ASEN 5052-001, 5052-001B Analytical Astrodynamics

TTh, 10:05-11:20, AERO 111

Instructor: Daniel Scheeres, scheeres@colorado.edu
AERO 454
Office Hours TBD

Introduction to astrodynamics with an emphasis on analytical approaches — alternative to ASEN 5050. General solution of the 2-body problem. Orbital trajectories, transfers, targeting, and time of flight. Orbit perturbations and averaging analysis. Restricted 3-body problem.

Pre-requisite: Undergraduate orbital mechanics course (equivalent to ASEN 3200) or permission of the instructor.

Coursepack:

Selected excerpts from “Orbital Motion in Strongly Perturbed Environments" will be distributed, selected papers will be distributed.

Textbooks:

A.E. Roy, Orbital Motion 4th edition, Institute of Physics Publishing, 2005.

Additional Reference Books:

D.J. Scheeres. “Orbital Motion in Strongly Perturbed Environments: Applications to Asteroid, Comet and Planetary Satellite Orbiters,” Springer-Praxis Books in Astronautical Engineering. 2012. ISBN 978-3-642-03255-4, e-ISBN 978-3-642-03256-1, DOI 10.1007/978-3-642-03256-1

J.E. Prussing and B.A. Conway, Orbital Mechanics, 2nd Ed., Oxford University Press, 2012.

J.M.A. Danby, Fundamentals of Celestial Mechanics, 2nd Ed., Willmann-Bell, 1992.

V.I. Arnold, V.V. Kozlov, A.I. Neishtadt, Mathematical Aspects of Classical and Celestial Mechanics, 3rd edition, Springer, 2006.

C. Marchal, The Three-Body Problem, Elsevier, 1990.

F.R. Moulton, An Introduction to Celestial Mechanics, 2nd edition, Dover, 1970.

V. Szebehely, Theory of Orbits: The restricted problem of three bodies, Academic Press, 1967.

Computing:

Use of Matlab (or other computer languages) in homework.

Communications:

Homework and computer problems should be written as informal reports. They should be submitted as a single, combined PDF file.

Grading:

HW problems:	25%
Computational problems:	25%
Mid-term exam:	25%
Final exam:	25%

Topics:

Principles of orbital mechanics.
Orbital trajectories, transfers, time of flight.
Trajectory propagation and targeting.
Orbit perturbation formulation and analysis.
Restricted 3-body problem with applications.

Syllabus (Scheeres):

Orbital mechanics
- Formulation of two-body, three-body and n-body problems
- The two-body problem solution
- Elliptical and circular orbits
- Parabolic and hyperbolic trajectories
- 3-D trajectories and orbit elements
- Time of flight and orbit propagation

Orbital transfers
- Impulsive maneuvers
- Lambert's theorem
- 3-D Targeting
- Fuel optimal considerations

Orbit perturbation formulations
- Variation of constants
- Lagrange's Equations
- Gauss' Equations
- Mean elements and averaging

Orbit perturbation analysis
- Effect of non-spherical gravity fields
- Low-thrust trajectories
- Atmospheric drag
- Tidal and third body effects

Restricted 3-body problem with applications
- Derivation of equations of motion
- Jacobi Integral, Zero-Velocity Curves, and Lagrange Points
- Hill approximation
- Numerical computation and analysis of orbits

In-Class vs Remote course access:

The following items detail my plans for delivering lectures and office hours, accommodating any restrictions that may arise from the current pandemic crisis. If the campus transitions to a more restrictive stage, the course has been designed to be able to be run completely remotely. In this case, I will still deliver the lectures at the scheduled time, in general, and keep the Zoom channel open during the lectures. The lectures will also be recorded and available on the Canvas website.

The following guidelines apply to the 001 section. The 001B section is, by design, completely remote. Basically, the 001 students can access the 001B remote section functionality. The 001B students will also be able to dial into the Zoom broadcast if interested.

- Lectures will be delivered, except as noted, in AERO 111.
- All lectures will be recorded and available on the CANVAS website shortly after the lecture.
- I will stream a live Zoom session from my laptop during the lecture, allowing for questions from remote students over the Chat feature.
- When in the classroom, all CU guidelines will be strictly enforced.

Required Syllabus Statements

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. In this class, if you are sick or quarantined, alert the instructor by email with the length of your expected absence and any extensions or other accommodations you may need during this time period.

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 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, alert me as soon as possible, and at least two weeks before a given date, if there are any conflicts.

See the campus policy regarding religious observances for full details.