

# ASEN 5012: Mechanics of Aerospace Structures

Fall 2021

**Class meetings:** Tue/Thur 2:50 – 4:05 PM AERO 114 (In person and asynchronous)

## Instructor:

Alireza Doostan

E-mail: doostan@colorado.edu

**Office hours:** Tuesdays 1:30 - 2:30 PM and Wednesdays 11 - noon via Zoom: [https://cuboulder.zoom.us/](https://cuboulder.zoom.us/Meeting ID:)  
Meeting ID:

For meeting outside the class and office hours please contact the instructor via email.

## Prerequisite:

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

## Lectures:

Lectures will be given in person in AERO 114 during normal lecture times as specified above. The recordings of the lectures will be posted on CANVAS after the class for online (asynchronous) learning. Students signed up in section 001B are strongly encouraged to watch the lecture recordings prior to the following lecture and attend office hours to ask questions. Please notice this class does not have a synchronous (live) broadcast of the lectures.

## Online discussion forum:

To facilitate discussions on the material discussed in this course, including homework assignments and exams, this course will use Slack; student should sign up using this link.

## References:

This course does not use a single textbook. Instead, students can choose one or more of the following books as non-mandatory 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\*
3. A. F. Bower, "Applied Mechanics of Solids", Taylor and Francis, 2009\*
4. A. P. Boresi and K. P. Chong, "Elasticity in Engineering Mechanics", 2nd edition, Wiley Interscience Publications, New York, 2000\*<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; + available electronically through CU library

## Grading:

Homework (20%)\*\*, two mid-term exams (20%+20%), and an in-class final exam (40%). The homework assignment 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 will be dropped, and the weighting of the final will be 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 – Distance Section – can either take the exams with the students enrolled in ASEN 5012 or at a different time within a given time window. In the latter case, the student needs to provide a proctor.

All 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](http://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](#).

\*\* Groups of up to two students can work together on homework assignments. Homework will be graded partially for completeness and partially for correctness, i.e. only a randomly chosen subset of questions will be graded for technical correctness and presentation; 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.
- Class participation is highly recommended.
- All homework needs to be turned in electronically via Gradescope prior to class the day the homework is due (usually Thursdays). Only one solution per homework group needs to be turned in.
- No late homework will be accepted.
- It is strongly recommended that students work first independently on homework assignments before discussing the assignment with the members of their homework groups and/or the instructor.

## Exam dates:

- **Mid-term Exam 1:** Thursday, September 30, 2021 (tentative)
- **Mid-term Exam 2:** Thursday, November 11, 2021 (tentative)
- **Final Exam (comprehensive):** Wednesday, Dec. 15, 2021, 4:30–7:00 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 policies on classroom behavior and the Student Code of Conduct.

**REQUIREMENTS FOR COVID-19:** As a matter of public health and safety due to the pandemic, 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. Students who fail to adhere to these 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.

As of Aug. 13, 2021, CU Boulder has returned to requiring masks in classrooms and laboratories regardless of vaccination status. This requirement is a temporary precaution during the delta surge to supplement CU Boulder’s COVID-19 vaccine requirement. Exemptions include individuals who cannot medically tolerate a face covering, as well as those who are hearing-impaired or otherwise disabled or who are communicating with someone who is hearing-impaired or otherwise disabled and where the ability to see the mouth is essential to communication. If you qualify for a mask-related accommodation, please follow the steps in the “Accommodation for Disabilities” statement on this syllabus. In addition, vaccinated instructional faculty who are engaged in an indoor instructional activity and are separated by at least 6 feet from the nearest person are exempt from wearing masks if they so choose.

Students who have tested positive for COVID-19, have symptoms of COVID-19, or have had close contact with someone who has tested positive for or had symptoms of COVID-19 must stay home. In this class, if you are sick or quarantined, please let the instructor know immediately.

**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 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 policy may include: 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 the Honor Code (honor@colorado.edu); 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the Honor Code Office website.

**SEXUAL MISCONDUCT, DISCRIMINATION, HARASSMENT AND/OR RELATED RE-**

**TALIATION:** The University of Colorado Boulder (CU Boulder) is committed to fostering an inclusive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or [cureport@colorado.edu](mailto:cureport@colorado.edu). Information about the OIEC, university policies, anonymous reporting, and the campus resources can be found on the OIEC website.

Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

**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, students must let the instructor know of any such conflicts within the first two weeks of the semester so that reasonable arrangements can be worked out.

See the campus policy regarding religious observances for full details.