

ASEN 3700 – Orbital Mechanics/Attitude Dynamics and Control

Syllabus, Spring 2023

Smead Aerospace Engineering
University of Colorado Boulder

Overview

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| Professor: | M. J. Holzinger marcus.holzinger@colorado.edu |
| Schedule: | Tuesdays, Thursdays, 4:00pm-5:15pm, AERO 120 |
| Credits: | 3.0 semester hours |
| Required Texts: | Orbital Mechanics for Engineering Students, 4 th Ed. Rev. |
| Reference Texts: | None |
| Final Exam: | Monday, 18 December, 4:30pm-6:30pm, AERO 120 (Optional) |
| Online Support | Canvas |
| Prerequisites | ASEN 2003 or ASEN 2703 |
| Office Hours: | Mondays, 3:15pm-4:15pm in AERO 457 Wednesdays, 4-5pm on Zoom (Meeting ID: 940 6284 8322) |
| Teaching Team | Alex Meyer (Lead) (Alex.Meyer@colorado.edu) Office Hours: Mondays, 2-4pm (AERO N453) Wednesdays, 9-11am (AERO 403) Fridays, 12-2pm (AERO 403) Study Hall: Tuesdays, 5:30pm-7:00pm, AERO 120 Julian Lema Bulliard (Julian.LemaBulliard@colorado.edu) HW Review Session: Fridays, 10:00am-12:00pm, AERO N240 Study Hall: Thursdays, 5:30pm-7:00pm, AERO 120 Amanda Marlow (Amanda.Marlow@colorado.edu) Study Hall: Thursdays, 5:30pm-7:00pm, AERO 120 Ashwin Raju (Ashwin.Raju@colorado.edu) HW Review Session: Fridays, 10:00am-12:00pm, AERO N240 Study Hall: Tuesdays, 5:30pm-7:00pm, AERO 120 |

General Information

Course Description

Presents the fundamentals of orbital mechanics, 3D rigid body dynamics and satellite attitude dynamics and controls.

Goals and Learning Objectives

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

The first component 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. This is applied to 1-D constrained rotational motion only.

In the second portion 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.

Course Format

Class Times. Lecture will be delivered during scheduled course times. Class times are the best and most interactive way to be introduced to the course material. Seeing and hearing new information, processing it, and writing it in your own notes is a great start to learning. Asking questions, solving in-class example problems, and participating in scheduled group discussions are also excellent and diverse learning opportunities.

Recorded Lectures. Recorded lectures are automatically posted by OIT and are available to students. I *strongly* recommend students attend in-person as much as possible. Watching a recording in lieu of attending a live lecture is like watching a monochrome recording of a play!

Course Website. There will be a class website on Canvas. All course documents, assignments, schedules, and supplemental documents will be posted to this site throughout

the semester. Please check back to see what has been posted. The Canvas page will also contain discussion threads for homework assignments. All course announcements outside of the scheduled lecture times will be sent as Canvas announcements.

Study Hall. To improve academic support, provide peer mentorship, and build community for undergraduate students the Aerospace department launched the Undergraduate Study Hall program. During Study Hall course TAs and Engineering Fellows will be available to provide support. These are in addition to posted office hours (see Canvas)

Email. We will not respond to questions about homework or example exam problems sent by email. Please post your questions in the designated discussion threads on Canvas. Emails will not be answered over the weekend.

Students should email the teaching team only for logistical, confidential, or emergency purposes. Please include '3700' in the subject line to make sure Prof. Holzinger's inbox rules correctly file your email for response. Email responses to these types of questions will take approximately 1 business day. Exam regrade requests should follow the procedure identified in that section.

Grading & Assessment

Course grades will be determined using points and the weighting below:

| <i>Assessment</i> | <i>Weighting</i> |
|-------------------|---------------------|
| <i>Homework</i> | 25% |
| <i>Exam 1</i> | 25% |
| <i>Exam 2</i> | 25% |
| <i>Exam 3</i> | 25% |
| <i>Final Exam</i> | Special (see below) |

Information on each assessment is given below.

Homework

No late homework assignments will be accepted. Homework assignments will be due most weeks. All homework assignments will be posted during the first week of the semester. You will be allowed to drop the lowest homework score at the end of the semester.

All homework questions must be submitted to the Canvas discussion forum under the appropriate homework assignment/question or discussed in office hours. No homework questions should be emailed to the instructional team - all questions should be asked at office hours or posted to Canvas. The instructional team will not respond to posts that are posted after 5 PM the day before the homework is due. The instructional team will not answer questions about homework or practice exams outside of business hours.

Exams

There will be 3 exams during the semester. Students may use the Final Exam to make up or replace any 2 exams for any reason.

As the Final Exam can be utilized to replace or make up 2 exam grades, there are no make-up Exams or alternative Exam times in this course.

Makeup Exams or alternative Exam times will not be granted for any reason. The Final Exam will be used for replacing up to 2 exams grades per the policy stated above. Times for accommodation exams (pre-approved individuals only) will be announced during the first week of class.

Regrade requests must be submitted within 2 weeks of the grade posting to Canvas. Submit a single pdf document to the 'Regrade Request' folder on canvas with the exam problem with your original work, your hand-written CORRECT solution to the exam problem in question, and a page stating the problem number, grading issue, and what you believe the correct grade should be.

Final Exam

The final exam is optional: students are not required to take the Final Exam and the Final Exam will not be counted towards your grade on its own. The Final Exam will be used to replace up to 2 Exam grades. The Final Exam will consist of 3 questions, each one covering material from a different Exam. You will choose up to 2 questions to answer. If your score on a given Final Exam question is higher than your score for the corresponding Exam, your Exam score will be replaced with your score on that Final Exam question. If your score on a given Final Exam question is lower than your score for that Exam, your Exam score will remain unchanged.

The Final Exam will take place during the university-scheduled final exam time, which is:

Optional Final Exam: Monday, 18 December, 4:30pm-6:30pm, AERO 120 (Optional)

Academic Integrity Information

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.

Key Dates

Below is a list of key dates relevant to this course during the semester:

| Date | |
|------------|---|
| Sep. 13 | Last day to register or change schedule |
| Nov. 20-24 | Fall Break |
| Nov. 3 | Last day to drop with a 'W' |
| Dec. 14 | Last day of class |
| Dec. 18 | Final Exam (4:30-6:30pm) |

Expectations & Guidelines

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, 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.

Accommodations

If you qualify for accommodations because of a disability, a letter outlining your accommodations will be sent to the instructor by Disability Services. 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.

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 teaching team 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, all homework due dates and exam dates are posted at the beginning of the semester.

To accommodate any conflicts, you must coordinate with the instructor within the first two weeks of class (by 5pm, September 8, 2023).