

# ASEN 4218/5218 – Large Space Structures Design Spring 2022

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
- Analyze the deployment of origami folding patterns
- Predict the effect of a tension element in the mechanical response of a structure
- Pre-dimension inflatable structures
- Perform preliminary analysis of the dynamics of a lightweight structure

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**Teaching Assistant:** TBD

**Lecture Times and Location:** Tuesday and Thursday, 8:30am – 9:45am, AERO N240

**Zoom link (when required):**

**Office hours Times and Location:** TBD

**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 5212”. 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 must be written in Word/Latex, or by hand and scanned/digitized, and then 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 needs to be submitted in writing, through any of the available forms of communication. They will include the original problem, a written statement stating what the grading error was, and the suggested correct grade. 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. Also, please refer to the video of the first lecture for more details.

## EXAMS

The exams will take place on Thursday March 3<sup>rd</sup> and Thursday April 21<sup>st</sup>. Format is yet 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 all students will be graded as if registered for ASEN 5218. 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. Please refer to the video of the first lecture for more details.

## 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

Requirements for large space structures

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

## **COURSE EXPECTATIONS AND LIFE DURING COVID**

This 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, particularly during a pandemic, which will certainly still apply to the Spring of 2022. If you have an emergency (loss of job, sickness in family, mental health issues, unforeseen COVID related difficulties), 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**

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 Conduct & Conflict Resolution policies](#).

## **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. 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.

CU Boulder currently requires masks in classrooms and laboratories regardless of vaccination status. This requirement is a precaution 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.

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)). Please notify the instructor by email if you are to be absent due to illness or quarantine; it is not required to state the nature of the illness.

## **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 academic integrity policy. 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 the Honor Code ([honor@colorado.edu](mailto: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 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. The university 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 or against 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 email [cureport@colorado.edu](mailto:cureport@colorado.edu). Information about university policies, [reporting options](#), and the 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 incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about their rights, support resources, and reporting 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, please inform the instructor in the first three weeks of the course, so an alternative arrangement can be found. See the [campus policy regarding religious observances](#) for full details.