ASEN 6010
Advanced Spacecraft Dynamics and Control
Fall 2021

Instructor: Dr. Hanspeter Schaub, Office: AERO 415, Phone: (303) 492-2767,
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Lectures: TR 8:30-9:45am, AERO N240

Office Hours: MW 11-noon (or by appointment)

Final Exam: TBD

Text: H. Schaub and J. L. Junkins, *Analytical Mechanics of Space Systems*, AIAA Education Series, 4th Edition, 2018. (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.

Canvas Course Web Page: https://canvas.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, Boltzmann 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 a course projects which will require you to write a technical report. This report 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 – 30%
Project – 35%
Mid-Term – 35%

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 or injury, see Temporary Medical Conditions under the Students tab on the Disability Services website.

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 race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. 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 of Conduct.

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 policy may include: 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 the Honor Code (honor@colorado.edu); 303-492-5550). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the Honor Code Office website.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation : The University of Colorado Boulder (CU Boulder) is committed to fostering a positive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (including sexual assault, exploitation, harassment, dating or domestic violence, and stalking), discrimination, and harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or cureport@colorado.edu. Information about the OIEC, university policies, anonymous reporting, and the campus resources can be found on the OIEC website.

Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

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, 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 the campus policy regarding religious observances for full details.

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.