

## ASEN 5519-002 Analytical Astrodynamics

TTh, 2-3:15, ECCR 105

**Instructor:** Daniel Scheeres, [scheeres@colorado.edu](mailto:scheeres@colorado.edu)

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.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.

### **Grading:**

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

**Remote Access:**

- Meeting ID: 505-111-196
- Connection options:
  - Join via web browser: <https://cuboulder.zoom.us/j/505111196>
  - Join via Zoom app (using meeting ID)
  - Join via iPhone one-tap: US: +16699006833,,505111196# or +16465588656,,505111196#
  - Join via telephone: US: +1-669-900-6833 or +1-646-558-8656  
(Note: for higher quality, dial a number based on your current location)

This course requires the use of the Zoom conferencing tool, which is currently not accessible to users using assistive technology. If you use assistive technology to access the course material, please contact your faculty member immediately to discuss.

If you need help with getting Zoom up and running, please visit the following link:

<http://www.colorado.edu/oit/services/conferencing-services/web-conferencing-zoom>

**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

Additional information regarding general CU classroom policies:

### **Accommodation for Disabilities**

If you qualify for accommodations because of a disability, please submit to your professor a letter from Disability Services in a timely manner (for exam accommodations provide your letter at least one week prior to the exam) so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at [dsinfo@colorado.edu](mailto:dsinfo@colorado.edu). If you have a temporary medical condition or injury, see Temporary Injuries guidelines under the Quick Links at the Disability Services website and discuss your needs with your professor.

### **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 me with a list of potential conflicts within the first two weeks of the semester.

See the campus policy regarding religious observances for full details.

### **Classroom Behavior**

Students and faculty each have responsibility for maintaining an appropriate learning environment. 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 differences of race, color, culture, religion, creed, politics, veteran's status, sexual orientation, gender, gender identity and gender expression, age, disability, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. For more information, see the policies on classroom behavior and the student code.

### **Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation**

The University of Colorado Boulder (CU Boulder) is committed to maintaining a positive learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct, discrimination, harassment or related retaliation against or by any employee or student. CU's Sexual Misconduct Policy prohibits sexual assault, sexual exploitation, sexual harassment, intimate partner abuse (dating or domestic violence), stalking or related retaliation. CU Boulder's Discrimination and Harassment Policy prohibits discrimination, harassment or related retaliation based on race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity,

gender expression, veteran status, political affiliation or political philosophy. Individuals who believe they have been subject to misconduct under either policy should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127. Information about the OIEC, the above referenced policies, and the campus resources available to assist individuals regarding sexual misconduct, discrimination, harassment or related retaliation can be found at the OIEC website.

## **Honor Code**

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the academic integrity policy of the institution. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access, clicker fraud, resubmission, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code Council ([honor@colorado.edu](mailto:honor@colorado.edu); 303-735-2273). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code Council as well as academic sanctions from the faculty member. Additional information regarding the academic integrity policy can be found at [honorcode.colorado.edu](http://honorcode.colorado.edu).