

TAM 445: Continuum Mechanics

Spring 2024

T, Th 11:00–12:50 PM, 3100 Sidney Lu Mech Engr Bldg

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Office hours: W:10:00–11:00, Th 1:00–2:00

Prerequisite: TAM 251

TA/Grader: Tusher Ahmed, mtahmed2@illinois.edu. Office hours: M, W 2:00–3:00 pm in 0028 Sidney Lu Mech Engr Bldg

Objectives: This course introduces continuum mechanics which is a foundation for solid and fluid mechanics. It provides the most general description of how materials deform under external loading.

Topics:

1. Scalars, Vectors and Tensors: indicial notation, vector algebra, tensor algebra
2. Kinematics: deformation mapping, local deformation and strain measures, linearized kinematics, compatibility, kinematic rates
3. Balance laws: mass, linear and angular momentum
4. Thermodynamics: thermal equilibrium and temperature, First Law (conservation of energy), direction of time, Second Law and entropy
5. Constitutive equations: thermodynamic constraints, material-frame indifference, material symmetry
6. Applications: heat transfer, fluid mechanics, elasticity theory

Course Website and Lecture Notes TAM 445 website is on Campuswire and Canvas. You will find the syllabus, announcements and discussion forum on Campuswire, while homework assignments and grades will be posted on Canvas. In addition, my scanned lecture notes will be made available on Campuswire as the course progresses. The lecture notes are derived from multiple references such as

- Ellad B. Tadmor, Ronald E. Miller and Ryan S. Elliott, Continuum Mechanics and Thermodynamics: From Fundamental Concepts to Governing Equations, Cambridge University Press, 2012
- Chadwick, Peter. Continuum mechanics: concise theory and problems. Courier Corporation, 2012
- Gurtin, Morton E. An introduction to continuum mechanics. Vol. 158. Academic press, 1982

Exams: Students will be tested based on homeworks, an in-class midterm, and a final exam. The following distribution will be used to decide the course grade.

Homework (8-9)	55%
Class participation	5%
Midterm	20%
Finals	20%

Homework submission: Homeworks will be assigned on Thursdays, and have to be submitted in a week

Contact and obtaining help: The main way to obtain help is online via Campuswire. Please do not send email directly to TA or the instructor.

Online forum (Campuswire):

This class uses Campuswire for ALL communications between the instructor, TA, and students. Students should not communicate with instructor via email. This is so we can ensure a faster response and keep everyone informed about what's going on.

Students are encouraged to post public messages on Campuswire ("Post to Entire Class"). If you like, you can post anonymously, but we encourage everyone to use their name because it makes a friendlier and more welcoming environment. We will never judge anyone for asking anything on Campuswire. We all make mistakes, or say things that make no sense - it is how we learn!

You can use the private feature on Campuswire by posting a message visible only to the Instructors. In this, you must type "Instructors", instead of sending a message to the TA or instructor. Again, this helps to ensure that you get a prompt response. Do not use the Direct Message (DM) feature of Campuswire.

Academic integrity: Carefully review the following links on academic integrity:

- [Students' Quick Reference Guide to Academic Integrity](#)
- [University of Illinois Student Code: Part 4. Academic Integrity and Procedure](#)

Equity and diversity: This is an equal opportunity classroom environment. We value the diversity represented by the participants in this course. Our diversity is a primary source of ideas and perspectives. As you work through the course, practice using this diversity to your advantage.

Disability-related accommodations: To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, e-mail disability@illinois.edu or go to <http://disability.illinois.edu>. If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnosis a previously undiagnosed disability. You may access these by visiting the DRES website and selecting "Request an Academic Screening" at the bottom of the page.

Anti-racism and inclusivity: 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.

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, micro-aggressions, 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 [Bias Assessment and Response Team \(BART\)](#). Based on your report, BART 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.

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 link [here](#) for more information on FERPA.

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 outlined [here](#) 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](#).

Other information about resources and reporting is available [here](#).

Tentative syllabus and schedule

Date	Topic
Tu 1/16	introduction, indicial notation
Th 1/18	vector space
Tu 1/23	inner product, affine point space
Th 1/25	tensors
Tu 1/30	order of a tensor, change of basis, transpose of a tensor
Th 2/1	product of tensors; determinant and trace; inner product of tensors
Tu 2/6	orthogonal tensors and cross product
Th 2/8	eigenvalues and eigenvectors of second order tensors
Tu 2/13	Cayley–Hamilton theorem, positive definite tensors and the polar decomposition theorem
Th 2/15	scalar, vector and tensor fields; divergence, gradient and curl operators
Tu 2/20	kinematics: continuum body, deformation and its gradient; the concept of strain
Th 2/22	Lagrangian strain; characterization of a rotation
Tu 2/27	material and spatial fields
Th 2/29	infinitesimal strain
Tu 3/5	motion; material and spatial velocity and acceleration fields; rate of change of local deformation measures
Th 3/7	midterm exam
Tu 3/12	Spring break
Th 3/14	Spring break
Tu 3/19	characterization of rigid motions; spin and stretch tensors
Th 3/21	isochoric motion, Reynold’s transport theorem
Tu 3/26	balance laws, Cauchy’s theorem and the existence of stress
Th 3/28	material description of balance laws; continuum thermodynamics
Tu 4/2	laws of thermodynamics; thermodynamic process
Th 4/4	constitutive relations and thermodynamic constraints
Tu 4/9	invariance with respect to superposed rigid body motions; objective scalars, vectors and tensors
Th 4/11	reduced constitutive relations
Tu 4/16	material symmetry; simple fluids
Th 4/18	isotropic and anisotropic solids
Tu 4/23	boundary value problems
Th 4/25	limitations of continuum mechanics
T 4/30	reserve day...