MatSE 406: Thermal and Mechanical Behavior of Materials
Fall 2023

Schedule
TR 11:00–12:20pm in Everitt
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 on canvas
- 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 deformation of materials and thermal behavior
  - Polymer behavior
  - Composite behavior
  - Elementary theory of plasticity
  - Strengthening of metallic alloys
  - Fracture and toughening of polymers, composites, natural materials and metals
  - Connecting underlying microscopic mechanisms to macroscopic material behavior, with the goal of controlling or designing novel materials.

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)
- TA/MSEM 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 email 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 and synthesis (solidification, 3D printing, thermal-mechanical processing, sputtering) and materials behavior in extreme environments (mechanical performance, corrosion, irradiation)

Teaching assistants
• Christopher Bean (cmbean2@illinois.edu), Racheff scholar 2024-2025
• Jackson Nie (yuhengn2@illinois.edu), Racheff scholar 2024-2025

Discussion sections
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*.

- Please refer to the course schedule onto the Canvas' page or PrairieLearn for due dates and times. Late submissions will not be accepted and will lead to a 0% grade. You can rework completed items after the due date to prepare for exams and quizzes, however this work will not be saved and will not affect your grades.
- You will receive a single grade for ALL assigned online homework problems. Your average 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.

Participation (4%)
During lecture time, we will use ***iclickers*** to help check your understanding of the material, and give you practice working some problems. The iclicker grade is calculated based on participation, and not correctness of your answers.

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, e.g. at 11AM, 12PM, or 1PM.
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 and your grade for that session will be 0%. Please send an email to the TAs in advance (as much as possible) regarding missed sessions or late arrivals.

There are two main goals for the discussion worksheets:

- Gain experience in teamwork. 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. You should work with your team to study outside of the class, and you will work together on computational reports (see below).

Written Reports (8%)
Written reports consist 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 individually** on Canvas. 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 is important but not the focus (20%). Late written reports will not be accepted.

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 throughout the semester
Please refer to the course' Canvas page for dates and details. 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: https://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, 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 $16S_1 + 14S_2 + 12S_3 + 10S_4 + 8S_5 = 60S$, 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."

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

Tuesday	Thursday	Friday
Aug 27 **(01)** ***Elastic behavior*** Syllabus overview + MSE 206 recap + Math recap	Aug 29 **(02)** ***Elastic behavior*** Stress-strain curves, elastic isotropy	Aug 30 (WS0) ***Elastic behavior*** Spring behavior
Sept 3 **(03)** ***Elastic behavior*** Stiffness and compliance tensors lecture, elastic anisotropy (no slides on that day, bring you notebook!)	Sept 5 **(04)** ***Elastic behavior*** Elastic anisotropy: application examples in class (no slides on that day, bring your notebook!) **HW0 due: syllabus + stress-strain**	Sept 6 (WS1) ***Elastic behavior*** Copper wire & anisotropic elasticity
Sept 10 **(05)** ***Polymer mechanics*** Stress-strain curves and phenomenology **WR1 due: copper wire**	Sept 11 **(06)** ***Polymer mechanics*** Modeling polymer response **HW1 due: elastic anisotropy**	Sept 12 (WS2) ***Polymer mechanics*** Polymer models **Weekend: Quiz 1 Elasticity**
Sept 17 **(07)** ***Composites*** Intro and stress-strain curves **WR2 due: polymer models**	Sept 19 **(08)** ***Composites*** Fibers orientation effects on composite strength (lecture taught by Chris Bean) **HW2 due: polymers**	Sept 20 (WS3) ***Composites*** Strength calculation & no report to follow (solutions to the worksheet will be given)
Sept 24 **(09)** ***Composites*** Statistics of composite failure	Sept 26 **(10)** ***Composites*** Review + quiz prep **HW3 due: composites**	Sept 27 No discussion- work on computational report
Oct 1 **(11)** ***Plasticity*** Introduction to dislocations With demo **WR3 due: composites (computational report)**	Oct 3 **(12)** ***Plasticity*** Motion of dislocations	Oct 4 **OH sessions for Quiz 2** **Weekend: Quiz 2 Polymers & Composites**
Oct 8 *No lecture – work on computational report*	Oct 10 **(13)** ***Plasticity*** Stress fields of dislocations **HW4 due: dislocations**	Oct 11 (WS4) ***Plasticity*** Dislocation forces
Oct 15 **(14)** ***Plasticity*** Schmid's law and crystal orientation effects **WR4 due: dislocations (computational report)**	Oct 17 **(15)** ***Plasticity*** Pole figures and stereographic projections	Oct 18 (WS5) ***Plasticity*** Pole figures and slip systems. (Marie + Jackson)
Oct 22 **(16)** ***Strengthening*** Theory and work-hardening (lecture taught by Jackson Nie) **WR5 due: stereographic projections**	Oct 24 **(17)** ***Strengthening*** Grain boundary strengthening (online lecture, no need to come in class) **HW5 due: plasticity**	Oct 25 **OH session for Quiz 3** (Jackson + Chris) **Weekend: Quiz 3 Dislocations**
Oct 29 **(18)** ***Strengthening*** Solid solution strengthening	Oct 31 **(19)** ***Strengthening*** Precipitation strengthening	Nov 1 (WS6) ***Strengthening*** Precipitation strengthening
Nov 5 **(20)** ***Strengthening*** Review + quiz preparation **WR6 due: strengthening**	Nov 7 **(21)** ***Fracture mechanics*** Cracking phenomena **HW6 due: strengthening**	Nov 8 **OH session for Quiz 4** **Weekend: Quiz 4 Strengthen'**
Nov 12 **(22)** ***Fracture mechanics*** Stress intensity factors	Nov 14 **(23)** ***Fracture mechanics*** Fracture	Nov 15 (WS7) ***Fracture mechanics*** Materials selection, no report to follow

Nov 19 **(24)** ***Fracture mechanics*** Toughening of metals and ceramics	Nov 21 **(25)** ***Fracture mechanics*** Toughening of polymers, composites, and natural materials	Nov 22 No discussion in anticipation of Fall break
Fall Break		
Dec 3 **MRS Boston (TBD)** **(26)** ***Fracture mechanics*** Test prep, OH format, virtual? **WR7 due: cracking (computational report)**	Dec 5 **MRS Boston (TBD)** **(27)** ***Review*** Final exam prep, OH format, virtual? **HW7 due: fracture mechanics**	Dec 6 **MRS Boston** **OH session for Quiz 5** **Weekend: Quiz 5 Fracture**
Dec 10 **(28)** ***Review*** Open session: we answer all your questions	Dec 13-19 **Final exam**	