Mechanical Engineering 548
Spacecraft Orbit and Attitude Dynamics and Control

Instructor:	Dr. David S. Rubenstein
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Class Hours:	Tuesdays, Thursdays, 11:00AM – 12:15 PM
Location:	Remote via Adobe Connect Pro
Office Hours:	Through email and Adobe Connect meetings (Students can log on as if it were a class session) through special arrangement.
Prerequisites:	MEE 446 or by permission of instructor
Text:	*Orbital Mechanics for Engineering Students*, Second Edition, H. D. Curtis
Technical software:	MATLAB Student Version (includes Matlab and Simulink).

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Course description

This course covers the orbit and attitude dynamics, modeling and fundamental control aspects of space vehicles. This includes rotational kinematics and dynamics of rigid-bodies as well as passive and active attitude control and stabilization methods. Additionally, Keplerian and non-Keplerian orbital motion, orbital transfers and orbit determination topics are covered. Finally, an introduction to spacecraft navigation systems will be presented.

Educational Objectives: After completing this course, students will be able to:

I. analyze the free and forced rotational dynamics of rigid bodies;
II. apply rigid body dynamic equations and basic control concepts to the modeling of orbiting spacecraft maneuvers;
III. determine attitude stability of orbiting spacecraft;
IV. demonstrate basic knowledge of passive and active methods of attitude stabilization and control;
V. analyze and simulate simple attitude maneuvers of controlled spacecraft;
VI. analyze Keplerian motion and non-Keplerian perturbation effects;
VII. compute and analyze optimum impulsive maneuvers and orbit transfers;
VIII. demonstrate knowledge of preliminary (two-body) orbit determination techniques.

Topics

I. Introduction

a) *Fundamental Review of Astronautics*
- 3-D Kinematics and Dynamics, DCMs
- Basic Two-Body Orbital Mechanics and Maneuvers
- Rigid-Body Dynamics

II. Attitude Dynamics and Control

a) *Spacecraft Attitude Dynamics*
- Quaternions and other Attitude Methods
- Torque-free Motion
- Stability about Principal Axes
- Constant Body-Fixed Torques
- Dual-Spin Spacecraft
- Approach to Multi-Body Spacecraft

b) *Basic Attitude Maneuvers and Control*

- Spinning Spacecraft
- Nutation and Precession
- Energy Dissipation Aspects
- Attitude Maneuvers
- Attitude Control Devices
- Gravity Gradient Stabilization

III. Orbital Dynamics and Control

a) Review of Two-Body Problem
- Lagrange Coefficient Method
- Restricted Three-Body Problem

b) Orbit Determination Techniques
- Gibbs Method
- Lambert's Problem

c) Additional Orbital Maneuvering Topics
- Phasing Maneuver
- Rotation of Apse Line
- Nonimpulsive Considerations

d) Interplanetary Missions
- Interplanetary Hohmanns
- Sphere of Influence
- Planetary Rendezvous and Flybys

IV. Introduction to Spacecraft Navigation

a) Sensors and instruments
b) Inertial Navigation Systems
c) GPS and Navigation Integration Filters

Additional References

1. Wie, Bong, *Space Vehicle Dynamics and Control, Second Edition,* AIAA Education Series, Published by AIAA, Reston, VA, 2008.
2. Kaplan, M. H., *Modern Spacecraft Dynamics and Control*, Wiley & Sons, New York, 1976
3. Bate, RR., Mueller, D.D., White, J.E., *Fundamentals of Astrodynamics*, Dover Publications, New York, 1971.
4. Chobotov, V. A., *Spacecraft Attitude Dynamics and Control*, Krieger Publishing, Malabar, Fl, 1992.

Class Time

Students are expected to attend the live lecture sessions.

Homework

- Homework problems will be assigned approximately every one to two weeks. You are expected to do the homework assignments individually. The homework problems are the basis for the preliminary and final exams. You are responsible for submitting the assigned homework if you are absent from the class.
- Late homework will NOT be accepted.
- Please be very neat and clear on homework. Clearly define variables, vectors, reference frames, etc. Nomenclature and convention can be pretty much as you please but you MUST be clear and consistent.

Preliminary Examinations
There will be two preliminary examinations.

Simulation Project
A simulation project will be assigned mid to late semester.

Final Exam
A comprehensive final exam will cover all material up to and including the last lecture before the exam.

Grading

Homework	5%
Preliminary Exam #1	20%
Preliminary Exam #2	20%
Simulation Design Project	30%
Final Exam	25%

Disabilities (ADA) Statement
Students with disabilities who may need services or accommodations to fully participate in this class should contact Ann Smith, Director of Disability Services in 121 East Annex, (voice) 581-2319, (TTY) 581-2325 as early as possible in the semester. Any student requiring an accommodation due to a disability is also encouraged to speak to the instructor privately at the beginning of the semester. Appropriate arrangements will be made to accommodate the student.

Academic Integrity
Academic dishonesty includes cheating, plagiarism and all forms of misrepresentation in academic work, and is unacceptable at The University of Maine. As indicated in the University of Maine's on-line "Student Handbook," plagiarism (the submission of another's work without appropriate attribution) and cheating are violations of The University of Maine Student Conduct Code. An instructor who has probable cause or reason to believe a student has cheated may act upon such evidence, and should report the case to the supervising faculty member or the Department Chair for appropriate action.

Class Disruption:
In the event of an extended disruption of normal classroom activities, the format for this course may be modified to enable its completion within its programmed time frame. In that event, you will be provided an addendum to the syllabus that will supersede this version.