

Mechanical Engineering 4943: Special Topics in Aerospace Engineering (Space Systems)

Instructor

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Course Description:

This course is a survey of the design and operation of manned and unmanned spacecraft. The class is designed as a broad overview both of the design of individual systems of the spacecraft, such as propulsion, power, and guidance, and their integration into a complete mission. The course also covers the design process, from mission requirements to detailed design of the spacecraft. Where appropriate, the instructor will incorporate discussion of related topics, such as the space environment, frontiers in space exploration, the history of spaceflight, and the political and security aspects of space flight.

This course is different from most engineering elective courses in that it is certified as both *Communications Intensive* and as a *Service-Learning* course. There are specific reasons for incorporating these approaches into this course.

Design of any system as complex as a spacecraft involves hundreds of individuals with different skill sets. Functioning in this environment requires strong written and oral communications skills. To reflect this, development of professional communications skills is incorporated into the class. This will be done through presentations and written reports on the semester-long project.

Because space exploration is a tax-payer funded activity, NASA emphasizes outreach to the community- the people who pay to support the exploration of the universe. After discussion with the Spring 2011 class, a service-learning component was added to the class. You will work with Baton Rouge schools to present material on space exploration to elementary school classes. This will challenge your technical understanding, and your communications skills. It will also give you a great opportunity to learn from our community partners about the challenges and excitement of science education.

By the end of this class, you will possess (1) a broad technical understanding of the individual systems of a spacecraft, (2) the challenges in designing these systems to fit a specific objective, (3) an understanding of the unique challenges of human spaceflight, and (4) the communications skills needed both to work in a multi-disciplinary team, and to share your knowledge in these areas with a broader audience.

Prerequisites:

Students should have completed courses in classical dynamics, fluid dynamics and thermodynamics prior to taking this class. Students will find having a class in heat transfer useful, but will be able to learn the necessary material during the class. Several assignments will require the ability to solve engineering problems numerically using MATLAB.

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Course topics:

The course will cover the following topics:

1. Overview of Space Systems
2. Astrodynamics
3. Launch Systems
4. Atmospheric entry
5. Overview of future mission objectives
6. Astrobiology
7. Science Objectives and Payloads
8. System Requirements and Integration
9. Spacecraft Systems:
 - a. Space Propulsion
 - b. Spacecraft Attitude Determination and Control
 - c. Thermal Management
 - d. Power Systems
 - e. Communications
10. Spacecraft reliability
11. Human spaceflight
 - a. Safety
 - b. Life support
 - c. Mission planning

Relationship of Course to Program Objectives

The organization that certifies all engineering programs, ABET (*Accreditation Board for Engineering and Technology*) asks the LSU mechanical engineering program to list program objectives, and then define how each course helps meet those program objectives. This material covered in this course incorporates the following program objectives:

- (a) an ability to apply knowledge of mathematics, science, and engineering;
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, societal, political, ethical, health and safety, manufacturability, and sustainability;
- (d) an ability to function on multidisciplinary teams;
- (e) an ability to identify, formulate, and solve engineering problems;
- (g) an ability to communicate effectively;
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
- (i) a recognition of the need for, and an ability to engage in life-long learning;
- (j) a knowledge of contemporary issues;
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

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Course Materials:

The textbook for this class is

Space Vehicle Design, 2nd Edition, M. D. Griffin and J. D. French. ISBN 1-56347-539-1.

Note that this book is available through the AIAA web page at a discount to student members. The price of a student membership plus the discounted price of the book is approximately equal to the price of the book in the bookstore, and membership has additional benefits.

The course will also use Volume 1 of the Columbia Accident Investigation Board (CAIB) report, which is available on-line at

http://caib.nasa.gov/news/report/pdf/vol1/full/caib_report_volume1.pdf

You may also find it useful to look at the National Research Council's report "New Frontiers in the Solar System: An Integrated Exploration Strategy," which is available on-line at:

http://www.nap.edu/catalog.php?record_id=10432

However, this is reference material and you will not need your own copy.

A wiki of articles in the popular press (NY Times, Washington Post, BBC, etc.) will be maintained. You will need to read these articles for class and to maintain your journal. The course wiki is

<http://lsu-me-4943.wikispaces.com>

Assignments that require numerical simulations should be coded in MATLAB, which can be used on computers on the campus network through a campus-wide shared license. Students who wish to have MATLAB on their own personal computers can purchase a discounted MATLAB & Simulink Student Version from mathworks.com.

Graded items:

The course grade will be based on two exams, homework, short reports, in-class presentations, an educational project, a final project, and class participation.

The weight of each item in the grade is:

Item	Weight
Take-home exam	15%
Final exam	15%
Homework	15%
Short	15%
Reports/Presentations	
Educational Project	15%
Project Report	15%
Participation	10%

Short reports, presentations, and the project reports will be done in small groups. Each group will be assigned to evaluate the technology challenges, and mission objectives, for a particular

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proposed mission, such as exploration of Venus, sending a probe to a comet, etc. As explained below, when a particular technology or concept is explained, each group will write a short report, and give a short presentation, relating the concept to the proposed mission. The results will then be integrated into a project report.

Groups will be assigned by the instructor after the first week of class, to ensure each group has the necessary set of skills for the assignments. *Your first homework assignment will be to e-mail an up-to-date resume as a pdf file to the instructor by 5 PM on January 22.*

Take-home exam

A take-home examination will be given at the mid-point of the semester. Students may use the text and their notes to complete the exams but may not consult other students or outside sources.

Final exam

The final exam will be on Friday, May 13, from 3 to 5 PM.

Homework

6-8 homework assignments will be given over the course of the semester. The format of the homework will be posted on moodle. You may consult with other students on the homework but the final product must be your own work.

Short reports and Presentations

Most homework assignments will be accompanied by a short assignment to relate the material to your assigned mission. For instance, if your “mission” is the exploration of Venus, and the material is on spacecraft orbits, you may be asked to calculate the energy requirements for moving a spacecraft from earth orbit to land on Venus. This will be done as a group. The report should be 2 to 5 pages, depending on the complexity of the calculations, at 1 ½ line spacing and 12 point font. The lowest report grade will be dropped. However, all reports must be submitted, since the calculations will be used in the final report.

Each group will give a 3-5 minute presentation on their results from each short report to the class. The report sessions will be conducted as an engineering meeting. Each meeting will be moderated by two class members selected by the instructor.

Educational Project

You will work in a small group, which may not be identical to your project small group, to prepare a lesson for (School X). You will have to make 4 visits to the school- one to observe the class, one to discuss the lesson plan with the instructor, and two to deliver the lesson once developed. The lesson topics will be:

- 1) Staying in orbit- balancing forces.
- 2) Rocket science
- 3) Power plants in space
- 4) Re-entry from space
- 5) Looking for life in space

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You will submit a report on your education project, documenting the materials you developed. You will also write a few paragraphs after each visit, explaining what you observed and learned, and the challenges you faced in trying to teach science material in this context.

Report Draft and Final Report

As you work through the short reports assessing the challenges for sending a spacecraft to achieve a set of science objectives, the outline of a spacecraft design will start to emerge. You will use this information to prepare a 10 page proposal for a spacecraft design. *Note that over the course of the semester, you will have to go back and change systems designed earlier to meet new needs imposed by new requirements. For instance, you may have to change your power system based on the power needs of your communications system. This is part of the process of systems integration, a key step in the design of aerospace systems.*

The draft report will be due about 2 weeks before the end of the semester.

Based on comments on the draft, you will revise and resubmit your proposal, making changes in both the technical content and the presentation. This report will be due on the last day of the class.

Participation

Participation will be based on weekly quizzes on the reading material on the wiki.

To prepare for the quizzes, you should keep a notebook summarizing the key points of each article you read. You may use the notebook during the quizzes.

Grading scale:

The grading scale is

A= 100-90, B = 89.999-80, C = 79.999-70, D = 69.999-60, F <60