

ASEN 6010

Advanced Spacecraft Dynamics and Control

Fall 2015

Instructor: Dr. Hanspeter Schaub, Office: ECNT 321, Phone: (303) 492-2767,
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Lectures: TR 8-9:15am, ECCS 1B14

Office Hours: M 1:30-3:00pm, W 9:00-10:00am (or by appointment)

Final Exam: TBD

Text: H. Schaub and J. L. Junkins, *Analytical Mechanics of Space Systems*, AIAA Education Series, 3rd Edition, 2014. (please download the errata sheet from the web page <http://hanspeterschaub.info/books.html>
Course notes supplied on the class D2L web site.

Alternate text book: Junkins, J. L, and Kim, Y., “Introduction to Dynamics and Control of Flexible Structures,” AIAA Education Series, 1993.

Course Web Page: <http://learn.colorado.edu>

Overview: Studies the dynamic modeling and control of spacecraft containing multiple momentum exchange devices, and/or flexible spacecraft components. Will develop nonlinear feedback control algorithms, explore singularity avoidance strategies. The 2nd half of the course derives analytical methods (D’Alembert’s equations, Lagrange’s equations, Boltzman Hamel equations) to model a hybrid rigid/flexible spacecraft system. Pre: ASEN 5010 or equivalent, or permission of instructor (3H, 3C)

Goal: To introduce students to the advanced modeling and control spacecraft attitude motion.

Homework Policy: Each homework assignment is due on the specified due date and must be turned in at the beginning of the lecture. Normally, late homework will not be accepted. Some homework will require simple programs to be created. These can be done in Matlab, Maple, Mathematica, C, or Fortran. See instructor if not sure about the software package being used. If a homework has been graded incorrectly, you need to see me within 2 weeks of having the homework returned to you.

Exams: There will be a mid-term exam and no final exam. If you have exam grading issues, you must see me within 2 weeks of having the exam returned to you. There will also be two course projects which will require you to write a technical report. These reports must be type written and composed as a professional technical report.

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 an exam or 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: A conventional ten-point system will be used for grading. If I feel it necessary, I will curve the exam scores to reflect the difficulty level of the problems assigned. Thus, your final assigned scores on each set of papers is your true grade and should be interpreted on a 100 point scale (i.e. A(90-100), B(80-89), C(70-79), D(60-69), F(below 60)). I will assign "+" and "-" grades at my discretion. The percent worth of exams and class assignments are:

- Homework/Quizzes – 20%
- Project 1 – 25%
- Mid-Term – 30%
- Project 2 – 25%

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; 303-735-2273). 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>

As of the fall of 2010, all ASEN students are required to signed an acknowledge form of the honor code which is available at <http://www.colorado.edu/aerospace/HonorCode.html>

Students with 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.

If you have a temporary medical condition or injury, see Temporary Medical Conditions: Injuries, Surgeries, and Illnesses guidelines under Quick Links at Disability Services website and discuss your needs with your professor.

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, 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. See policies at <http://www.colorado.edu/policies/classbehavior.html> and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

Religious Observances 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, provide the instructor with a 2-week warning if you are unable to make an exam date due to a religious observance. If regular class lectures are missed, it is up to the student to make up the material. If a homework or project due date falls on a religious observance, then the student must turn in the assignment the day before. See full details at http://www.colorado.edu/policies/fac_relig.html

Discrimination and Harassment The University of Colorado Boulder (CU-Boulder) is committed to maintaining a positive learning, working, and living environment. The University of Colorado does not discriminate on the basis of race, color, national origin, sex, age, disability, creed, religion, sexual orientation, or veteran status in admission and access to, and treatment and employment in, its educational programs and activities. (Regent Law, Article 10, amended 11/8/2001). CU-Boulder will not tolerate acts of discrimination or harassment based upon Protected Classes or related retaliation against or by any employee or student. For purposes of this CU-Boulder policy, "Protected Classes" refers to race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, or veteran status. Individuals who believe they have been discriminated against should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Student Conduct (OSC) 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>

Estimate of Topics Covered

Introduction Review of vector notation, Vector Differentiation, Euler angles

Variable Speed Control Moment Gyroscopes Modeling and nonlinear control spacecraft orientations with a set of N VSCMG devices

Spacecraft equations of motion Use momentum and energy equations for rigid bodies

Analytical Mechanics Derive dynamical equations of motion using D'Alembert's principle, Lagrangian equations, as well as the Boltzmann-Hamel equations

Flexible spacecraft equations of motion Use Hamilton's principle to develop the equations of motion and boundary conditions of a hybrid rigid body/flexible component system.