

# ASEN 5010

## Spacecraft Attitude Dynamics and Control

### Spring 2023

**Instructor:** Dr. Cody Allard, Office: Remote  
Email: [Cody.Allard@colorado.edu](mailto:Cody.Allard@colorado.edu)

**Lectures:** T, R 8:30-9:45am, AERO 111

**Office Hours:** T, R 9:45am-11:00am (or by appointment)  
Location: AERO N110 Tutoring Space  
Zoom Link:

**TA Information:** Jesse Greaves ([Jesse.Greaves@colorado.edu](mailto:Jesse.Greaves@colorado.edu))  
Office Hours: Monday and Wednesday 4-5pm  
Zoom Link:

**Final Exam:** (Take-Home)

**Text:** H. Schaub and J. L. Junkins, *Analytical Mechanics of Space Systems*, AIAA Education Series, 4th Edition, 2018. (please download the errata sheet from the web page <http://hanspeterschaub.info/books.html>)  
Course notes supplied on the class Canvas web site.

**Canvas Course Web Page:** <https://canvas.colorado.edu>

**Live Zoom Course Video Feed:**

**Coursera.org Lectures/Homework:**

**Overview:** Studies the rotational motion of spacecraft, including attitude parameters and spacecraft torques. Applies Euler equations to the attitude motions of simple spacecraft and their stability. Pre: ASEN 3200 or equivalent, or permission of instructor. (3H, 3C)

**Goal:** To introduce students to the spacecraft attitude dynamics, kinematics, as well as control.

**Homework Policy:** Each homework assignment is due on the specified due date and must be turned in at the beginning of the lecture. Normally, late homework will not be accepted. Some homework will require simple programs to be created. These can be done in Matlab, Python, or Mathematica. See instructor if not sure about the software package being used. If a homework has been graded incorrectly, you need to see me within 2 weeks of having the homework returned to you.

**Exams:** There will be a mid-term exam and one comprehensive final exam. If you have exam grading issues, you must see me within 2 weeks of having the exam returned to you. There will also be one course project which will require you to write a technical report. These reports must be type written and composed as a professional technical report.

**Class Attendance:** You are expected to attend class. If you need to miss a lecture, it is your responsibility to catch up on the material. Don't go to the instructor to catch up on missed material, speak with class mates and get the notes from them. Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. If you cannot attend a regularly scheduled class, it is up to the student to catch up on the missed material. If you cannot take an exam on a particular day, please let the instructor know at the time the exam is being scheduled.

**Make-Up Policy:** There are no make-up homework assignments. If you miss the assignment, you get a zero for it. If you can't make an exam or a pressing reason, you need to contact the instructor *one week prior* to the exam date. If you can't take the exam for some emergency reason, you still need to notify the instructor prior to the exam. Without prior consent, there will be no make-up exams.

**Grading Policy:** A conventional ten-point system will be used for grading. If I feel it necessary, I will curve the exam scores to reflect the difficulty level of the problems assigned. Thus, your final assigned scores on each set of papers is your true grade and should be interpreted on a 100 point scale (i.e. A(90-100), B(80-89), C(70-79), D(60-69), F(below 60)). I will assign "+" and "-" grades at my discretion. The percent worth of exams and class assignments are:

- Homework/Quizzes – 20%
- Project – 25%
- Mid-Term – 25%
- Final Exam – 25%
- Mystery Points – 5%

**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)).

**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 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](mailto:honor@colorado.edu)); 303-492-5550). Students who are 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 Retaliation** 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 [cure-report@colorado.edu](mailto:cure-report@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 graduate 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, provide the instructor with a 2-week warning if you are unable to make an exam date due to a religious observance. If regular class lectures are missed, it is up to the student to make up the material. If a homework or project due date falls on a religious observance, then the student must turn in the assignment the day before.

See the [campus policy regarding religious observances](#) for full details.

## Estimate of Topics Covered

**Introduction** Review of vector notation, Vector Differentiation

**Spacecraft attitude coordinate choices** direction cosine matrix, Euler angles, Euler parameters, modified and classical Rodrigues parameters

**Spacecraft equations of motion** Use momentum and energy equations for rigid bodies

**Linear and nonlinear attitude control of rigid bodies** Learn how to exploit attitude coordinate descriptions to create regulator and tracking feedback control laws.

**Momentum exchange devices** Develop equations of motion of satellite with multiple VSCMGs.