**Management of Space Systems**

**AERO/SPACE 583**

**Winter 2024**

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**Zoom Number for Sponsor Participation on Project Presentations:**

[https://umich.zoom.us/j/5652882445Links to an external site.](https://umich.zoom.us/j/5652882445)

Meeting ID: 565 288 2445  
Passcode: 1531

**Honor Code:**

The CoE Honor Code holds that students are honorable and trustworthy people and encourages them to behave with integrity in all phases of university life. Examinations will not be proctored, but the instructor or his representative will always be available to answer questions. At the end of each homework assignment, test and examination the students must write the Honor Pledge “I have neither given nor received unauthorized aid on this homework, test or examination, nor have I concealed any violations of the Honor Code” and sign their name under it.

**UM Honor Code:**

<http://www.engin.umich.edu/students/honorcode/code/coursepolicy.html>

**Mental Health and Well-Being:**

Students may experience stressors that can impact both their academic experience and their personal well-being. These may include academic pressures, and challenges such as those associated with relationships, mental health, alcohol or other drugs, identities, and finances. If you experience concerns, seeking help is a courageous thing to do for yourself and those who care about you. If the source of your stressors is academic, please contact the instructor(s) so that we can find solutions together. For personal concerns, the University of Michigan offers a variety of resources, many which are listed on the [Resources for Student Well-being](https://wellbeing.studentlife.umich.edu/resources-list)webpage. You can also search for additional well-being resources at <https://wellbeing.studentlife.umich.edu/well-being-resources>

**Course Approach and Goals:**

This course involves guest lecturers and mentors from various departments, industry, and National laboratories. Students participate from the conception to the completion of spaceflight projects. The main course goal is to provide students with the basic understanding of systems engineering and the design of spaceflight missions with the objective to develop:

1. The ability to define requirements, design and test spaceflight missions and their subsystems, taking cost, schedule, environmental, ethical, and safety constraints into consideration;
2. The ability to thrive in multidisciplinary teams;
3. A good understanding of ethical and professional responsibility;
4. The ability to communicate effectively;
5. The ability and desire to engage in lifelong learning activities.

**Course Overview:**

The course is intended to introduce the students to systems engineering and the processes by which technology and system engineering decisions are implemented into the design of spaceflight missions. The course will provide an overview of critical tools supporting project planning and tracking, with emphasis on technical budgets and requirements management. Strategic approaches to technology development for spacecraft systems will be discussed.

The course begins with a brief overview of systems engineering and the practices used to design spaceflight systems. It will follow the axiomatic design process and the management processes used by NASA. The course then focuses on the specific design of a particular space system as a team project. The design processes include schedule maintenance, budget management, and system analysis. This includes detailed modeling of both engineering and budgetary performance, as well as technological impacts of engineering based decisions. A large fraction of the course effort is spent in team projects. AERO/AOSS 583 students are expected to spend 20% of their time supporting the educational goals of AERO 483, by teaching tutorials and mentoring students. The goal of this activity is to train AERO/AOSS 583 students as technology instructors, technology support personal, and members of project review teams.

**Course Structure:**

Lectures are structured around the modern design process common to all engineering disciplines. In particular, the importance of clear and well-thought conceptual ideas in the earliest phases of the design process is emphasized. The course focuses on the development and capture of requirements, analysis, synthesis of solutions and trades. Lectures, discussions, and laboratory sessions are structured around the following themes:

1. **Systems engineering practices**: overview of the design of spaceflight systems.
2. **Problem definition**: definition of the engineering problem.
3. **Requirements**: quantitative definition of the project requirements.
4. **Concept generation**: collection and categorization of a large number of conceptual designs to solve the engineering problem.
5. **Concept evaluation**: quantitative evaluation of each conceptual design.
6. **Convergence**: reduction of the number of conceptual designs by merging the best ideas of selected designs.
7. **Concept selection**: identification of the best conceptual designs for detailed design and analysis.
8. **Detailed design and trades**: analysis of the best concepts using quantitative methods.
9. **Subsystem prototyping**: subsystem prototyping and tests with demonstration of critical concepts.
10. **Project wrap-up/transition**: documentation of the design in detail for use by future student teams.

**Class Hours and Location:**

Mondays, Wednesdays and Fridays from 2:30 am to 4:20 pm.

2246 Space Research Building.

**Office Hours:**

Mondays and Wednesdays from 1:30 to 2:20 pm.

Any other time by appointment.

**Required Textbook:**

Space Mission Analysis and Design *by J. R. Wertz, and W. J. Larson*

**Useful Textbooks:**

Axiomatic Design: Advances and Applications *by**Nam Pyo Suh*

INCOSE Systems Engineering Handbook *by Walen et al.*

Observation of the Earth and its Environment *by H.J. Kramer*

Space Vehicle Design *by Michael D. Griffin and French*

System Engineering Management *by Benjamin S. Blanchard*

**Prerequisites:**

1. AOSS/AERO 582
2. Basic skills in Matlab and Excel programming.
3. Basic skills in Mathematics including introductory knowledge of Partial Differential Equations.
4. Basic physics at Engineering Undergraduate Level, including Mechanics and Electrodynamics.
5. Basic skills in space system analysis software, such as STK, I-DEAS, CAD, and Radiation analysis programs are desirable but they will be developed in this course.

**Homework and Final Examination:**

The objectives of homework and the final examination are:

1. To measure the students' ability to use the knowledge acquired in the course;
2. To provide feedbacks to the teacher on how well the course's long-range objectives were achieved.

**Homework Assignments:**

Homework will consist of specific questions about key systems engineering processes, analysis and management.Homework must be handed in electronically before midnight on the due date.

**Homework Policy:** grades will be reduced by at least 10% for any homework turned in after the due date. After the answer sheet is handed out (usually one week after the due date) 50% of the grade will be deducted from a late homework. It is absolutely *not* permitted to consult answer sheets for help. Some collaboration on doing homework is encouraged, but each student must work out the answers on their own and the solutions they hand in must be individually prepared. When in doubt, write an honest note at the top of your assignment saying who you worked with and how much. Rule of thumb: < ¼ of your effort may be jointly if you don't mention a collaborator, < ½ if you do mention the collaborator. The write-up must be entirely your own.

**Final Examination**

The final examination will consist of specific questions about key systems engineering processes, analysis and management. It will be completed in class.

**Final Grade:**

The final score will be computed by

SCORE = 1/5 (HMW + EXAM + PEER + PROJ + CPTC),

Where HMW is the average grade of all Homework Assignments, EXAM is the grade of the Examination, PEER is the average grade of the Peer Evaluations, PROJ, and CPTC is Class Participation (attendance to lectures, responding to instructors’ questions and prompts, and asking questions) is the average grade of the Project Presentations Final Report (including the mid-term and final presentations).

The final grade will be based on the grading displayed scale below, with pluses and minuses added at the instructor’s criteria.

|  |  |
| --- | --- |
| **Score** | **Grade** |
| 90-100 | A |
| 80-90 | B |
| 65-80 | C |
| 50-65 | D |
| < 50 | E |

**Complaints about Grades:**

The instructor or GSI will go over the test of any student who brings a written paragraph describing his/her concerns. However, the review might affect the grade either positively or negatively.

**In Class Participation:**

The mastering of the basic concepts and ideas to be presented in this course requires the students to participate actively in class. Therefore, students are expected to be active and ask and answer questions during lectures.

**Tentative Course Outline**

**January 10:** **Part 1:** Course Philosophy

Class Projects Presentations

(News Students will Select their Projects)

**Lab.:** Project Team Formation (New Student Join Projects)

**January 12:** Managing the Development of Space Systems **by Steve Battel**

**Lab.:** Project Work

**January 15**: No Classes – Martin Luther King Jr. Day

**Lab.:** No Lab

**January 17:** Guest Lecture by Don Winter Safety of Complex Systems or Margin Management)

**Lab.:** Project Work

**January 19:** **Approaches to Systems Verification by Steve Battel**

**Lab.:** Project Work

**Homework 1 Released:** The Axiomatic Design Process

**January 22:** The Axiomatic Design Process

Traceability Matrices and Requirements

NASA Science Strategy Example: The Search for Life in the Universe

**Lab.:** Project Work

**January 24:** System Engineering 101

**Lab.:** Tutorial

**January 26:** Team Forming by Steve Battel

**Lab.:** Tutorial

**Homework 1 Due:** The Axiomatic Design Process

**January 29:** Mission Analysis and Utility

**Lab.:** Tutorial

**January 31:** Formal Requirements Definition

Trade Studies

**Lab.:** Tutorial

**February 2:** Work Breakdown Structures (WBS)

**Lab.:** Tutorial

**Homework 2 Released:** SOW and Project Requirements

**February 5:** Statement of Work and Related Documents (SOW)

**Lab.:** Project Work

**February 7:** Cost Estimation

**Lab.:** Project Work

**February 9**: Mission Cost and Schedule

**Lab.:** Project Work

**Homework 2 Due:** SOW and Project Requirements

**February 12**: Space Systems Verification

**Lab.:** Project Work

**February 14**: Defining an Acquisition

**Lab.:** Project Work

**February 16**: Technology Insertion

**Lab.:** Project Work

**Homework 3 Released:** WBS and Schedule

**February 19:** Proposal Writing & Example of a Successful Proposal

**Lab.:** Project Work

**February 21:** Example of Unsuccessful Proposal

**Lab.:** Project Work

**February 23:** Observation Payloads

**Lab.:** Project Work

**Homework 3 Due:** WBS and Schedule

**February 28:** Winter Break

**Lab.:** No Lab

**February 28:** Winter Break

**Lab.:** No Lab

**March 1:** Winter Break

**Lab.:** No Lab

**March 4:** Earned Value Management Systems (EVMS)

**Lab.:** Project Work

**March 6:** Guest Lecture on EVM by Linda Chadwick (TBC)

**Lab.:** No Lab

**March 8:** Project Work

**Lab.:** Project Work

**Homework 4 Released:** Trade Study

**March 11:** Trade Studies

**Lab.:** Project Work

**March 13**: Margin Management

**Lab.:** Project Work

**March 15**: End of Mission Considerations

**Lab.:** Project Work

**Homework 4 Due:** Trade Study

**March 18**:Project Presentations

**Lab.:** Project Work

**March 20**: Project Presentations

**Lab.:** Project Work

**March 22**: Project Presentations

**Lab.:** Project Work

**Homework 5 Released:** System Engineering Report

**March 25**:Launch and Operations

Hints for Examination

**Lab.:** Project Work

**March 27**: No Lecture: 48 Hours Examination Released at 9 am

**Lab.:** 48 Hours Examination

**March 29**: An Example of Project Failure

**Lab.:** Project Work

48 Hours Examination due at 9 am

**April 1**:Mission Operations

**Lab.:** Project Work

**April 3**: Ethics

**Lab.:** Project Work

**April 5**: Ethics

**Lab.:** Project Work

**Homework 5 Due:** System Engineering Report

**April 8**: **Part 1:** NASA Science Missions

**Part 2:** Project Report: Fact Pages, Theme Boxes, Traceability Matrices **-** The Mars Radar and Radiometry Subsurface Investigation

**Lab.:** Project Work

**April 10**: Project Work

**Lab.:** Project Work

**April 12**: Project Work

**Lab.:** Project Work

**April 15**:Final Presentations

**Lab.:** Project Work

**April 17**: Final Presentations

**Lab.:** Feedback and Discussions

**April 19**: Final Presentations

**Final Report Due**

**April 22**:Financing and Space Law

**Lab.:** No Lab

**April 24**: Study Day

**Lab.:** No Lab

**April 26**: Study Day

**Lab.:** No Lab

**May 2-5**: **Commencement Activities**