ENAE741
Interplanetary Navigation and Guidance
Syllabus
Spring 2015

Department of Aerospace Engineering
The University of Maryland

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Office hours: Tu, Th 6:15–7:15 PM; or, by appointment
Class meeting location and time: 2154 Martin Hall (EGR); Tu, Th: 5:00–6:15 PM

Required Text: There is no required textbook for this course; materials will be provided by the instructor, and some useful material is available online (instructor will indicate the locations of such materials). Supplemental reading material is also suggested in the list of **Recommended Texts** below.

Prerequisites: ENAE432 (Control of Aerospace Systems) and ENAE601 (Astrodynamics)

Note: At least some experience with a computer programming language (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®.

Course Description:
Interplanetary trajectory construction; patched and multiconic techniques. Methods of orbit and attitude determination; applied Kalman filtering. Guidance algorithms and B-plane targeting. Interplanetary navigation utilizing in situ and radio techniques.

The UMD ELMS (Canvas) website for this course can be accessed by logging into:
https://umd.instructure.com/login

Communication Outside the Classroom & Emergency Protocol
Email is the primary means of communication with students outside of the classroom. Class cancellations, changes in class meeting time/location, and other timely announcements will be communicated via email. Additionally, if the University is closed for an extended period of time for any reason (e.g., some sort of emergency), the instructor will use email to communicate with students regarding continuation/completion of the course.

Recommended Texts

The student may find the following books useful for the course (and for general reference), but they are not required texts.

- Battin, Richard H., *An Introduction to the Mathematics and Methods of Astrodynamics*, AIAA Rev Sub edition (1999), ISBN-10: 1563473429, ISBN-13: 978-1563473425
- Chobotov, Vladimir A., ed., *Orbital Mechanics*, AIAA; 3rd edition (September 1, 2002), ISBN-10: 1563475375, ISBN-13: 978-1563475375
- Kaplan, Marshall H., *Modern Spacecraft Dynamics & Control*, Wiley; 1st edition (October 19, 1976), ISBN-10: 0471457035, ISBN-13: 978-0471457039
- Press, William H., et al., *Numerical Recipes in C: The Art of Scientific Computing*, Cambridge University Press; 2nd edition (October 30, 1992), ISBN-10: 0521431085, ISBN-13: 978-0521431088
- Vallado, David A., *Fundamentals of Astrodynamics and Applications*, Microcosm Press; 4th edition (March 29, 2013), ISBN-10: 1881883183, ISBN-13: 978-1881883180

- Wie, Bong, *Space Vehicle Dynamics and Control*, AIAA; 2nd edition (August 28, 2008), ISBN-10: 1563479532, ISBN-13: 978-1563479533
- Wiesel, William E., Spaceflight Dynamics, McGraw-Hill; 2nd edition (1997), ISBN-10: 0070701105, ISBN-13: 978-0070701106
- Scheeres, D. J., *Orbital Motion in Strongly Perturbed Environments: Applications to Asteroid, Comet and Planetary Satellite Orbiters*, Springer; 2012 edition (April 21, 2012), ISBN-10: 3642431631, ISBN-13: 978-3642431630
- Brown, Charles D., *Spacecraft Mission Design*, AIAA; 2nd Edition, ISBN-10: 1563472627, ISBN-13: 978-1563472626
- Brown, Robert G. and Hwang, Patrick Y. C., *Introduction to Random Signals and Applied Kalman Filtering*, Wiley; 3rd Edition, ISBN-10: 0471128392, ISBN-13: 978-0471128397
- Gelb, Arthur, ed., *Applied Optimal Estimation*, The M.I.T. Press, Cambridge, Massachusetts, and London, England, ISBN-10: 0262570483, ISBN-13: 978-0262570480

Course Topics

Course topics are subject to change to accommodate time constraints.

1. The interplanetary space environment
2. Historical perspective on interplanetary missions
3. Interplanetary mission destinations
4. Review of spacecraft motion dynamics
5. Coordinate frames & time systems
6. Patched conics for planetary departure/arrival
7. Interplanetary trajectory design & optimization
8. Launch vehicle performance
9. Ephemeris data
10. Modern software tools
11. Gravity assist maneuvers
12. B-plane targeting
13. The Deep Space Network (DSN)
14. Navigation measurements & spacecraft state estimation

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 the instructor 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 a student may email the instructor an electronic copy of their homework as a PDF file.
- Grading: HW Assignments (50%), Midterm exam (25%), Final exam (25%) with the instructor on an individual basis.

Midterm Exam

The midterm exam is the first *Major Scheduled Grading Event* of the semester and will be held during regular class time. The tentative date is Thursday, March 12$^{\text{th}}$, 2015.

Final Exam

The final exam is the second and last *Major Scheduled Grading Event* of the semester. The day and time of the final exam for this course, set by the University, is Tuesday, May 19$^{\text{th}}$, 2015 from 4:00 to 6:00 PM. The location for the final exam will nominally be the regular class meeting location.

Important Dates

- First Day of Classes: January 26 (Monday)
- First Day of ENAE741: January 27 (Tuesday)
- Midterm Exam: March 12 (Thursday)
- Spring Break: March 15–22 (Sunday–Sunday)
- Last Day of Classes: May 12 (Tuesday)
- Reading Day: May 13 (Wednesday)
- Final Exams Begin: May 14 (Thursday)
- Our Final Exam: May 19 (Tuesday), 4:00–6:00 PM
- Final Exams End: May 20 (Wednesday)

Attendance

Regular attendance and participation in this class is the best way to grasp the concepts and principles being discussed. However, in the event that a class must be missed due to an illness, the policy in this class is as follows:

1. For every medically necessary absence from class, a reasonable effort should be made to notify the instructor in advance of the class. When returning to class, students must bring a note identifying the date of and reason for the absence, and acknowledging that the information in the note is accurate.
2. If a student is absent more than one time, the instructor may require documentation signed by a health care professional.
3. If a student is absent on days when assignments are due, he or she is required to notify the instructor in advance, and upon returning to class, bring documentation of the illness, signed by a health care professional.

If a student must be absent due to extenuating circumstances that are not medical in nature, the student must discuss the absence with the instructor in advance and will be responsible for class material covered while absent. Multiple repeated absences for non-medical reasons are not permitted. Finally, the instructor may cancel or reschedule 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` or `http://www.studentconduct.umd.edu`.

To further exhibit your commitment to academic integrity, remember to sign the Honor Pledge on all of your work:

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

- Spring Break: March 15–22 (Sunday–Sunday)

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.

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