Introduction - Mech 5105

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Carleton University

Fall 2021

Department of Mechanical & Aerospace Engineering

Bruce Burlton I

- 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

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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).

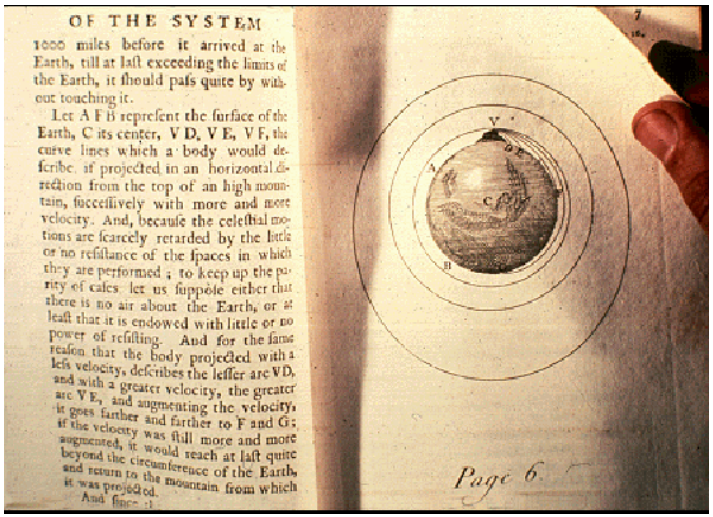

Figure 1: Dynamics

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

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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

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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*

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Course Outline VI

- 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.

Course Outline VII

- 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.
    - Basic Magnetotorquer Control Algorithms for Satellite Detumbling.
    - Active Passive Gravity Gradient Attitude Control System for a Satellite in LEO.

Course Outline VIII

- 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)

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Course Outline IX

- 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

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Course Outline X

- 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).

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