

ASEN 4218/5218 – Large Space Structures Design Spring 2024

The goal of the class is to provide students with the tools necessary to analyze a wide range of large and lightweight space structures, ranging from deployable gossamer structures to high precision rigid space frames. Emphasis will be given to preliminary designs, back of the envelope calculations, and scaling laws. At the end of the class, the students will be able to:

- Identify different architectures for deployable structures
- Determine if a bar structure is rigid or a mechanism.
- Calculate the strain energy of a folded thin shell
- Assess the efficiency of different mast and boom designs
- Predict the effect of a tension element in the mechanical response of a structure
- Pre-dimension inflatable structures
- Estimate the effect of thermal deformation on a large space structure
- Perform preliminary analysis of the dynamics of a lightweight structure

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Lecture Times and Location: Tuesday and Thursday, 11:30am – 12:45pm, AERO 114

Zoom link (when required):

Office hours Times and Location: Monday 4pm – 5pm, AERO 303 and Zoom

Wednesday 9am – 10 am, AERO 303 and Zoom

Wednesday 6pm – 7pm, Zoom

Prerequisites: ASEN 3112 or equivalent required. ASEN 5012 is recommended. Matlab will be used in assignments, and coding proficiency is expected.

Textbook: No textbook is required. Material for the class will be posted in Canvas.

Course communication:

- Announcements will be made through Canvas and Slack. Students are required to join both. The instructor will make every possible effort to post all announcements in both platforms; however, in case there is a mishap, students are **strongly recommended to pay attention to both platforms**.
- Grades will be posted to Canvas. However, the final grade calculated by Canvas will not correspond to the real grade, which will be calculated separately.

- Technical questions and discussion must be limited to Slack; in particular, use the public channels, instead of privately messaging the instructor. That helps other students, and fosters discussion.
- Students will also be able to use email to communicate with the instructor. Please, start the subject of each email with “ASEN 4218 / 5218”. This will make sure that emails can be identified at the end of the course and no regrading request is neglected.

GRADING

The final grade will be evaluated based on homework assignments (30%), two midterm exams (20% each) and a final project (30%). All will be submitted to Gradescope.

Plagiarism or any other form of cheating in any of the assignments, exams, or the final project will result in failing the course. As a reminder: using someone else’s code, or not referencing the source of items (images, formulas, etc.) used in homework or project reports, are also forms of plagiarism.

Requests to regrade any item need to be submitted within two weeks of the date in which the assignment or exam is returned to students. The request will be submitted using the features available in Gradescope. Note: this procedure can only be used in the case of mistakes during grading, not to argue about the rubric.

HOMEWORK ASSIGNMENTS

Homework assignments must be turned in before the deadline, which will be specified in each homework set. No late assignments will be accepted for credit. Six or seven homework assignments are expected through the semester, with due dates approximately every other week.

The assignment with lowest grade will be dropped when evaluating the final grade. In addition, the assignment with the second lowest grade will be substituted by the average of that assignment, and the rest of assignments. Example: If the scores in the homework assignments are 80, 60, 90, 95, 65, 85, then the score of 60 will be dropped, and the score of 65 will instead be substituted by $(65 + (80 + 90 + 95 + 85) / 4) / 2$.

There will be the opportunity to submit a correction of your assignment for a small bonus in grade. If you submit a document with a self-grading, based on the provided solution and rubric, you will receive a 5% bonus. If you submit a correction (i.e., explaining what you did wrong, why, and what you should have done), you will recover 20% of the grade you lost. There will be specific instructions released with the solution of every assignment. It will also be discussed in the first lecture.

EXAMS

The exams will take place on the weeks of March 4th to 8th, and April 22nd to 26th. The exams will be take-home, with additional details to be decided. The specific material covered on each midterm will be detailed in class.

FINAL PROJECT

The purpose of the project is to allow students to actively explore a topic they are particularly interested in. It can be done in groups of up to three (for ASEN 5218) or four (for ASEN 4218) people. Mixed groups are allowed, but then the conditions for ASEN 5218 will apply to all students. The expected amount of work will take into account the number of members in the team. It will be graded based on relevance, technical quality, and overall writing and presentation. Details on the project, including topics, timeline, and the possibility of oral presentations, will be provided later.

COURSE CONTENT

The following list of topics is not comprehensive. The instructor reserves the right to adapt the course content to adapt to the progress of the course and the interest of the students.

Bar structures

- Rigidity of structures
- Trusses
- Tessellations
- Space frames

Mechanisms

- Kinematics of linkages
- Pantographs
- Rigid panel structures

Flexible structures

- Foldable booms
- Flexible shells
- Bi-stable structures
- High strain composites

Tension structures

- Balloons and inflatables
- Membrane structures and solar sails
- Tensegrity

Origami

- Rigid foldable origami
- Miura-Ori pattern and derivatives
- Curved folding

Dynamics of large structures

- Estimation of natural frequencies
- Response to actuation

Influence of space environment

- Variation of thermal loading during orbit
- Modeling of heat transfer within structure
- Other environmental effects

Requirements for large space structures

- Optical performance
- Dynamic response of lightweight structures
- Testing on non-zero gravity

COURSE EXPECTATIONS

This is a senior elective / graduate course, and as such, professionalism, initiative and self-sufficiency are expected from students. Deadlines (for assignments, for regrading requests, to give notice of conflicts) will be enforced, if nothing else to ensure fairness among students. Students are encouraged to attend office hours and receive all the help needed to complete assignments; however, they will be expected to come with specific questions after having already attempted to solve the assignments.

The grading for the assignments, particularly when it relates to dropping those with low scores, is designed to add flexibility and allow students to deal with short term emergencies without affecting their grade. Please, do not ask for an extension for the homework assignments, even if it is short. Be on time or let that the assignment that is dropped.

This is also a course based on previous material (e.g., basics in stress and strain, constitutive laws) that will be reviewed only briefly if at all. Students are expected to review independently if they need to refresh concepts; suggested reading will be provided if needed/requested.

However.

I understand that life happens. If you have an emergency (loss of job, sickness in family, mental health issues), particularly one that affects you during a significant amount of time please let me know as soon as possible. Even if you are just overwhelmed by your life situation, please let me know as soon as possible. I expect professional, serious, focused students, not robots. I believe we can all distinguish between minor issues or troubles with planning (which are the reason for the flexibility in grading), and major difficulties (that

require a different, more substantial response). But I can only help you if you give me enough warning, and we can take action when it is still possible to do so (not, say, after the solution for an assignment is posted). So, if something happens, let me know, and we will figure something out.

Let's try to have the best semester possible.

CLASSROOM BEHAVIOR

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure 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 INFECTIOUS DISEASES

Members of the CU Boulder community and visitors to campus must follow university, department, and building health and safety requirements and all applicable campus policies and public health guidelines to reduce the risk of spreading infectious diseases. If public health conditions require, the university may also invoke related requirements for student conduct and disability accommodation that will apply to this class.

If you feel ill and think you might have COVID-19 or if you have tested positive for COVID-19, please stay home and follow the [guidance of the Centers for Disease Control and Prevention \(CDC\) for isolation and testing](#). If you have been in close contact with someone who has COVID-19 but do not have any symptoms and have not tested positive for COVID-19, you do not need to stay home but should follow the [guidance of the CDC for masking and testing](#).

ACCOMMODATION FOR DISABILITIES, TEMPORARY MEDICAL CONDITIONS, AND MEDICAL ISOLATION

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. If you have a required medical isolation for which you require adjustment, please contact the instructor as soon as possible. Deadlines in this course should be flexible enough to accommodate most conflicts; otherwise, please contact the instructor to discuss alternatives.

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 (including use of paper writing services or technology [such as essay bots]), 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, 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. Visit [Honor Code](#) for more information on the academic integrity policy.

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 [protected-class](#) discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, 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 concerns, and individuals who have been subjected to misconduct can contact OIEC at 303-492-2127 or email 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 must inform OIEC when they are made aware of incidents related to these policies regardless of when or where something occurred. This is to ensure that individuals impacted receive outreach from OIEC about resolution options and support resources. To learn more about reporting and support for a variety of concerns, visit the [Don't Ignore It page](#).

RELIGIOUS ACCOMMODATIONS

Campus policy requires faculty to provide reasonable accommodations for students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please communicate the need for a religious accommodation in a timely manner. Deadlines in this course should be flexible enough to accommodate most conflicts; otherwise, please contact the instructor to discuss alternatives. See the [campus policy regarding religious observances](#) for full details.

MENTAL HEALTH AND WELLNESS

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact [Counseling and Psychiatric Services \(CAPS\)](#) located in C4C or call (303) 492-2277, 24/7. Free and unlimited telehealth is also available through [Academic Live Care](#). The [Academic Live Care](#) site also provides information about additional wellness services on campus that are available to students.