Introduction - Mech 5105

Bruce Burlton
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Carleton University

Fall 2021
Bruce Burlton

- Educated at Carleton University
- Combined Honours B.Sc. in Math & Physics - 1970
- M.Sc in Applied Math - 1971
Bruce Burlton II

- Employed at Telesat from 1972 until 2002 in Space Systems Department
- Worked in Mission Analysis and Flight Dynamics groups
- Expertise includes Orbit/Attitude Dynamics and Control, Mission Planning and Operations, Satellite Design, Flight Dynamics Software
- Responsible for the first 12 of 13 Telesat satellites during LEOP
- Also consulted to various clients around the world and supported (in some fashion) some 50 satellites
- Instrumental in the Rescue/Recovery of the Anik E satellites
Bruce Burlton III

- Joined MA&E in 2003
- Have taught Aero 4802, Mech 5105, Mech 5106, Mech 4501, Aero 4540 and Aero 4842
- Lead Engineer for Aero 4907 B (Satellite Design Project), managing it for the last several years
- Several successful graduate students
Prerequisites

- Familiarity with Kinematics, Dynamics, vectors and matrices, and the solution of differential equations (both analytic and numerical)
- Familiarity with MATLAB/Simulink (or another mathematical programming language).
Course Outline I

- Spacecraft Motion (6 DOF)
  - 3 DOF translation
  - 3 DOF rotation
- Orbital Mechanics
  - Study of translational motion
- Attitude Dynamics
  - Study of rotational motion
Course Outline

Course Outline II

- History
- Some Fundamentals and Basics
  - Time
  - Coordinate Systems
  - Rotations
  - Angular Velocity
- The n-body problem
- The Two body problem
- The Three body problem
- Orbits in three space; various representations
- Universal Variables
- f & g series
- Orbit Perturbations
- Orbital Manouvres
- Lambert’s Problem
- Interplanetary Flight
- Geostationary Satellites
Course Outline III

▶ Lectures
  ▶ Virtual - ZOOM
  ▶ 80 minutes, twice a week (Mondays and Wednesdays, 8:35 am to 11:25 pm, Ottawa time)
  ▶ Present the theory and discussion
  ▶ Material posted to BrightSpace

▶ Tutorials
  ▶ Virtual - ZOOM/MS Teams,
  ▶ 80 minutes Thursday, 11:35 am to 12:55 pm tbc
  ▶ Work on problems independently
  ▶ Problems serve as a means to introduce new concepts and to expand on the ones covered during the lectures
Course Outline IV

▶ Evaluation
  ▶ Midterm Exam 30%
  ▶ Final Exam 30%
  ▶ Individual project 35%
  ▶ STK Certification 5% Bonus
  ▶ Total not to exceed 100%
Course Outline V

▶ Midterm
  ▶ Take home
  ▶ tbd, probably 2-3 days
  ▶ Held on October 2021, near the break *tbc*

▶ Final
  ▶ Take home
  ▶ tbd, probably 2-3 days, November 2021 *tbc*
Individual Project

Objective: expand on a topic covered in class, or to treat a topic not covered in class yet still related to the field of spaceflight mechanics (including attitude dynamics and control).

Typical scope: Investigating and simulating using Matlab/Simulink and/or Systems Tool Kit a technique or a development published in the literature (journal articles or books).

Must get approval by February 18, 2021 tbc.

Simple reproduction of “something from a text book or paper” is not sufficient.
Individual Project

- Oral presentations near end of term *tbc*.
- A written report, to be submitted by end of term (*tbc*), electronically.
- Examples from previous years:
  - Autogeneration of Symmetric Free-Return Circumlunar Trajectories.
  - Solar Sail Dynamics in the CR3BP: Artificial Lagrange Point Orbits.
  - Active Passive Gravity Gradient Attitude Control System for a Satellite in LEO.
MATLAB/Simulink

- Is required to solve some problems.
- Not required for midterm or final.
- MATLAB/Simulink is available in the following rooms:
  - ME 3149
  - ME 3290
  - MC 6065
  - AA 514
- Installation on your personal laptop is HIGHLY recommended (student licenses available through Carleton CCS)
Satellite Tool Kit (STK)

- Analyze and visualize spacecraft motion (orbital and attitude)
- Not required for this course, but often used in industry/academia
- Free certification for Mech 5105 students (worth $500)

STK is available in the following rooms:

- ME 3149
- ME 3290
- MC 6065
- ME 2363
Contact: bruce.burlton@carleton.ca

Often found in ME 2333

Academic Accommodation: Students who require any accommodations should do so early on during the term (2 weeks into the term).