

AOE 4134 — Astromechanics — Fall 2000 (CRN 90253)

Instructor: Dr. Chris Hall, Randolph 228, 231-2314, chall@aoe.vt.edu

Lectures: 1:25-2:15 MWF, Randolph 216

Office hours: 9:30–10:30 MWF (*or by appointment*)

Text: *Fundamentals of Astrodynamics*, Bate, Mueller, & White, Dover, 1971

Course Web Page: <http://www.aoe.vt.edu/~chall/courses/aoe4134>

Astromechanics. Application of Newton's Laws to the dynamics of spaceflight. Two-body problem, Kepler's Laws, energy and time relations, orbit specification and determination. Orbital maneuver and transfer, patched conic approximations, relative motion, and elements of optimal maneuvering. This course is normally taught in the fall semester. It involves three hours of classes per week and is worth three semester credits. ESM 2304 is a prerequisite.

Goal: To introduce you to the problems associated with analyzing, predicting and controlling the orbital dynamics of spacecraft.

Homework Policy: There will be homework assignments approximately once per week, and the assignment will specify the due date. Homework must be turned in to me at the beginning of the lecture hour on the due date. Late homework will not normally be accepted. Some computer work will be required; MatLab is recommended, and I will teach MatLab to interested students.

Exams: Short quizzes will be given approximately once per week. Two mid-term exams and one final exam will be given. The first mid-term will be closed book and notes, the second mid-term will be open notes, and the final exam will be open book and notes.

Grading Policy:	Quizzes	5%
	Homework	20%
	Midterm Exam I	20%
	Midterm Exam II	25%
	Final Exam	30%

Honor Code: The University Honor Code will be maintained. You are encouraged to discuss homework assignments with your instructor, teaching assistant, and classmates. However, all work submitted for a grade must reflect your own understanding of the material. You may not copy answers to homework problems and you may not assist others or seek assistance on exams.

Topics: (text reference) *Objective*

Formulation of the two body problem (Ch. 1)

Understand the assumptions and principles that lead to the two-body equations of motion and their solution.

Constants of the motion and orbital elements (Chs. 1–2)

Understand and use the relationships between position, velocity, energy, angular momentum, and the classical orbital elements.

Coordinate systems and sidereal time (Ch. 2)

Understand and use rotation matrices to relate various coordinate systems. Understand the relationship between time and coordinates.

Orbit determination methods (Ch. 2, Ch. 5)

Given position and/or velocity observations, determine a satellite's orbit.

Basic orbital maneuvers (Ch. 3)

Know the classes of orbits and understand and apply methods of transferring from one orbit to another, including changing the plane of the orbit.

The time-of-flight problem (Ch. 4)

Understand the relationship between time-of-flight and orbital geometry. Apply numerical methods to solve a variety of mission analysis problems involving time-of-flight.

Patched conic interplanetary trajectories (Ch. 8)

Understand the patched conic approximation to interplanetary space flight. Apply this approach to the problem of interplanetary mission design.

Supplementary References:

- M. H. Kaplan, *Modern Spacecraft Dynamics & Control*, 1976, Wiley. Comparable to Wiesel's book. Several advanced problems worked out in some detail.
- J. E. Prussing and B. A. Conway, *Orbital Mechanics*, 1993, Oxford U. Press. Covers essentially the same topics as BMW.
- M. J. Sidi, *Spacecraft Dynamics and Control*, 1997, Cambridge. A "practical engineering approach" to both orbital and attitude dynamics and control.
- V. G. Szebehely, *Adventures in Celestial Mechanics*, 1991, U. of Texas. Covers the usual topics in orbital dynamics, including some excellent insights into the historical development of this subject.
- W. T. Thomson, *Introduction to Space Dynamics*, 1986, Dover. An excellent and affordable introduction to a variety of topics in spacecraft dynamics.
- D. A. Vallado, *Fundamentals of Astrodynamics and Applications*, 1997, McGraw-Hill. Excellent compendium of astrodynamics methods, examples, and problems.
- W. E. Wiesel, *Spaceflight Dynamics*, 1989, McGraw-Hill. Comparable to Kaplan or Thomson. Covers a variety of topics in astronautics, with practical examples.

Space Design References:

- B. N. Agrawal, *Design of Geosynchronous Spacecraft*, 1986, Prentice-Hall. This book is about communication satellites. It includes chapters on communications, orbital and attitude dynamics as well as structural dynamics and thermal control.
- A. E. Bryson, Jr., *Control of Spacecraft and Aircraft*, 1994, Princeton U. Press. The author covers a lot of topics on both subjects, emphasizing linear control systems.
- M. D. Griffin and J. R. French, *Space Vehicle Design*, 1991, AIAA. Similar to Agrawal's book, but with more on propulsion.
- V. L. Pisacane and R. C. Moore, (editors), *Fundamentals of Space Systems*, 1994, Oxford U. Press. This is a useful reference covering a wide range of topics related to space system analysis, design, test, integration and operations.