

ASEN 3200 Fall 2021

Instructor (1st Half): Dr. Hanspeter Schaub

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Office Hours: Monday and Wednesday, 3:00-4:00pm (or by appointment)

Instructor (2nd half): Dr. Marcus Holzinger

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Office Hours: TBD

Lectures: MWF 1:10–2:00pm, AERO 120

Lab: TR 12:50–2:40pm, AERO 141

Lab Coordinator: Bobby Hodgkinson

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Graduate Teaching Assistants:

Name, email

Office hours: day, time, location)

Text: Howard D. Curtis, *Orbital Mechanics for Engineering Students*, 4th Edition, Elsevier Aerospace Engineering Series 2021. Electronic edition available for free through CU Libraries.

Supplementary Text:

- H. Schaub and J. L. Junkins, *Analytical Mechanics of Space Systems*, 4th Edition AIAA Education Series, Reston, VA, 2014.
- Larson and Wetz, *Space Mission Analysis and Design*

Prerequisites: requires prerequisite courses of ASEN 2003 and ASEN 2004 and APPM 2360 and ASEN 2350 or MATH 2400, or equivalent (all with minimum grade of C)

Course Web Page: <http://canvas.colorado.edu>

Overview and Goals: Students will learn the basics of spacecraft orbital and attitude motion.

The first half of the course focuses on dynamics and control of the pointing attitude of spacecraft. Nearly all spacecraft must be accurately pointed to accomplish their mission, yet the natural behavior in orbit is typically uncontrolled tumbling. We will develop a fundamental understanding of these natural 3D rigid body kinematics and dynamics, using this to discuss common methods of passive and active attitude control. Attitude sensor and actuator technology will be investigated, as well as common ways of representing and determining attitude. On the topic of rigid body kinematics, the goal is to make the student comfortable with a small subset of attitude representations such as the DCM and the 3-2-1 Euler angles, and make them at least aware of other set of coordinates such as other Euler angle sequences and the Euler parameters (quaternions). On the topic of rigid body dynamics, the goal is to expose the students to repeated uses of Euler's equation and the angular momentum vector to develop the system equations of motion. On the topic of control, the goal is to show the students how simple open-loop and closed-loop flow diagrams can be created, and how to use the frequency space modeling methods to develop single-input-single-output linear controls. This is applied to 1-D constrained rotational motion only.

Lab experiments will be conducted to measure spacecraft mass properties, understand the operation of gyroscopic instruments, and design feedback control to achieve precise spacecraft pointing. In these labs the goal is for students to receive hands-on opportunities to see the complex dynamic interactions that can occur with spinning rigid bodies, or even gyroscopic systems.

In the second half of the course, students will learn the characteristics of the motion of a system of particles with emphasis on the two-body problem, a model that offers a good preliminary approximation for the dynamics governing the motion of a planetary orbiter or interplanetary transfer vehicle. We will study the motion of a spacecraft under the influence of gravitational perturbing forces and n-body perturbations from additional celestial bodies. Also, the perturbations caused by atmospheric drag, and solar radiation pressure will be considered. In addition to studying the motion, we will look at ways to determine the ephemeris or trajectory of a satellite from observations. Finally, we will study aspects of designing an Earth orbiting and/or interplanetary mission.

The orbits section does not have labs, but instead engages an individual research project. Here the student programs a fund orbital dynamics scenario and investigates the response.

Class Format: The first half of the course will focus on attitude dynamics and is led by Professor Schaub, led by Professor Schaub. The second half is devoted to orbit mechanics. Each section has a similar format:

- Three weekly Monday, Wednesday and Friday
- **Laboratory** sections are held on Tuesday and Thursday in the weeks were hardware labs are performed. Note that the class is split in two to have the lab administered over 2 weeks to reduce the lab group size. Only come to lab on the week and day where you are assigned. Lab experiments will be conducted on the

assigned lab day and written reports will generally be due a week and a half later. Any collaborations with other lab groups including shared diagrams or extensive discussion of results must be acknowledged at the end of your report. Copying text or answers from another group with or without their permission constitutes cheating and will result in a zero grade for the lab. A repeated instance of cheating will result in an F for the course.

- **Reading** assignments are given weekly.
- **Homework** will be assigned in 1-2 week intervals and is due at the beginning of class. Collaboration with others on homework is acceptable, but line-by-line copying of someone else's homework is cheating, and will result in a grade of zero for that assignment. A repeated instance of cheating will result in an F for the course.
- In each of the two sections of the course there is a **midterm and final exam** (a total of 4 exams for the course). These exams are held in-person during the class period (see the class schedule). The final exam for the orbit section will be given on during the scheduled final exam period, but will only cover the orbit part of the class. All exams must be completed individually. Any type of collaboration or copying on an exam constitutes cheating and will result in an F for the course. If you have exam grading issues, you must see the instructor within 2 weeks of having the exam returned to you.

Homework Policy: Please note the following policies regarding completing and turning in your homework:

- For grading purposes, homework is considered part of the group grade and only contributes to the total grade when the individual work is C or better.
- Collaboration is permitted on homework. You may discuss the means and methods for formulating and solving problems and even compare answers, but you are not free to copy someone's assignment. **Copying material from any resource (including solutions manuals) and submitting it as one's own is considered plagiarism and is an Honor Code violation. Remember, the less you think about the problems yourself, the less you actually learn, and the more difficult it will be to succeed on exams.**
- Homework solutions must demonstrate an understanding of the principles involved by including diagrams, using correct notation and terminology, explaining the approach, showing the key steps to obtaining the solution, and outlining the answer with proper units. These problem solving steps are critical for developing problem formulation skills.
- Always submit work with a professional appearance. Neatness, clarity, and completeness count.
- If you must miss class for an excused absence, you may submit your homework early. Late assignments are not accepted without prior instructor approval. If you know in advance that you must miss a homework due date or lab, send your instructor an e-mail to make arrangements.

- Although each homework assignment will have several problems, all problems may not be graded. However, solutions will be provided to you for all the problems.
- If you believe that your homework was graded incorrectly, you have 2 weeks from when it is handed back to ask for a regrade. To ask for a regrade, you must attach a cover page describing what you think the error in grading was, and hand it in with your complete homework package from that problem set to a course CA or instructor.
- All completed homework documents must be uploaded through the Canvas assignment page before the beginning of class.

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 a quiz or exam for a pressing reason, you need to contact the instructor at least 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: In an effort to ensure that each student leaves the class with a fundamental understanding of the topics covered in this course, the final grades will be heavily weighted on each student's individual performance. That is, if a student does not pass the individually graded aspects of the course, he/she will not pass the class overall. Keeping this in mind, the final grades will be determined as shown in Tables 1 and 2.

All Homework	15%
Orbit Quiz	10%
Orbital Final Exam	15%
Attitude Quiz	10%
Attitude Final Exam	15%
Lab Experiments	15%
Orbits Project	15%
Research Projects	5%
Mystery Points	5%

Table 1: Course Grade Percentages if the student achieves an overall score of **C or greater** of the total possible points on all exams.

Orbit Quiz	20%
Orbital Final Exam	30%
Attitude Quiz	20%
Attitude Final Exam	30%

Table 2: Course Grade Percentages if the student achieves an overall score of **less than C** of the total possible points on all exams.

Class Room 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 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 [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, you can follow the recorded class lecture. Reach out to the instructor if you will be missing a hardware lab section.

Accommodation For Disabilities If you qualify for accommodations because of a dis-

ability, 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 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); 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 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 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. Information about OIEC, university policies, [reporting options](#), 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 their rights, support resources, and reporting options.

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, we will attempt to accommodate any conflicts with exam times if you let me know at least 2 weeks in advance See full details at [this web page](#).