ASEN 3405 ASTRODYNAMICS

Syllabus, Fall 2026

Lectures: Tuesday and Thursday 8:30am-9:45am, AERO 114

Instructor:

Dr. Vishala Arya: vishala.arya@colorado.edu

Teaching Facilitators:

Office hours:

Dr Arya: Tuesday 10am-11am at AERO 465,
: Wednesday 5pm-6pm,

TF: Study hall, 5:30pm-7pm, Thursday
: Monday, 1pm-2:30pm, Room TBA

Final Exam: Thursday, December 10 from 7:30-10:00 PM, AERO 114

Textbooks Required:

Craig Kluever, *Space Flight Dynamics*, 2nd Edition, Wiley, 2018.

Supplementary (not required)

- Bedford and W. Fowler, Engineering Mechanics: Dynamics, 5th Edition Pearson Prentice Hall, Upper Saddle River, NJ, 2008. See Chapter 20 and Appendix C.
- H. Schaub and J. L. Junkins, *Analytical Mechanics of Space Systems*, 4th Ed, AIAA Ed Series, Reston, VA, 2014.
- Howard D. Curtis, *Orbital Mechanics for Engineering Students*, 4th Edition, Elsevier Aerospace Engineering Series 2021. Electronic edition available for free through CU Libraries.
- Vallado, D. A., *Fundamentals of Astrodynamics and Applications*, 4th Ed Microcosm, Hawthorne, CA 2013.

Requisites: Requires prerequisite course of ASEN 2501 (minimum grade C-). Requires co-requisite course of ASEN 3404.

Course Web Page: http://canvas.colorado.edu

Overview and Goals:

In this course, students will study and describe the characteristics of the motion of a particle in space and relative to a single celestial body; this particle could approximate a spacecraft or a celestial object. By the end of the semester, students should be able to:

1. Formulate and derive the equations of motion for the two-body problem, approximating the dynamics governing a spacecraft or celestial object in the vicinity of a single celestial body that is modeled with the same gravity field as a point mass.
2. Derive and use the analytical solution to the two-body problem to calculate the state of the object at any location along an orbit that follows a conic section.
3. Derive, numerically solve, and use Kepler's equation to relate the location of the object along its orbit to time.
4. Describe different reference frames used in astrodynamics and how one can transform position and velocity vectors between the different frames.
5. Describe and calculate Keplerian orbital elements that capture the size, shape, and orientation of an orbit in three-dimensional space.
6. Describe and assess the influence of the orbit size, shape, and orientation on the groundtrack formed by the projection of its path onto the surface of a nearby celestial body.
7. Calculate the influence of an impulsive maneuver on the state of a spacecraft and design foundational transfers that connect two distinct orbits.
8. Derive and describe an analytical approximation of the relative motion between two nearby spacecraft with near-circular orbits about a common celestial body.
9. Describe additional perturbing forces that may influence the path of the spacecraft. Use analytical approximations of the impact of the oblateness of a celestial body to design orbits with special characteristics.
10. Calculate interplanetary orbits and how they can be approximated using the patched conics method. Discuss the Circular Restricted Three Body Problem (CRTBP).
11. Describe and discuss foundational preliminary orbit determination method to extract the state of an object from successive estimates of its position vector.
12. Outline the mission design process and discuss how the techniques learned in the class can be used to design a satellite mission.

Course Format

Class Times. Lecture will be delivered during scheduled course times. Class times are the best and most interactive way to be introduced to the course material. Seeing and hearing new information, processing it, and writing it in your own notes is a great start to learning. Asking questions, solving in-class example problems, and participating in scheduled group discussions are also excellent and diverse learning opportunities.

Recorded Lectures. Recorded lectures are automatically posted by OIT and are available to students. I strongly recommend students attend in-person as much as possible. Watching a recording in lieu of attending a live lecture is like watching a monochrome recording of a play! If the professor is unable to attend in person, the class may be delivered via recording or on Zoom.

Course Website. There will be a class website on Canvas. All course documents, assignments, schedules, and supplemental documents will be posted to this site throughout the semester. Please check back to see what has been posted. All course announcements outside of the scheduled lecture times will be sent as Canvas announcements.

Study Hall. To improve academic support, provide peer mentorship, and build community for undergraduate students the Aerospace department launched the Undergraduate Study Hall program. During Study Hall course, the TA will be available to provide support. These reinforce and are in addition to posted office hours (see Canvas)

Email. We will not respond to questions about homework or example exam problems sent by email. You can post your questions over the class slack (if available) in the designated channels or make use of the office hours. Emails will not be answered over the weekend.

Students should email the instructional team only for logistical, confidential, or emergency purposes. Please include 3405 in the subject line to make sure Prof. Arya s inbox rules correctly file your email for response. Email responses to these types of questions will take approximately 1 business day. Exam regrade requests should follow the procedure identified in that section.

Grading & Assessment

Course grades will be determined using points and the weighting below:

Description	Percentage
Exam 1	20%
Exam 2	20%
Homework	25%
Final Exam	35%
Iclicker Portion	5% (Bonus)
Total	**105%**

Information on each assessment is given below. Please read carefully.

Homework:

- Homework problems will be regularly assigned throughout the semester, including both problems from the textbook and more complex problems. These problems are designed to help you learn and practice the concepts covered in class.
- Collaboration is permitted on homework. You may discuss the means and methods for formulating and solving problems and even compare answers, but you are not permitted to copy someone's assignment. Copying material from any resource (including solution manuals) and submitting it as one's own is considered plagiarism and is an Honor Code violation. Honor code violations on homework will result in a grade penalty and a violation report being filed with the honor code office.
- Homework solutions must demonstrate an understanding of the principles involved by including diagrams, using correct mathematical notation and terminology, explaining the approach, showing the key mathematical steps to obtaining the solution, reporting

important intermediate values, and outlining the answer with proper units. These problem-solving steps are critical for developing problem formulation skills and communicating your approach. Although you may use mathematical software to aid in computations, code (even when commented) may not be submitted solely as your solution. Full credit for a problem requires both an accurate written presentation of the working and a correct answer.

- Always submit professional and readable work.
- The use of generative AI tools to produce or substantially complete homework solutions is not permitted. Students remain responsible for understanding and explaining all submitted work and the instructor may ask you to explain any part of your submitted work or code.
- Homework must be submitted via Gradescope by the listed deadline.
- Assignment due dates will be indicated on the Canvas page. Students are responsible for ensuring that submitted documents are uploaded correctly, readable, and in the correct location. Corrupt files will not be graded.
- No late homework assignments will be accepted. Homework assignments will be due most weeks. You will be allowed to drop two lowest homework score at the end of the semester.
- The instructional team will not respond to posts that are posted after 5 PM the day before the homework is due. The instructional team will not answer questions about homework or practice exams outside of business hours except for during designated study hall sessions.
- If you believe that your homework was graded incorrectly, you have 1 week from when it is returned to request a regrade in Gradescope (except at the end of the semester). This request should include a brief description of the error and the relevant rubric item/s. These requests will be reviewed by a member of the instructional team.

Exams and Finals:

- There are total of 3 exams in this course.
- Exams will be closed book with students allowed to bring a pre-specified number of note sheets. Additional exam policies will be provided ahead of each exam and must be followed.
- At the end of the semester a comprehensive final exam is scheduled which will have questions from the entire course. The current schedule for the final is on Thursday, December 10 from 7:30-10:00PM.

- The exams are currently scheduled for:
  - Exam 1: in-class on Thursday September 24.
  - Exam 2: in-class on Thursday, October 29.
  - Comprehensive final: 7:30-10:00pm on Thursday, December 10.
  - Note: in the event of an emergency or campus closure, changes to these dates will be communicated promptly to the entire class.
- The instructors will provide information for timing or logistics of exams to students with accommodations.
- Exams are to be completed independently. Any type of collaboration or copying on an exam or final constitutes cheating and will result in an F for the course. An Honor Code violation report will also be filed.
- No make up exams are provided but a flexibility is provided to all students (please look at the special clause for more details).
- ***Students should expect to receive accommodations for a timed assessment (e.g., exam) only if their faculty instructor(s) receive the student's accommodations letter at least 5 business days before the assessment, as a departmental policy, in order to facilitate administering the assessment.***

Special Clause (Exam + Bonus 5%):

- **Exam:**

The final exam is worth 35% of the total course grade. In addition, if your final-exam percentage is higher than the percentage on either midterm exam, the final exam will replace the lower-scoring midterm. In that case, the final exam will account for 55% of the total course grade (35% for the final exam itself and 20% for the replaced midterm). Only one midterm can be so replaced. If the final exam is equal to or lower than both midterm scores, no replacement will occur.

For example, if Adam's midterm scores were E1 = 80%, E2 = 85% and his final exam score was FE = 90%, the final exam FE can replace midterm E1 in the following way:

Exam contribution to final grade = E2*0.2 + FE*0.55

Alternatively, if Eve's midterm scores were E1 = 90%, E2 = 85% while her final exam score was FE = 80%, the total would be calculated thus:

Exam contribution to final grade = E1*0.2 + E2*0.2 + FE*0.35

Thus, while the homework and exams aim to quantify your understanding of the course material, the grading policy intends for you to be evaluated on your best performance and to allow room for the unexpected. There will be no additional make up exams and late submissions on homework will not be accepted.

• **Bonus points:**

While I hope you enjoy the lectures and find them useful, iClicker questions are an added incentive to attend them. iClicker credit is intended to reflect participation during the lecture and is available only to students who are present in class. These in-class multiple choice questions are an opportunity to increase your final grade by up to 5 percentage points. For each iClicker question, 50% of the points are awarded for attempting the question, regardless of whether your answer is correct. The remaining 50% are awarded for answering correctly. A question not attempted receives a score of zero. Additionally, the lowest 20% of your iClicker scores will be discarded in the final grade. If you have university approved accommodations that prevent you from participating in the iClicker questions, please reach out to me within the first two weeks of the course so that we can discuss suitable alternatives for you. Any final course grade greater than 100% will be capped to 100%.

Grading: Grades on individual assignments and for the overall course are set based on the following criteria.

A, A- Demonstrates superior understanding of the material, excellent technical work

B+, B Demonstrates comprehensive understanding of the material, very strong technical work

B-, C+ Demonstrates good understanding of the material, complete technical work

C Demonstrates sufficient understanding of the material to proceed to the next level; adequate technical work

C- Does not demonstrate sufficient understanding of the material to proceed to the next level

D Poor technical work

F Unsatisfactory performance

- If you believe that an error has been made in grading any of your submissions, you may submit a regrade request in Gradescope by the listed deadlines. Your regrade request must list a precise and clear reason that a specific rubric item should be applied to the grading of a particular problem.
- Please note: the Canvas gradebook is a guide to ensure that your assignments have been graded and that the grade entered is consistent with the score that has been reported to you. The Canvas gradebook does not contain all information related to the final course grade calculation; the final course grade calculation will follow the procedure outlined in this syllabus.

University Policies

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 Disease

Members of the CU Boulder community and visitors to campus must follow university, department, and building health and safety requirements and all applicable campus policies and public health guidelines to reduce the risk of spreading infectious diseases. If public health conditions require, the university may also invoke related requirements for student conduct and disability accommodation that will apply to this class.

If you feel ill and think you might have COVID-19 or if you have tested positive for COVID-19, please stay home and follow the guidance of the Centers for Disease Control and Prevention (CDC) for isolation and testing. If you 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 but should follow the guidance of the CDC for masking and testing.

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation

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.
If you have a required medical isolation for which you require adjustment, please notify both instructors as soon as possible.

Students should expect to receive accommodations for a timed assessment (e.g., exam) only if their faculty instructor(s) receive the student's accommodations letter at least 5 business days before the assessment, as a departmental policy, in order to facilitate administering the assessment.

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, 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 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 must 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 outreach from OIEC about resolution options and support resources. To learn more about reporting and support for a variety of concerns, visit the Don't Ignore It page.

Religious Observances

Campus policy requires faculty to provide reasonable accommodations for students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please communicate the need for a religious accommodation in a timely manner. In this class, please provide both instructors with a list of these conflicts in the first week of classes.

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.