

# ASEN 3200 Spring 2011

**Instructor (1st half):** Dr. Steve Nerem

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Office Hours: TR 9–10am

**Instructor (2nd Half):** Dr. Hanspeter Schaub

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Office Hours: M 1:30-3:00pm

**Lectures:** TR 2–3:15pm, ECCR 200

**Lab:** F 10–11:50 and 1–2:50, ITLL 2B10

**Lab Coordinator:** Trudy Schwartz

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**Graduate Teaching Assistants:**

*Shervin Shajiee*, shervin.shajiee@colorado.edu

Office hours Monday 10:00am – 12:00pm (Aero Grad Lounge)

*Boris Papazov*, boris.papazov@colorado.edu

Office hours Wednesday 1:00 – 3:00pm (Aero Grad Lounge)

**Text:** Howard D. Curtis, *Orbital Mechanics for Engineering Students*, 2nd Edition, Elsevier Aerospace Engineering Series 2010.

**Supplementary Text:**

- H. Schaub and J. L. Junkins, *Analytical Mechanics of Space Systems*, 2nd Edition AIAA Education Series, Reston, VA, 2009.
- Larson and Wetz, *Space Mission Analysis and Design*

**Prerequisites:** ASEN 2003, ASEN 2004, and ASEN 2380, or equivalent

**Course Web Page:** <http://culearn.colorado.edu>

**Overview and Goals:** Students will learn the characteristics of the motion of a system of particles with emphasis on the two-body problem which is a good approximation for the motion of a low- Earth orbiter. We will study the motion of a spacecraft under the influence of gravitational perturbing forces due to the Earth and n-body perturbations such as the sun and moon. Also, the perturbations caused by atmospheric drag, and solar radiation pressure will be considered. In addition to studying the motion, we will look at ways to determine the ephemeris or trajectory of a satellite from observations. Finally we will study aspects of designing an Earth orbiting and/or interplanetary mission.

The lab will involve a combination of Matlab and Satellite Tool Kit (STK), e.g. students will be asked to solve a problem with STK, verify the solution, and/or use data generated by STK in a follow-on application. The objective here is to teach the students how to determine if a result from off the shelf software is reasonable. A primary complaint of employers is that recent graduates often believe whatever comes out of blackbox software even when results are obviously unreasonable. When completed with the orbit portion of the class the student should be somewhat proficient with STK and more skilled in the use of Matlab. They will understand the basics of orbital motion and attendant perturbations as well as mission design and preliminary orbit determination techniques. They will be able to solve problems on these subjects using both their analytical and computer skills.

The second half of the course focuses on dynamics and control of the pointing attitude of spacecraft. Nearly all spacecraft must be accurately pointed to accomplish their mission, yet the natural behavior in orbit is typically uncontrolled tumbling. We will develop a fundamental understanding of these natural 3D rigid body kinematics and dynamics, using this to discuss common methods of passive and active attitude control. Attitude sensor and actuator technology will be investigated, as well as common ways of representing and determining attitude. On the topic of rigid body kinematics, the goal is to make the student comfortable with a small sub-set of attitude representations such as the DCM and the 3-2-1 Euler angles, and make them at least aware of other set of coordinates such as other Euler angle sequences and the Euler parameters (quaternions). On the topic of rigid body dynamics, the goal is to expose the students to repeated uses of Eulers equation and the angular momentum vector to develop the system equations of motion. On the topic of control, the goal is to show the students how simple open-loop and closed-loop flow diagrams can be created, and how to sue the frequency space modeling methods to develop single-input-single-output linear controls. This is applied to 1-D constrained rotational motion only.

Lab experiments will be conducted to measure spacecraft mass properties, understand the operation of gyroscopic instruments, and design feedback control to achieve precise spacecraft pointing. In these labs the goal is for students to receive hands-on opportunities to see the complex dynamic interactions that can occur with spinning rigid bodies, or even gyroscopic systems.

**Class Format:** The first half of the course will focus on orbit mechanics, led by Professor Nerem. The second half is devoted to attitude dynamics and is led by Professor Schaub. Each section has a similar format:

- Twice-weekly **lectures** on Tuesday and Thursday
- Two **laboratory** sections each Friday. Lab experiments will be conducted on Fridays and written reports will generally be due a week and a half later. Any collaborations with other lab groups including shared diagrams or extensive discussion of results must be acknowledged at the end of your report. Copying text or answers from another group with or without their permission constitutes cheating and will result in a zero grade for the lab. A repeated instance of cheating will result in an F for the course.
- **Reading** assignments are given weekly.
- Half-way through each section a **Quiz** will be held in class, covering the lecture and reading material covered thus far. Quizzes are to be completed individually. Any type of collaboration or copying on a quiz constitutes cheating and will result in an F for the course. If you have quiz grading issues, you must see me within 2 weeks of having the quiz is returned to you.
- **Homework** will be assigned every other Tuesday and is due in two weeks at the beginning of class. Collaboration with others on homework is acceptable, but line-by-line copying of someone else's homework is cheating, and will result in a grade of zero for that assignment. A repeated instance of cheating will result in an F for the course.
- **Final Exams** are held at the end of each of the two sections of the course. Check with the orbits section instructor on the orbit final exam. The attitude exam is during the regular class final exam period. Any type of collaboration or copying on an exam constitutes cheating and will result in a zero grade for the exam. A repeated instance of cheating will result in an F for the course.

**Class Attendance:** You are expected to attend class. If you need to miss a lecture, it is your responsibility to catch up on the material. Don't go to the instructor to catch up on missed material, speak with class mates and get the notes from them. Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. If you cannot attend a regularly scheduled class, it is up to the student to catch up on the missed material. If you cannot take an exam on a particular day, please let the instructor know at the time the exam is being scheduled.

**Make-Up Policy:** There are no make-up homework assignments. If you miss the assignment, you get a zero for it. If you can't make a quiz or exam for a pressing reason, you need to contact the instructor *one week prior* to the exam date. If you can't take the exam for some emergency reason, you still need to notify the instructor prior to the exam. Without prior consent, there will be no make-up exams.

**Grading Policy:** In an effort to ensure that each student leaves the class with a fundamental understanding of the topics covered in this course, the final grades will be heavily weighted on each students individual performance. That is, if a student does not pass the individually graded aspects of the course, he/she will not pass the class overall.

Keeping this in mind, the final grades will be determined as showing in Tables 1 and 2.

All Homework	10%
Orbit Quiz	10%
Orbital Final Exam	15%
Attitude Quiz	10%
Attitude Final Exam	15%
Lab Experiments	30%
Research Projects	5%
Mystery Points	5%

Table 1: Course Grade Percentages if the student achieves an overall score of **70% or greater** of the total possible points on all exams, quizzes, and homework.

All Homework	15%
Orbit Quiz	25%
Orbital Final Exam	15%
Attitude Quiz	25%
Attitude Final Exam	15%
Mystery Points	5%

Table 2: Course Grade Percentages if the student achieves an overall score of **less than 70%** of the total possible points on all exams, quizzes, and homework.

**Honor Code:** All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council ([honor@colorado.edu](mailto:honor@colorado.edu); 303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at <http://www.colorado.edu/policies/honor.html> and at <http://www.colorado.edu/academics/honorcode/>

**Students with Disabilities** If you qualify for accommodations because of a disability, please submit to me a letter from Disability Services in a timely manner so that your needs may be addressed. Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322, and <http://www.Colorado.EDU/disabilityservices>

Disability Services' letters for students with disabilities indicate legally mandated reasonable accommodations. The syllabus statements and answers to Frequently Asked

Questions can be found at  
<http://www.colorado.edu/disabilityservices>

**Class Room 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, culture, religion, politics, sexual orientation, gender, gender variance, 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. See policies at  
<http://www.colorado.edu/policies/classbehavior.html>  
and at  
[http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student\\_code](http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code)

**Religious Observances** Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class I will attempt to accommodate any conflicts with exam times if you let me know at least 2 weeks in advance See full details at  
[http://www.colorado.edu/policies/fac\\_relig.html](http://www.colorado.edu/policies/fac_relig.html)

**Discrimination and Harassment** The University of Colorado at Boulder policy on Discrimination and Harassment, the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships apply to all students, staff and faculty. Any student, staff or faculty member who believes s/he has been the subject of discrimination or harassment based upon race, color, national origin, sex, age, disability, religion, sexual orientation, or veteran status should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Judicial Affairs at 303-492-5550. Information about the ODH, the above referenced policies and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at  
<http://www.colorado.edu/odh>