

## **ASEN 6020-002/003 Optimal Trajectories**

MW 3:00-4:15PM, ASEN N240

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AERO

Final date: N/A

### **Optimal Trajectories**

An introduction to the theory and practice of trajectory optimization. The general theory behind optimization and optimal control will be introduced with an emphasis on the properties of optimal trajectories. The main application will be to space trajectories, but other applications will also be considered.

Pre-requisites are familiarity with basic orbit mechanics and linear systems theory.

Recommended Texts:

Analytical Methods of Optimization, D.F. Lawden, Dover 2006.

ISBN 0-486-45034-1

(Available for purchase on [store.doverpublications.com](http://store.doverpublications.com))

Optimal Control with Aerospace Applications, J.M. Longuski, J.J. Guzman and J.E. Prussing, Springer 2014.

ISBN 978-1-4614-8945-0

(Available for download at the CU Library)

### **Course Topics:**

#### **I. Optimal Orbit Transfers**

Basic results for optimal 2 and 3 body transfers involving 2 body orbit mechanics. This will also serve as an introduction to some the basic methods by which parametric trajectory optimization is carried out.

#### **II. Parametric Optimization**

General theory for parametric optimization. General derivation of the necessary and sufficient conditions for constrained optimization problems.

#### **III. Optimal Control**

Introduction to the variational calculus and its application to the continuous optimal control problem. Derivation of the necessary and sufficient conditions for trajectory optimization and optimal control/guidance of a spacecraft trajectory. This will cover the

mathematical background of the optimal control and guidance problem and will be motivated by examples from spaceflight.

#### IV. Solution Methodologies

Solution methodologies for trajectory optimization, optimal control and guidance problems. This will review some of the methods used to solve these problems, motivating the algorithms by direct appeal to the necessary and sufficiency conditions. The class will be introduced to a few "practical" methodologies for computing optimal trajectories via HW problems and projects.

#### V. Applications of Optimality

Applications of optimal control to specific problems. Interrelations between dynamics and optimal trajectories.

#### **Homework and Grading:**

Select HW reports will be assigned throughout the term, with answers recorded in a HW binder and graded occasionally. (30%)

One "mid-term" exam will be held in March/April, covering the basic theory and principles presented in the course and their applications to simple dynamics problems. (30%)

A single term project will be assigned to each student, to be completed by the end of the semester. Each student will be required to choose, define and solve a particular problem of interest, applying a computational method of interest. The written project report must provide a detailed analysis of the problem, discuss the solution methodology of the problem, and present detailed results for this problem.

## **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](mailto: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](mailto: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](mailto: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.