

# ASEN 5050: Space Flight Dynamics

## Spring 2023

### 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

**Email:** natasha.bosanac@colorado.edu

**Office Hours:** Tuesdays and Thursdays 2pm-3pm MT over Zoom.

### Teaching Assistant Information

**Name:** Jake Carter

**Email:** jacob.carter@colorado.edu

**Office Hours:** Wednesdays 3.30pm-5.30pm MT over Zoom.

**Name:** Grant Hevia

**Email:** grant.hevia@colorado.edu

**Office Hours:** Tuesdays 10am-11am MT in-person only in Aero N453; and Mondays 10.30am-11.30am MT over Zoom.

### Course Information

**Lectures:** in-person lectures on Tuesdays and Thursdays 11:30am-12:45pm MT in AERO 111 (-001 section); asynchronous viewing of recorded in-person lectures (-001B section).

**Course webpage:** [canvas.colorado.edu](https://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.

**Notes:** 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. In addition, the information contained within this syllabus is subject to change as needed in response to the pandemic or unforeseen circumstances.

**Recommended prerequisites:** ASEN 3200 or equivalent, or instructor permission required. Degree credit not granted simultaneously for this course and ASEN 5052.

## Textbooks

A textbook will not be required this semester for this course but is optional. This semester, you may use either of the following editions of this book:

- 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 4<sup>th</sup> edition and optional reading assignments will be provided for the book. Links to additional optional and freely-available resources will be provided on the Canvas page where needed throughout the semester.

## Software

Numerical software packages, such as MATLAB (recommended) or Python, may be used.

Throughout the semester, you will supplement your understanding of foundational astrodynamics concepts with industry-standard software, selecting 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.

We will use Zoom for office hours.

## 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 will be made available on the course webpage. Exams are scheduled as follows:

Take Home Exam 1: assigned 2/23 and due 2/28

Take Home Exam 2: assigned 4/20 and due 4/25

**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 the accuracy of the answers and the accompanying working/discussion. Homework submissions – including those that require implementing numerical procedures – require a clear and technically precise discussion that demonstrates an understanding of the problem via the following elements: discussion of relevant theory and technical details, correct notation and terminology, diagrams (where appropriate), description of the solution approach to a problem, listing intermediate steps and quantities, description of the results, analysis of the results, and justification of the results. Where appropriate, the text of any computational scripts must be appended to the end of your homework submission. However, a commented script/code alone is not considered a sufficient homework submission. 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 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, 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 submission deadline.

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 shorter period of time. Homework regrade requests must be submitted via Gradescope and include a clear explanation of the technical issue.

## **Homework Submission Policy**

Homework will 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. Once you submit your homework electronically, please double check that the submission has uploaded correctly, is readable and is not corrupted; we cannot grade a homework if we cannot open the file and resubmissions will not be accepted.

Each student in the course will be granted 2 opportunities during the semester to submit a late homework by 5pm MT the day 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, 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. 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 will 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).

## **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)). In this class, we do not have any required in-person attendance. If you are sick or quarantined, please let me know whenever you need any accommodations and/or extensions and please use the recorded videos to catch up on any missed lectures.

## 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 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 Student Conduct & Conflict Resolution ([honor@colorado.edu](mailto: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. 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. University policy prohibits sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, protected-class discrimination and harassment, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email [cureport@colorado.edu](mailto:cureport@colorado.edu). Information about university policies, [reporting options](#), and 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 any issues related to these policies regardless of when or where they occurred to ensure that individuals impacted receive information about their rights, support resources, and resolution 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 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.

## 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
- Groundtracks
- Perturbations
- Relative motion
- Initial orbit determination
- Introduction to the three-body problem