

# ASEN 5012: Mechanics of Aerospace Structures

Fall 2022

**Class meetings:** TTh 11:30 – 12:45 PM in Aero 114

Recording of lectures available on CANVAS.

## Instructor:

Kurt Maute

E-mail: maute@colorado.edu

## Office hours:

- Tuesdays, 4:00 - 5:00 PM, via Zoom:
- Wednesdays 1:00 - 2:00 PM, in Person: Onizuka conference room (AERO 303), except for 8/31: Office Maute (N309)

## Prerequisite:

ASEN: APPM 2360 and ASEN 2001, 2003, and 3112, or equivalent

## Lectures:

Lectures will be given in person and recorded, but not live-streamed. The recordings of the lectures will be posted on CANVAS.

## Online discussion forum:

To facilitate discussions on the material discussed in this course, including homework assignments and exams, this course will use the following Slack Workspace:

Note that students are not required to use this Slack Workspace, and all course notifications will be sent out via email and posted on Canvas. The Slack channel is primarily set up to help improve communication and collaboration within the course. While the Instructor aims to regularly monitor the Slack Workspace you should not expect communication outside of regular business hours.

## References:

This course does not use a single textbook. Instead, students can choose one or more of the following books as resource. In addition, students are provided with summary slides for each lecture.

1. W. M. Lai, D. Rubin, and E. Krempl, “Introduction to continuum mechanics”, 4th ed., Butterworth-Heinemann/Elsevier, Amsterdam, 2010<sup>\*,+</sup>
2. J. N. Reddy, “An Introduction to Continuum Mechanics”, Cambridge University Press, 2013<sup>\*,+</sup>
3. A. F. Bower, “Applied Mechanics of Solids”, Taylor and Francis, 2010<sup>\*,+</sup>
4. A. P. Boresi and K. P. Chong, “Elasticity in Engineering Mechanics”, 2nd edition, Wiley Interscience Publications, New York, 2010<sup>\*,+</sup>

5. Y. C. Fung and P. Tong, “Classical and computational solid mechanics (Advanced series in engineering sciences)”, World Scientific Publishing, Singapore, 2001\*
6. M. E. Gurtin, “An introduction to continuum mechanics (Mathematics In Science and Engineering)”, Academic Press, 2003<sup>+</sup>
7. Y. C. Fung, “A first course in continuum mechanics”, Englewood Cliffs, N.J. : Prentice Hall, 1994
8. L. E. Malvern, “Introduction to the mechanics of a continuous medium”, Englewood Cliffs, N.J. : Prentice-Hall, 1969

\* recommended; <sup>+</sup> available electronically through CU library

## Grading:

Homework (10%)\*\*, two mid-term exams (25%+25%), and an in-class final exam (40%). The homework assignments with the lowest score will be dropped. If the score of any of the two midterm exams is lower than the score of the final exam, the midterm is dropped, and the weighting of the final is increased from 40% to 60% (or 80% if both midterms score lower than the final).

No make-up homework assignments and make-up exams will be offered. If a student does not turn in a homework assignment (in time) or does not take an exam, a zero score will be assigned. Please, see policy on grading homework assignments and exams. A make-up final will be offered if the student provides a valid justification for missing the final.

All students enrolled in ASEN 5012, the midterm exams and the final exams need to be taken during scheduled times, i.e., during lecture for the two midterms and the time schedule by the registrar’s office for the final. Students enrolled in ASEN 5012-B – Distance Section – can either take the exams with the students enrolled in ASEN 5012 on campus or at a different time within a given time window. In the latter case, the student needs to provide a proctor.

All homework assignments need to be uploaded to Gradescope. Students will receive an email to sign up with their CU email address. Students will need to upload their assignment. In case of hand-written assignments, students can use a smartphone or use scanners at the CU library. Should a student not have access to either, please, contact the instructors. Instructions how to upload assignments can be found at [help.gradescope.com](https://help.gradescope.com). Instructions how to upload assignments can be found at: How to upload PDF assignments. Instructions how to view scores and feedback after an assignment is graded can be found at: How to view scores and feedback.

\*\* Each student needs to submit the homework assignments individually. Homework will be graded for completeness only; solutions for all homework problems will be posted.

## Notes:

- All communication outside the classroom will be done via the course Canvas website and email. It is the student’s responsibility to check regularly for updates to the Canvas website. It is strongly recommended to activate the option in Canvas to receive automatic notifications whenever the course website is updated. The Slack channel is only used for discussing questions among students and the instructor.
- All homework needs to be turned in electronically via Gradescope prior to class the day the homework is due (usually Thursdays).
- No late homework will be accepted.

- Students are allowed to discuss homework assignment with each other. However, it is strongly recommended that students work first independently on homework assignments before discussing the assignment with other students and/or the instructor.
- Office hours should be used to discuss specific questions with the instructor. Students are expected to have attempted to work through homework assignments and practice exam questions before discussing these questions with the instructor. Office hours are not meant as time to work on assignments for the first time.

### Exam dates:

- **Mid-term Exam 1:** Thursday, October 6, 2022
- **Mid-term Exam 2:** Thursday, November 17, 2022
- **Final Exam (comprehensive):** Tuesday, Dec. 13, 2022, 1:30–4:00 p.m.

### Course content:

1. Scalar, Vector, and Tensor Algebra
  - (a) Concept of scalars, vectors, and tensors
  - (b) Some basic operations of scalars, vectors, and tensors
2. Stress and Strain Tensors
  - (a) Traction and stress tensor
  - (b) Equation of static equilibrium
  - (c) Linear and nonlinear kinematics, finite deformation, strain tensor
  - (d) Compatibility of strain fields
  - (e) Plane stress and plane strain
  - (f) Transformation of stress and strain tensor
  - (g) Stress invariants and stress deviations
3. Constitutive Equations
  - (a) Classification of materials
  - (b) General Hooke's law
  - (c) Concept of hyperelasticity
4. Conservation Laws
  - (a) Material derivatives
  - (b) Equations of continuity
  - (c) Equations of motion
5. Linear Elasticity
  - (a) Governing equations and uniqueness of boundary value problems
  - (b) Plane stress and plane strain models
  - (c) Saint Venant's theory of torsion
  - (d) Airy stress function in Cartesian coordinates
6. Energy Theorems and Variational Methods

- (a) Principle of virtual displacement, strain energy, complementary energy, potential energy
  - (b) Variational method
7. Nonlinear Elasticity
- (a) Finite deformation
  - (b) Principle of virtual work applied to geometrically nonlinear problems
  - (c) Elastic buckling
8. Advanced Topics \*\*\*
- (a) Elasto-Plasticity and models for material failure
  - (b) Thermo- and viscoelasticity
  - (c) Method of Lagrange multipliers

\*\*\* covered only if time permits

## University policies:

**Classroom Behavior:** Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

**Requirements for COVID-19:** As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. CU Boulder currently requires COVID-19 vaccination and boosters for all faculty, staff and students. Students, faculty and staff must upload proof of vaccination and boosters or file for an exemption based on medical, ethical or moral grounds through the MyCUHealth portal.

The CU Boulder campus is currently mask-optional. However, if public health conditions change and masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, see the policy on classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the “Accommodation for Disabilities” statement on this syllabus.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the Public Health Office ([contacttracing@colorado.edu](mailto:contacttracing@colorado.edu)). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the Public Health Office ([contacttracing@colorado.edu](mailto:contacttracing@colorado.edu)).

In this class, if you are sick or quarantined, please notify the instructor of your absence from in-person activities and continue in a completely remote mode until you are able and allowed to return to campus. Please note that for health privacy reasons you are not required to disclose to the instructor the nature of your illness, however you are welcome to share information you feel necessary to protect the health and safety of others in the course.

**Accommodation for Disabilities:** If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or [dsinfo@colorado.edu](mailto:dsinfo@colorado.edu) for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

**Preferred Student Names and Pronouns:** CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

**Honor Code:** All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include, but are not limited to: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution ([honor@colorado.edu](mailto:honor@colorado.edu); 303-492-5550). Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found on the Honor Code website.

**Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation:** CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, protected-class discrimination and harassment, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these policies, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email [cureport@colorado.edu](mailto:cureport@colorado.edu). Information about university policies, reporting options, and support resources can be found on the OIEC website.

Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of any issues related to these policies regardless of when or where they occurred to ensure that individuals impacted receive information about their rights, support resources, and resolution options. To learn more about reporting and support options for a variety of concerns, visit Don't Ignore It.

**Religious Holidays:** Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, you must let the instructors know of any such conflicts within the first two weeks of the semester so that we can work with you to make reasonable arrangements.

See the campus policy regarding religious observances for full details.