

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 the restrictions that have arisen 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 a 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.
- Live participation in the course is not required, as all lectures will be available on Canvas. Thus attendance during course lectures is ****not**** required to successfully participate in the course.
- There is a limit of 21 students allowed in the AERO 111 classroom. We will likely have more than 21 people enrolled in the 001 Section of the course, thus there will need to be some class members that will access the course remotely.
- I will run an anonymous poll of the 001 students to see if anyone wishes to only do the class remotely. Following this, if there are more than 21 students who plan to be “live” in the classroom, I will institute a revolving schedule of live vs remote attendance.
 - Based on the poll information, we do not need to institute a revolving attendance schedule, although this may be revised at a later date.
- When in the classroom, all CU guidelines will be strictly enforced.

Required Syllabus Statements:

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 Code of Conduct](#).

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 public health orders in place to reduce the risk of spreading infectious disease. Required safety measures at CU Boulder relevant to the classroom setting include:

- maintain 6-foot distancing when possible,
- wear a face covering in public indoor spaces and outdoors while on campus consistent with state and county health orders,
- clean local work area,
- practice hand hygiene,
- follow public health orders, and
- if sick and you live off campus, do not come onto campus (unless instructed by a CU Healthcare professional), or if you live on-campus, please alert [CU Boulder Medical Services](#).

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 policies on [COVID-19 Health and Safety](#) and [classroom behavior](#) and the [Student Code of Conduct](#). If you require accommodation because a disability prevents you from fulfilling these safety measures, please see the “Accommodation for Disabilities” statement on this syllabus.

Before returning to campus, all students must complete the [COVID-19 Student Health and Expectations Course](#). Before coming on to campus each day, all students are required to complete a [Daily Health Form](#).

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 and complete the [Health Questionnaire and Illness Reporting Form](#) remotely. In this class, if you are sick or quarantined, you must alert me to your general status and follow all CU guidelines.

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. Violations of the policy may include: 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 at the [Honor Code Office 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 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 cureport@colorado.edu. Information about the OIEC, university policies, [anonymous reporting](#), and the campus resources can be found on the [OIEC website](#).

Please know that faculty and 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 options for reporting and support resources.

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 make me aware of any pending conflicts at least two weeks in advance.

See the [campus policy regarding religious observances](#) for full details.