

# ENAE 601–Astrodynamics Syllabus Fall 2008

Department of Aerospace Engineering  
The University of Maryland

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**Office hours:** T, TH: 6:15 - 7:15 PM

**Class meeting location and time:** Building 45 (ITV), Room 1100 ; T, TH: 5:00 - 6:15 PM

**Required Text:** Battin, Richard H., *An Introduction to the Mathematics and Methods of Astrodynamics, Rev. Ed.*, AIAA Education Series, Reston, VA, 1999  
(ISBN: 1-56347-342-9)

**Prerequisites:** ENAE 404, ENAE 441

*Note: At least some computer programming experience (e.g., MATLAB) is highly recommended. Students are free to use any programming language but must be able to generate data plots. The instructor can provide code debugging help with C and MATLAB.*

“Astrodynamics is the study of the motion of human-made objects in space, subject to both natural and artificially induced forces.”

- From *Space Vehicle Design* (Griffin & French, 1991, 85)

The UMD ELMS (Blackboard) website for this course can be accessed by logging into:

<https://elms.umd.edu/>

## Recommended Texts

The student may find the following books useful for the course, but they are not required texts.

Kaplan, Marshall H., *Modern Spacecraft Dynamics & Control*, John Wiley & Sons, Inc., 1976  
(ISBN: 0471457035)

Press, William H., et al., *Numerical Recipes in C: The Art of Scientific Computing*, 2nd Ed., Cambridge University Press, 1999  
(ISBN: 0521431085)

Vallado, David A., *Fundamentals of Astrodynamics and Applications, 2nd Ed.*, Microcosm Press, El Segundo, CA, 2001  
(ISBN: 1881883124)

Wie, Bong, *Space Vehicle Dynamics and Control*, AIAA Education Series, Reston, VA, 1998  
(ISBN: 1563472619)

Wiesel, William E., *Spaceflight Dynamics, 2nd Ed.*, Irwin/McGrawHill, 1997  
(ISBN: 0070701105)

## Course Topics

(subject to change to accomodate time constraints)

1. The n-Body Problem
  - (a) Equations of Motion
  - (b) Conservation of Total Linear Momentum
  - (c) Conservation of Total Angular Momentum
    - i. Invariable (Laplace) Plane
  - (d) Potential Functions
  - (e) Conservation of Total Energy
  - (f) Review of solving differential equations
    - i. Analytical vs. numerical
  - (g) Review of spherical coordinates
  - (h) Using JPL ephemerides
2. The Two-Body Problem
  - (a) Equations of Motion
  - (b) Integrals of the Two-Body Problem
  - (c) Orbital Elements and Coordinate Systems
  - (d) Deriving and solving Kepler's Equation
    - i. Regula Falsi
    - ii. Successive Substitutions
    - iii. Lagrange's Expansion Theorem
3. The Osculating Orbit and Encke's Method
4. The Restricted Problem of Three Bodies
  - (a) Equations of Motion
  - (b) Jacobi's Integral
  - (c) Surfaces of Zero Relative Velocity
  - (d) Linearizing the Dynamics
  - (e) Lagrangian Points
    - i. Stability of the Lagrangian Points
5. Relative Spacecraft Orbital Motion
  - (a) Maneuvering
  - (b) The Ideal Rocket Equation
  - (c) The Radial, In-Track, Cross-Track frame
    - i. Rotating coordinate system transformations

- (d) Derivation of Hill's / Clohessy–Wiltshire (CW) Equations of Relative Spacecraft Motion
- (e) Periodic Out-of-Plane Relative Motion (Safety Ellipses)

#### 6. Spacecraft Rendezvous

- (a) Hill's / CW Targeting
- (b) Lambert Targeting (Inertial and Relative Frames)
- (c) Special Application: Safety Ellipse Rendezvous Methods
- (d) Rendezvous Strategies
  - i. Application: Rendezvous with the International Space Station

#### 7. Interplanetary Trajectories

- (a) Lambert Targeting
  - i. Selection of Departure/Arrival Geometry for Minimum Energy Transfers

### Homework, Exams, and Grading

- Homework will nominally be assigned every one to two weeks and will typically involve at least some computer programming.
- Late homework will not be accepted and make-up exams will not be offered unless the student has spoken with me in advance and has sound reason.
- All students should submit paper copies of their homework when turning it in. Exceptions may be made on a limited basis, e.g., if a student is going to be out of town when a homework assignment is due, in which case the student may email an electronic copy of their assignment to the instructor. *Note: Students taking the course remotely may always email their assignments to the instructor.*
- Grading: HW Assignments (30%), 1 Midterm exam (30%), 1 Final exam (40%)
- Students may create a final project for extra credit. Interested students should speak with me on an individual basis.

#### Midterm Exam

Date is TBD. Will be held during regular class time.

#### Final Exam

The day, time, and location of the final exam for this course will be set by the University. For reference:

- Last Class 12/12/2008 (Friday)
- Study Day 12/13-14/2008 (Saturday and Sunday)
- Final Exams Start 12/15/2008 (Monday)

- Final Exams End 12/20/2008 (Saturday)

### **Attendance**

Regular class attendance is expected of all students. In any case, students are responsible for all course material presented by the instructor during class meetings. The instructor may cancel class meetings in advance on a very limited basis for logistical reasons.

### **Academic Integrity**

The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit <http://www.shc.umd.edu>.

To further exhibit your commitment to academic integrity, remember to sign the Honor Pledge on all examinations and assignments:

*I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/examination.*

### **Students with Disabilities**

Any students with disabilities should inform the instructor as soon as possible so that appropriate arrangements can be made according to University policy.

### **Holidays, Religious and Otherwise**

- Labor Day Holiday 9/1/2008 (Monday)
- Thanksgiving Holiday 11/27/2008 (Thursday) through 11/28/2008 (Friday)

It is the student's responsibility to inform the instructor of any intended absences for religious observances in advance. Prior notification is especially important in connection with final examinations, since failure to reschedule a final examination before the conclusion of the final examination period may result in loss of credits during the semester.