dislocations
F Sep 29	CBTF Quiz 2; Posted: WR4	Worksheet 4
T Oct 03	Due: HW4, Posted: HW5	10. Dislocation stress fields (3.6)
R Oct 05	Due: WR4	11. Dislocation energies and directions (3.6D-3.7)
F Oct 06	Posted: WR5	Worksheet 5
T Oct 10	Due: HW5, Posted: HW6	12. Plasticity (3.9, 4.1-4.5)
R Oct 12	Due: WR5	12. Plasticity (3.9, 4.1-4.5)
F Oct 13	CBTF Quiz 3; Posted: WR6	Worksheet 6
T Oct 17		13. Strengthening, work-hardening (5.1-5.3)
R Oct 19	Due: WR6	14. Solid solution strengthening (5.5)
F Oct 20	Posted: CR7 Files	Worksheet 7
T Oct 24	Due: HW6, Posted: HW7	15. Particle hardening (5.6)
R Oct 26	Due: CR7	16. Boundary strengthening, polycrystals (4.4, 5.5)
F Oct 27	CBTF Quiz 4	No recitation
T Oct 31	Due: HW7, Posted: HW8	17. Creep (7.1-7.4)
R Nov 03		18. Fracture intro (9.1-9.3)
F Nov 03	Posted: WR8	Worksheet 8
T Nov 07	Due: HW8, Posted: HW9	19. Fracture mechanics, toughness, stats (9.4-9.7B)
R Nov 09	Due: WR8	20. Toughening of metals, ceramics
F Nov 10	CBTF Quiz 5; Posted: WR9	Worksheet 9
T Nov 14	Due: HW9	21. Toughening of polymers, composites (10.4-10.5)

R Nov 16	Due: WR9	Review
F Nov 17		No recitation
<i>Thanksgiving break</i>		
T Nov 28	Posted: HW10	22. Fatigue intro, crack propagation (12.1-12.3; 12.4-12.6)
R Nov 30		23. Selection / Design slides
F Dec 01	CBTF Quiz 6; Posted: CR10 Files	Worksheet 10
T Dec 05	Due: HW10	Review
R Dec 07	Due: CR10	
TBA	<i>Begin FINAL</i>	<i>Optional Final, Prairie Learn (1-10,12)</i>