ASEN 5050: Space Flight Dynamics Fall 2021

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/hers)

Email: natasha.bosanac@colorado.edu

Office Hours: Wednesdays 4pm-5pm MT and during lecture periods where no synchronous components are planned. All office hours will be held via Zoom.

Teaching Assistant Information

Teaching Assistant: Giuliana Miceli (she/her/hers)

Email: giuliana.miceli@colorado.edu

Office Hours: Mondays 12-1pm and Tuesdays 9-10am via Zoom.

Course Information

Instruction mode: Remote/Online.

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 any emails I may send you through Canvas.

Course format: This course will be divided into subject matter modules. Lecture content will be delivered asynchronously via videos accessible through the course webpage. Partially-completed lectures notes will be provided for you to use as you take your own notes while watching the lectures. Selected lecture periods (T,Th: 1.15pm-2.30pm) will be used for synchronous recitation-style discussions via Zoom; these designated lecture periods and the

associated logistics for participation will be noted in Canvas. To ensure flexibility in your participation in this course, I will not monitor or mandate attendance during these synchronous discussions; parts of these sessions will be recorded and videos made available so that you can watch them later if you are unable to attend. However, if you are registered in the -001 section and/or are available at the designated course time, I strongly encourage you to attend and actively participate in the synchronous discussions. Office hours will be held weekly but will not be recorded. You may attend office hours either to ask us questions or to work with other students. You may also use Piazza to ask questions to your peers and the instructional team questions as you work through concepts and homeworks.

Notes: Lecture notes, lecture videos, videos of the synchronous discussions, 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 during the pandemic.

Recommended prerequisites: ASEN 3200 or equivalent, or instructor permission required. As a result, this course will assume foundational mathematical knowledge on concepts such as vector and matrix operations, ordinary differential equations, and geometry, and fundamental dynamics. Degree credit not granted simultaneously for this course and ASEN 5052.

Textbooks

Due to the global pandemic that has interrupted our lives, a textbook will not be required this semester for this course. However, an optional textbook that is typically used in this course is: David A. Vallado, "Fundamentals of Astrodynamics and Applications, 4th Edition", 2013, ISBN: 978 11881883180. An errata document and optional reading assignments will be provided for this edition. 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 GMAT or 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 the synchronous course components and office hours; please ensure you have the most recent version of Zoom installed on your device. Please also feel free to use Zoom in a manner that you feel comfortable with. For instance, while turning on your video facilitates group discussion and collaboration, it is certainly not required; there are many reasons why you may be unable or uncomfortable with this and I will respect your decision.

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 9/30 and due 10/5

Take Home Exam 2: assigned 11/11 and due 11/16

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), complete 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 separate write-up (by hand or typed using word-processing software) with the components described above must accompany the solution to each problem (unless otherwise specified).

For any writeups, you are welcome to either hand-write or type in word-processing software your responses; please ensure they are clear and legible. Box/highlight final answers with units specified. Commented code (full or in snippets) does not constitute a write-up and will not receive full credit.

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) is plagiarism and is an Honor Code violation.

Although each homework assignment will have several problems, all problems may not be graded. However, 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. Homework regrade requests must be submitted to the teaching assistant in writing via email and include a clear explanation of the issue.

Homework Submission Policy

Homework will be submitted electronically 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. Instructions for electronic homework submission will be provided before the first homework deadline. You may consider submitting your homework before the 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 file has uploaded correctly, is readable and is not corrupted; it is your responsibility to ensure it is uploaded correctly and we cannot grade a homework if we cannot open the file.

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 homework deadline with no grade penalty and without needing to request advance permission from the instructor.

If you need to request additional extensions on the homework, please send me an email no later than 24 hours before the deadline so that I have an opportunity to respond during reasonable working hours. However, we are all trying to survive a global pandemic and unforeseen emergencies may very well arise. In these emergencies, I will do my best to accommodate these requests with a solution that is both flexible for you and feasible for me.

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.

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 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 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.

Note: In this class, we do not have any in-person participation; however, if you are sick or quarantined, please let me know whenever you need any accommodations and/or extensions.

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 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 Observances

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 me 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