ASEN 5050: Space Flight Dynamics Fall 2024

Course description:

This course focuses on studying the motion of celestial bodies and artificial satellites. Most of the course will focus on using the two-body problem as a model of the dynamical environment. Using this model, we will: study natural motions that follow conic sections, describe a state along its trajectory, and explore common state and time descriptions. We will leverage this foundation to design a variety of transfers for spacecraft using impulsive maneuvers. We will also extend these concepts to study relative motion between two spacecraft orbiting about a common central body and to understand the impact of additional forces.

Instructor Information

Instructor: Prof. Natasha Bosanac (she/her)

Email:

Teaching Assistant Information

Name: Austin Bodin (he/him)

Email:

Course Information

Lectures: in-person lectures on Tuesdays and Thursdays 1:00pm-2:15pm MT in AERO 111 (-001 section); asynchronous viewing of recorded in-person lectures (-002 section).

Course webpage: canvas.colorado.edu Please confirm that your settings in Canvas enable you to receive regular course notifications and announcements, and that you can receive emails I send you through Canvas.

Restrictions on use of course materials:

- Lecture notes and any course materials provided to you may not be distributed publicly or shared with individuals who are not registered in the course this semester without instructor consent.
- Lecture recordings may not be shared, reused, or distributed outside of this class, consistent with FERPA protections.

Note: The information contained within this syllabus is subject to change as needed, e.g., in response to unforeseen circumstances.

Recommended prerequisite knowledge: ASEN 3200/3700 or equivalent foundational dynamics class. You are expected to have the following foundational knowledge before starting this class:

- Foundational dynamics
- Foundational math concepts such as ordinary differential equations, vector operations, linear algebra, trigonometry, etc.

Textbooks

A textbook is not required for this course but is optional. You may use either of the following editions of this optional textbook:

- David A. Vallado, "Fundamentals of Astrodynamics and Applications", 5th Edition, 2022, ISBN: 9781881883210.
- David A. Vallado, "Fundamentals of Astrodynamics and Applications", 4th Edition, 2013, ISBN: 9781881883180.

An errata document will be provided for the 4th edition and optional reading assignments are provided in the course schedule document. These two textbooks are also available to borrow for up to 4 hours at a time via the Course Reserves at the Norlin Library on campus.

Links to additional optional and freely-available resources will be provided on the Canvas page where needed throughout the semester.

Software

Some homework problems will require numerical computation. You are expected to have sufficient coding skills to implement numerical computations. Please use MATLAB (preferred). Although you may use an alternative language (e.g., Python, or C++), the instructional team might not be able to provide you with any useful feedback on your scripts or suggestions for addressing any problems.

Throughout the semester, you will supplement your understanding of foundational astrodynamics concepts with industry-standard software (assuming no general availability or technology-related issues that prohibit our using these software in this class). You may select either NASA Goddard Space Flight Center's General Mission Analysis Tool (GMAT) or Ansys' Systems Tool Kit (STK). Neither of these software may be accessible to users of assistive technology. If you use assistive technology to access the course material, please contact me as soon as possible. These software may have usage restrictions that must be followed.

To participate in virtual or hybrid office hours, we will use Zoom. The Zoom link is available on the course webpage.

To optionally discuss technical concepts and general questions as well as connect with other members of the class, we will use Slack. A Slack invitation link is available on Canvas.

Grading Policy

Take Home Exam 1: 25%

Take Home Exam 2: 25%

Homework: 50%

Important Dates

A course schedule including topics and assessment due dates is available on the course webpage. Exams are scheduled as follows:

Take Home Exam 1: Assigned 10/3 and due 10/8

Take Home Exam 2: Assigned 11/14 and due 11/19

Note: Assessment dates are subject to change, if needed

Assessment Policies

Homework Assignments

Homework assignments throughout the semester will feature a combination of derivations, analysis, calculations, and creating simulations. Homework submissions will be graded on both 1) the accuracy of the answers and 2) the accuracy and completeness of the accompanying working/discussion. Homework submissions – including those that require implementing numerical procedures – require a complete and technically precise discussion that demonstrates an understanding of the problem via the following elements, where applicable: discussion of relevant theory and technical details, correct notation and terminology, diagrams, working and/or derivation to solve the problem, showing intermediate steps and quantities, description of the results, analysis of the results, and correct units. Where appropriate, the text of any computational scripts must be appended to the end of a homework problem (or, where applicable in Gradescope, in a dedicated submission component). A commented script/code alone (with no accompanying working or writeup) is not considered a sufficient homework submission unless specifically listed in the problem statement. For full credit, a hand-written or typed write-up with the components described above must be submitted for each problem using mathematical notation and/or text (unless otherwise specified).

For any writeups, you are welcome to either hand-write or type your responses; please ensure they are clear and legible. Please box/highlight final answers with correct units specified.

You are welcome to collaborate with your peers to discuss solution approaches, compare results, and debug numerical procedures. However, you must write your own scripts, implement your own scenarios in STK or GMAT, calculate values on your own, and write up your own responses. Copying material from any person or resource (including previous solutions or autonomously-generated responses) is plagiarism and is an Honor Code violation.

Solutions will be provided where appropriate in a timely manner after the late submission deadline, except for questions that use STK or GMAT.

If you believe that your homework has been graded incorrectly, you will have one week from the date that the homework is returned to request a regrade. The exception is towards the end of the semester when regrade requests may only be accepted for a brief duration. Homework regrade requests must be submitted via Gradescope and include a clear explanation of the technical issue and rationale.

Homework Submission Policy

Homework must be submitted electronically via Gradescope and will generally be due in the evening on the specified deadline to accommodate students who need a flexible schedule due to their current location, work, carer, or other commitments. You may consider submitting your homework before this deadline and during your preferred working hours to facilitate creating work/life boundaries during the semester. It is your responsibility to familiarize yourself with Gradescope. In Gradescope, you must also manually identify the correct pages that are associated with each homework problem. Once you submit your homework electronically, please double check that the file has uploaded correctly and is not corrupted. We will not grade or accept a homework if we cannot open the file; in that case, the unreadable homework will receive a score of zero. We will not accept additional submission files outside of Gradescope (except outside of extenuating circumstances).

Each student in the course will be granted 2 opportunities during the semester to submit a late homework by 24 hours after the regular homework deadline with no grade penalty and without needing to notify or request advance permission from the instructor.

If you need to request additional extensions on the homework for excusable reasons, please send the instructor an email no later than 24 hours before the deadline so that I have an opportunity to respond during reasonable working hours. Extensions will only be granted where allowable and under extenuating circumstances. In the case of an unforeseen emergency when you are unable to request an extension within this time frame, please notify me as soon as you can and I will do my best to accommodate these requests with a solution that is both flexible for you and feasible for our instructional team.

Except in the circumstances listed in this section, late homework will not be graded and will not receive any credit. No opportunities for extra credit will be provided.

Exams

There will be two exams during the semester. These exams will be take-home exams. You must upload your exam submission electronically via Gradescope by the listed deadline; late submissions will not be accepted.

You must complete these exams individually, without any assistance from other people or resources. The expectations for the exam writeup will be the same as the homework submissions, listed previously in this syllabus. Additional, detailed exam guidelines will be provided to you before each exam and must be followed. Violation of any of the exam guidelines is considered an Honor Code violation.

If you believe that your exam has been graded incorrectly, you will have one week from the date that the exam is returned to request a regrade in Gradescope (unless an earlier regrade request deadline is listed in Gradescope).

Restrictions:

You are not permitted to use artificial intelligence (AI) or machine learning tools (e.g., ChatGPT or Dall-E 2) on any assignment or exam for this course. Each student is expected to complete each assignment and exam without assistance from AI. Use of AI will be treated as a form of academic dishonesty akin to plagiarism or cheating.

University Policies

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, marital 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.

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 temporary illness, injury or required medical isolation for which you require adjustment, please contact the instructor as soon as possible via email.

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. Understanding the course's syllabus is a vital part in adhering to the Honor Code.

All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: StudentConduct@colorado.edu. 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 abuse (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. 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 including confidential services 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. In this class, please provide the instructor with a list of these conflicts in the first two weeks of the semester.
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.

Tentative List of Topics

*These topics may change throughout the semester

- Two-body problem
- Orbital elements
- Coordinate systems and transformations
- Time along an orbit
- f and g series
- Orbital transfers (impulsive)
- Lambert's problem
- Interplanetary trajectories
- Perturbations
- Relative motion
- Groundtracks
- Initial orbit determination
- Introduction to the three-body problem