

## ASEN 5052-001,002 Analytical Astrodynamics

MW, 1:00-2:15, AERO 114

Zoom Meeting ID: 970 6932 0258

You must be signed on using your [colorado.edu](https://colorado.edu) account to access the Zoom meeting.

**Instructor:** Daniel Scheeres, [scheeres@colorado.edu](mailto:scheeres@colorado.edu)  
AERO 454  
Office Hours TBD

**TF:** Oliver Boodram, [oliver.boodram@colorado.edu](mailto:oliver.boodram@colorado.edu)  
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/Python (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.

**In-Class vs Remote course access:**

The following items detail my plans for delivering lectures and office hours. I will deliver the lectures at the scheduled time in the room 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 002 section is, by design, completely remote. The 001 students can access the 002 remote section from the Canvas website. The 002 students will also be able to dial into the Zoom broadcast if interested.

- Lectures will be delivered, except as noted, in AERO 114.
- 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.

## **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

# SYLLABUS STATEMENTS

## 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, 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 INFECTIOUS DISEASES

Members of the CU Boulder community and visitors to campus must follow university, department, and building health and safety requirements and all public health orders to reduce the risk of spreading infectious diseases.

The CU Boulder campus is currently mask optional. However, if masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class. Students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct & Conflict Resolution. Students who require accommodation because a disability prevents them from fulfilling safety measures related to infectious disease will be asked to follow the steps in the “Accommodation for Disabilities” statement on this syllabus.

For those who feel ill and think you might have COVID-19 or if you have tested positive for COVID-19, please stay home and follow the [further guidance of the Public Health Office](#). For those who have been in close contact with someone who has COVID-19 but do not have any symptoms and have not tested positive for COVID-19, you do not need to stay home.

## Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation

[Disability Services](#) determines accommodations based on documented disabilities in the academic environment. If you qualify for accommodations because of a disability, submit your accommodation letter from Disability Services to your faculty member in a timely manner so your needs can be addressed. 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 or required medical isolation for which you require accommodation, alert me as soon as possible and prior to any scheduled event. Also 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 (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.

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. 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 violence (dating or domestic violence), stalking, 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 incidents related to these policies regardless of when or where something occurred. This is to ensure that individuals impacted receive an outreach from OIEC about their options for addressing a concern and the support resources available. To learn more about reporting and support resources for a variety of issues, 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, 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.

## 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.