ASEN 5052-001, 5052-001B Analytical Astrodynamics

Tuesday-Thursday, 1:00-2:15, AERO 114

Instructors: Damennick Henry, Damennick.Henry@colorado.edu,
- Office Hours: Monday 9:00 am, AERO N453, and over zoom (see below)

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TA: Oscar Fuentes Muñoz, Oscar.FuentesMunoz@Colorado.edu
- Office Hours: Friday 11:00 am, AERO 302, and over zoom (see below)

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.

Slack: We will be using slack to facilitate course discussions. Please use the following link to join:

Zoom: A live feed of the class will streamed over zoom at the following link. We will also be using this zoom link to host office hours.

Link:
Passcode:

Coursepack:

Selected excerpts from "Orbital Motion in Strongly Perturbed Environments" and other material will be distributed via Canvas.

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
- Vallado, *Fundamentals of Astrodynamics and Applications*. 4th Ed. Microcosm Press, 2013.
- Bate, Roger R., D.D. Mueller, and J.E. White, *Fundamentals of Astrodynamics*, New Dover Publications, New York, 1971.

- 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.

Grading:

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

Assignment submission

- Collaboration is permitted on assignments. However, each student must submit a **unique** assignment write-up.
- Certain assignments in the class will require coding. You may use the coding language or software package of your choice. It is not necessary to include code as part of your submission. **Code may not be submitted solely as your solution.**
- Partial credit will be given based on intermediate steps and explanations provided in the assignment.
- Assignment due dates will be denoted on the Canvas/Gradescope webpages. Students are responsible to ensure that submitted documents are uploaded correctly, readable, and in the correct location. Corrupt files will not be graded.

Late Policy

- 1-2 days late: 10% deduction.
- 3+ days late: 10% deduction per day.
- Exceptions are granted for good reasons, of course. Please notify IN ADVANCE if you will be turning something in late (Conference, illness, etc)

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.

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 the 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, we 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 114.
- All lectures will be recorded and available on the CANVAS website shortly after the lecture.
- We will stream a live Zoom session from my laptop during the lecture, allowing for questions from remote students over the Chat feature (see zoom link above).
- 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 classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

Requirements for COVID-19

As a matter of public health and safety, 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. CU Boulder currently requires COVID-19 vaccination and boosters for all faculty, staff and students. Students, faculty and staff must upload proof of vaccination and boosters or file for an exemption based on medical, ethical or moral grounds through the MyCUHealth portal.

The CU Boulder campus is currently mask-optional. However, if public health conditions change and masks are again required in classrooms, students who fail to adhere to masking 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.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the Public Health Office (contacttracing@colorado.edu).

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 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 Student Conduct & Conflict Resolution (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. 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

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, protected-class discrimination and harassment, 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 policies, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email 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 any issues related to these policies regardless of when or where they occurred to ensure that individuals impacted receive information about their rights, support resources, and resolution options. To learn more about reporting and support options for a variety of concerns, 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.

See the campus policy regarding religious observances for full details.

Updated Aug. 15 2022