ASEN 3200 Spring 2018

Instructor (1st half): Dr. Daniel J. Scheeres
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O ce Hours: Tuesday & Thursday before class (2-3PM), immediately after class, and Friday between labs (12-1)

Instructor (2nd Half): Dr. Natasha Bosanac
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O ce Hours: TBD

Lectures: TR 3:30{4.45pm, FLMG 155

Lab: F 10{11:50am and 1{2:50pm, ITLL 2B10

Lab Coordinator: Trudy Schwartz
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Course Assistants:
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O ce hours: TBD

A. Bedford and W. Fowler, *Engineering Mechanics: Dynamics*, 5th Edition Pearson Prentice Hall, Upper Saddle River, NJ, 2008.
See Chapter 20 and Appendix C for an alternate and compressed version of the material in the first half of the course.

H. Schaub and J. L. Junkins, *Analytical Mechanics of Space Systems*, 3rd Edition AIAA Education Series, Reston, VA, 2014.
Provides an advanced introduction to the material given in this course.

Larson and Wetz, *Space Mission Analysis and Design*.
Provides useful hardware information.

Note: These three textbooks are not required for use in this course.

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

Course Web Page: `http://learn.colorado.edu`

Overview and Goals: The first 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 Euler's 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.

In the second half of the course, 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 o 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 pro cient 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.

Class Format: The rst half of the course will focus on attitude dynamics, led by Professor Scheeres. The second half is devoted to orbital mechanics and is led by Professor Bosanac. 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, 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 the appropriate instructor within 2 weeks of having the quiz returned to you.

Homework will be assigned each week intervals and is due at the beginning of class on Tuesdays in general, unless otherwise speci ed. 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 attitude section instructor on the attitude nal exam. The orbital exam is during the regular class nal 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.

Homework Policy:

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 e ort to ensure that each student leaves the class with a fundamental understanding of the topics covered in this course, the nal grades will be heavily weighted on each student's individual performance. That is, if a student does not pass

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 email at 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 alert the instructors about any possible conflicts you potentially foresee during the first week of class. Early knowledge of possible conflicts will enable us to plan appropriately with you.

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; 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 http://honorcode.colorado.edu.