ENAE788N
Selected Topics in Aerospace Engineering; Near-Earth Object Exploration
Syllabus
Fall 2014

Department of Aerospace Engineering
The University of Maryland

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Office hours: M, W 6:15–7:15 PM; or, by appointment
Class meeting location and time: Martin Hall (EGR) 2116 ; M, W: 5:00–6:15 PM

Required Text: There is no required textbook for this course; materials will be provided by the instructor. Supplemental reading material is also suggested in the list of **Recommended Texts** below.

Prerequisites: ENAE601 (Astrodynamics)

Course Description:
This course provides an overview of the near-Earth objects (NEOs) of our solar system—the asteroids and comets whose orbits closely approach Earth's orbit—and what we know about them, what we're learning about them, and how to design spacecraft missions to interact with them.

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.

Astrodynamics, Mission Design, and Programming

- 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; 2 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

Various Asteroid/Comet Topics

- Yeomans, D. K., *Near-Earth Objects: Finding Them Before They Find Us*, Princeton University Press, 2012, ISBN-10 0691149291, ISBN-13: 978-0691149295
- Belton, M. J. S., Morgan, T. H., Samarasinha, N. H., Yeomans, D. K., eds., *Mitigation of Hazardous Comets and Asteroids*, Cambridge University Press; Reissue edition (March 3, 2011), ISBN-10: 0521173329, ISBN-13: 978-0521173322
- 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
- Gehrels, T. (ed.), *Hazards Due to Comets and Asteroids*, University of Arizona Press (February 1, 1995), ISBN-10: 0816515050, ISBN-13: 978-0816515059
- Gehrels, T. (ed.), *Asteroids*, Univ of Arizona Pr; Reissue edition (November 1979), ISBN-10: 0816506957, ISBN-13: 978-0816506958
- Binzel, R. P., Gehrels, T., Matthews, M. S., eds., *Asteroids II*, Univ of Arizona Press (January 1989), ISBN-10: 0816511233, ISBN-13: 978-0816511235
- Bottke, W. F., Cellino, A., Paolicchi, P., Binzel, R. P., eds., *Asteroids III*, University of Arizona Press; 1St Edition edition (December 1, 2002), ISBN-10: 0816522812, ISBN-13: 978-0816522811
- Dymock, R., *Asteroids and Dwarf Planets and How to Observe Them*, Springer; 2010 edition (November 1, 2010), ISBN-10: 144196438X, ISBN-13: 978-1441964380
- Badescu, V., ed., *Asteroids: Prospective Energy and Material Resources*, Springer; 2013 edition (July 14, 2013), ISBN-10: 3642392431, ISBN-13: 978-3642392436
- Lewis, J. S., *Rain of Iron and Ice: The Very Real Threat of Comet and Asteroid Bombardment*, Perseus Books; First Edition edition (January 1996), ISBN-10: 0201489503, ISBN-13: 978-0201489507
- Lewis, J. S., *Mining The Sky: Untold Riches From The Asteroids, Comets, And Planets*, Basic Books (September 23, 1997), ISBN-10: 0201328194, ISBN-13: 978-0201328196
- Lewis, J. S., *Comet and Asteroid Impact Hazards on a Populated Earth: Computer Modeling*, Academic Press; 1 edition (October 7, 1999), ISBN-10: 0124467601, ISBN-13: 978-0124467606

Course Topics

The following is a broad, high-level overview of the topics that the instructor intends to cover throughout the semester. Note that these topics are not necessarily listed in presentation order, and the topics are subject to change to accommodate time constraints.

- **What are NEOs?**
  - Asteroids vs. comets; small bodies / primitive bodies of the solar system
  - The NEO population: orbit families, physical characteristics, knowns and unknowns
  - Earth co-orbitals, Trojans, temporarily captured NEOs, potentially hazardous objects
  - Historical and current surveys to detect and characterize NEOs (optical, radar)
  - The global online system for NEO data and how to utilize it
- **Why do we want to visit NEOs?**
  - How are NEOs connected to the origins of our solar system and life on Earth?
  - NEO impacts on Earth: past, present, and future
  - How dynamically accessible are NEOs for space flight missions?
  - What raw materials and resources do NEOs offer, and how might we use them?
- **What options are there for missions to NEOs?**

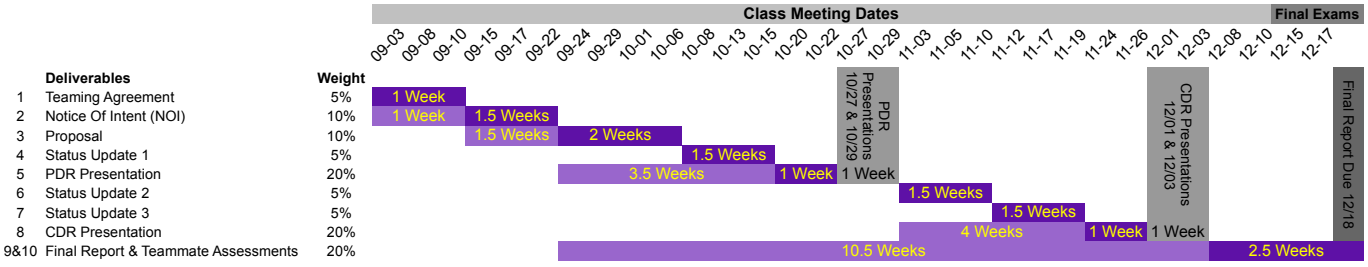
  - Historical and upcoming spacecraft missions to NEOs: What have we learned?
  - Future NEO mission concepts: What do we want to do? What do we want to learn?
  - Robotic missions vs. human space flight
  - Protecting Earth from NEO impacts ("Planetary Defense")

- **Techniques and principles for NEO mission design:**
  - Trajectory design and relevant considerations
  - Spacecraft motion in the vicinity of NEOs: a highly perturbed dynamical environment
  - Planetary Defense techniques, including asteroid deflection/disruption
  - One-way missions, round-trip sample return / human space flight, Planetary Defense

Assignments and Grading

Throughout the semester you will learn about NEO exploration and apply that knowledge in the creation of your own NEO mission design. Students will work on mission designs together in teams. The assignments that are due throughout the semester consist of "deliverables" that approximate the development of actual missions, beginning with teaming arrangements and a proposal, and concluding with a Critical Design Review (CDR) Presentation and Final Report. All deliverables will be provided to the instructor electronically (via email) unless otherwise specified. In particular, other means will be used to transmit files (e.g., large presentation files) that are too large for email transmission.

The information about the deliverables you are responsible for is summarized in two tables that appear below, and more details about each of them are provided in individual assignment documents on the Canvas course web-site. The first table herein is intended to convey a sense of the development timeline for your project (spanning the entire semester). There are two types of durations shown in the timeline: darker purple denotes the duration between deliverables, while *the lighter purple color highlights the fact that you can be, and are strongly encouraged to be, working on multiple deliverables simultaneously in order to meet the given deadlines.* This concept is further emphasized by the **boldface** text in the "Development Time" column in the second table. This workflow should feel natural, as the deliverables are intended to build upon—and feed back into—one another.



Assignment #	Deliverable	Format	Length	Weight	Due Date	Development Time
1	Teaming Agreement	Document	1–2 pgs	5%	09/10	1 week from start
2	NOI	Document	4–5 pgs	10%	09/22	1.5 weeks from #1; 2.5 weeks from start
3	Proposal	Document	≥10 pgs	10%	10/06	2 weeks from #2; **3.5 weeks from #1**
4	Status Update 1	Presentation	∼25 mins	5%	10/15	1.5 weeks from #3
5	PDR Presentation	Presentation	∼45 mins	20%	10/27–10/29	1 week from #4; **4.5 weeks from #2**
6	Status Update 2	Presentation	∼25 mins	5%	11/10	1.5 weeks from #5
7	Status Update 3	Presentation	∼25 mins	5%	11/19	1.5 weeks from #6
8	CDR Presentation	Presentation	∼45 mins	20%	12/01–12/03	1 week from #7; **5 weeks from #5**
9	Final Report	Document	≥25 pgs	20%	12/18	2.5 weeks from # 8; **13 weeks from #2**
10	Teammate Assessments	Document	∼1 pgs	–	12/18	2.5 weeks from # 8; **13 weeks from #2**

Important Dates

- First Class 09/02/2014 (Tuesday) *Note: Our first class day is, therefore, Wednesday, 09/03/2014*
- Last Class 12/12/2014 (Friday) *Note: Our last class day is, therefore, Wednesday, 12/10/2014*
- Reading Day 12/13/2014 (Saturday)
- Final Exams Begin 12/15/2014 (Monday)
- Our Final Exam Date 12/18/2014 (Thursday)
- Final Exams End 12/20/2014 (Saturday)

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

- Thanksgiving Recess 11/27/2014 (Thursday) through 11/30/2014 (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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