Eng 450: Multidisciplinary Engineering Design
Winter 2006

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Course Website: http://aoss.engin.umich.edu/class/eng450/

Course Goals:
To provide a capstone multidisciplinary design experience for undergraduate students.
The course involves mentors and guest lectures from various departments, industry, and
NASA centers. Students participate from the conception to the completion of space flight
projects.

Course Structure:
Lectures are structured around the modern design process common to all engineering
disciplines. In particular, we emphasize the importance of clear and well thought
conceptual ideas in the earliest phases of the design process. We focus on the
development and capture of requirements, analysis, and synthesis of solutions. Lectures,
discussions, and laboratory sessions are structured around the themes outlined below.

1. Problem definition: definition of the engineering problem
2. Design requirements: quantitative definition of the system requirements
3. Concept generation: collection and categorization of a large number of
   conceptual designs
4. Concept evaluation: quantitative evaluation of each conceptual design
5. Convergence: reduction of the number of conceptual designs by merging the best
   ideas of selected designs
6. Concept selection: identification of the best conceptual designs for detailed
   design and analysis
7. Detailed design and analysis: analysis of the best concepts using quantitative
   methods and tools
8. Alpha prototype fabrication: system prototyping to demonstrated critical and/or
   immature concepts
9. Alpha prototype evaluation: evaluation of the design based on “Figure of Merit”
   derived from the system requirements
10. **Re-design**: identification of opportunities to improve the performance of systems
11. **Beta prototype fabrication**: focus on system level integration
12. **Beta prototype evaluation**: evaluation of system level performance
13. **Project wrap-up/transition**: documentation of the design in detail for use by future teams

**Class Hours and Location:**
Lectures: Tuesdays and Thursdays from 1:30 pm to 2:30 pm
2246 Space Research Building (AOSS Auditorium)
Team Meetings: Tuesdays and Thursdays from 2:30 pm to 5:00 pm
(at least three hours of laboratory per week)

**Office Hours:**
Tuesdays and Thursdays from 2:30 pm to 4:30 pm
Any other time by appointment

**Required Textbook:**
None.

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

**Prerequisites:**
Senior status

**Grades:**
The final score will be computed by
\[
\text{SCORE} = \frac{1}{4} (\text{PEVAL} + \text{PRES} + \text{PROJ} + \text{REP}),
\]
Where PEVAL is the average grade of all peer evaluations, PRES is the average grade of all presentations, PROJ is the grade of the project performance, and REP is the grade of the final report.

The final grade will be based on the grading displayed scale below.

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<thead>
<tr>
<th>Score</th>
<th>Grade</th>
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<tbody>
<tr>
<td>90-100</td>
<td>A</td>
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<td>&lt; 50</td>
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**Complaints about Grades:**
I will review the grades of any student who brings a written paragraph describing the concerns. However, the review might affect the grade either positively or negatively.
Potential Projects:
See course website at: http://aoss.engin.umich.edu/class/eng450/

Tentative Course Outline:
Phase I (Jan): Requirements specification and concept generation.
Phase II (Feb): Concept development, selection, and quantitative analysis.
Phase III (Mar): Detailed design, a-prototype fabrication, and system evaluation.
Phase IV (April): Re-design, b-prototype fabrication, and system evaluation.

Deliverables:
Phase I (February 7):
Peer evaluation of each team member (confidential).
Project definition (no more than one page).
Pugh chart: Evaluation of at least three conceptual designs.
Gantt chart: timetable for each design step until a-prototype fabrication.
Functional metrics: how will the a-prototype be evaluated?

Phase II (March 7):
Peer evaluation of each team member (confidential).
Draft a-prototype design including:
• Bill of materials (BoM) including each part that will be purchased, vendors, and costs.
• Drawing of all parts that will be fabricated and a description of the fabrication process.
• System engineering management plan (SEMP)

Phase III (March 21):
Peer evaluation of each team member (confidential).
Completed Gantt chart showing projected timetable versus actual timetable.
Demonstration of the fabricated a-prototype.
Detailed critique of the prototype, including comparative comparison of projected and actual performance.
Updated system engineering management plan (SEMP).

Phase IV (April 18):
Peer evaluation of each team member (confidential).
Report on re-design based on evaluation of the a-prototype, including engineering change notices (ECNs), modifications to the design specification, detailed design and BoMs.
β-prototype demonstration and poster presentation at the CoE design Expo.
Engineering notebook including all notes from the design process and fabrication (since the design team was formed)
Final project report and all design files stored in the class server.
Tentative Course Schedule

January 5: Course philosophy and projects (Renno/Mehta)
   Lab.: Tour of the Fabrication Laboratory & Machine Shop
January 10: Project requirements and environmental constraints (Renno)
   Lab.: Team formation and project selection
January 12: Overview of NASA’s Space Exploration Program (Michael Sander, JPL)
   Lab.: Team meeting & project discussion
January 17: Designing and Testing Balloons (Andrew Baird, Cameron Balloons)
   Lab.: a-prototype design
January 19: Space Systems Conceptual Design (Brian Lewis, Aerospace Corporation)
   Lab.: a-prototype design
January 24: No Lecture – Nilton will be in Denver, CO.
   Lab.: a-prototype design
January 26: Deep Impact: The First Look Inside a Comet (Jennifer Rocca, JPL)
   Lab.: a-prototype design
January 31: System-level Overview of EDL (Jeffrey Umland, JPL)
   Lab.: a-prototype design
February 2: Responsive Space Testbed (Anna Paulson, Lockheed Martin Corporation)
   Lab.: a-prototype design
February 7: Preliminary Design Review (PDR)
   Lab.: No lab, just PDR presentations
February 9: Preliminary Design Review (PDR)
   Lab.: No lab, just PDR presentations
February 14: No Lecture – Nilton will be in Cambridge, MA.
   Lab.: a-prototype design
February 16: The Juno Jupiter Polar Orbiter Mission (Steven Matousek, JPL)
   Lab.: a-prototype design
February 21: Mechanism design (Kotas)
   Lab.: a-prototype design
February 23: Robotic and Human Exploration (David Atkinson, JPL)
   Lab.: a-prototype design
February 28: Winter break (No Lecture)

March 2: Winter break (No Lecture)
March 7: NG’s Space Exploration Program (Ray Haynes, Northrop Grumman)
   Lab.: a-prototype design
March 9: No Lecture, a-prototype design
March 14: No Lecture – Nilton will be at the National Academies Review Panel, DC
   Lab.: a-prototype design
March 16: No Lecture, a-prototype design
March 21: Critical Design Review (CDR)
March 23: Critical Design Review (CDR)
March 28: No Lecture, β -prototype fabrication
March 30: No Lecture, β -prototype fabrication
April  4: No Lecture, β-prototype design
April  6: No Lecture, β-prototype design
April 11: No Lecture, β-prototype fabrication
April 13: Final Design Review
    Project Demonstration during the CoE Design Expo at Media Union
April 18: No Lecture, Final project report and electronic files due

Project’s External Review Board (TBC): Brian Lewis (Aerospace), Erica Walsh (JPL),
Timothy Priser (LMCO), Anna Paulson (LMCO), Lewis Peach (USRA), Andrew Baird
(Cameron)