ENG 450: Multidisciplinary Engineering Design
Winter 2008

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

Course Goals:
To provide a capstone multidisciplinary design experience for undergraduates. The course involves mentors and guest lectures from various departments, industry, and NASA laboratories. Students participate from the conception to the completion of innovative engineering 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, synthesis of solutions and trades. Lectures, discussions, and laboratory sessions are structured around the following themes:

1. **Problem definition**: definition of the engineering problem.
2. **Requirements**: quantitative definition of the project requirements.
3. **Concept generation**: collection and categorization of a large number of conceptual designs to solve the engineering problem.
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 trades**: analysis of the best concepts using quantitative methods.
8. **Alpha prototype fabrication**: system prototyping and demonstration of critical concepts.

9. **Alpha prototype evaluation**: evaluation of the design based on “Figure of Merit” derived from the project requirements.

10. **Re-design**: identification of opportunities to improve the performance of the project.

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 student teams.

**Class Hours and Location:**

**Lectures**: Mondays, Wednesdays and Fridays from 1:30 pm to 2:30 pm.

2246 Space Research Building (AOSS Auditorium).

**Team Meetings**: Mondays, Wednesdays and Fridays from 2:30 pm to 3:30 pm.

**Office Hours**: Mondays, Wednesdays and Fridays from 2:30 pm to 4:00 pm.

Any other time by appointment.

**Required Textbook**: None.

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

**Prerequisites**: Senior status or authorization from instructor.

**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 scale displayed 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>D</td>
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<td>&lt; 50</td>
<td>F</td>
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Complaints about Grades:
I will review the grades of any student who brings a written paragraph describing their 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: Requirements specification and concept generation.
Phase II: Concept development, selection, and quantitative analysis.
Phase III: Detailed α-prototype design and evaluation.
Phase IV: α-prototype fabrication, re-design and β-prototype fabrication and evaluation.

Deliverables:
Phase I (February 9):
Peer evaluation of each team member including your self-evaluation (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 α-prototype fabrication.
Functional metrics: how will the α-prototype be evaluated?

Phase II (March 12):
Peer evaluation of each team member including your self-evaluation (confidential).
Draft α-prototype design including:
- Bill of materials (BoM) including parts 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 23):
Peer evaluation of each team member including your self-evaluation (confidential).
Completed Gantt chart showing projected timetable versus actual timetable.
α-prototype design and projected performance.
Updated system engineering management plan (SEMP).
α-prototype demonstration and poster presentation at the CoE design Expo on April 12.

Phase IV (April 16):
Peer evaluation of each team member including your self-evaluation (confidential).
Report on re-design based on evaluation of the α-prototype, including engineering change notices (ECNs), modifications to the design specification, detailed design and BoMs.
Engineering notebook including all notes from the design process and fabrication (since the design team was formed).
β-prototype demonstration and performance evaluation.
Final project report and all design files stored in the class website.
Tentative Course Schedule

**January 5:** Course philosophy and project descriptions (Renno)  
Lab.: Tour of the Fabrication Laboratory & Machine Shop (Robb)

**January 8:** Project requirements (Renno)  
Lab.: Team formation and project selection

**January 10:** Project requirements and traceability matrix (Renno)  
Lab.: Team meeting and project discussions

**January 12:** NASA’s Space Exploration Program (Michael Sander, NASA/JPL)  
Lab.: Team meeting & project discussions

**January 15:** No-Class (Martin Luther King Day)  
Lab.: No-Lab

**January 17:** Axiomatic Design (Renno)  
Lab.: α-prototype design

**January 19:** Axiomatic Design (Renno)  
Lab.: α-prototype design

**January 22:** TBD  
Lab.: α-prototype design

**January 24:** Scaling (Renno)  
Lab.: α-prototype design

**January 26:** Scaling (Renno)  
Lab.: α-prototype design

**January 29:** Scaling (Renno)  
Lab.: α-prototype design

**January 31:** Auto Safety (Srini Sundararajan, Ford Motor Co)  
Nilton will be at AMES, Robb and Shintaro will lead the discussions.  
Lab.: α-prototype design

**February 2:** Responsive Space Testbed (Anna Paulson, Lockheed Martin Corporation)  
Lab.: α-prototype design

**February 5:** Preliminary Design Review (PDR)  
Lab.: No lab, just PDR presentations

**February 7:** Preliminary Design Review (PDR)  
Lab.: No lab, just PDR presentations

**February 9:** No Class, just feedback from PDR  
**Phase I deliverables due**  
Lab.: α-prototype design

**February 12:** No lecture, α-prototype design  
Lab: α-prototype design

**February 14:** No lecture, just feedback from PDR.  
Lab.: α-prototype design
February 16: Deep Impact: The First Look Inside a Comet (Jennifer Rocca, NASA/JPL)
  Lab: α-prototype design

February 19: Designing and Testing Balloons (Andrew Baird, Cameron Balloons)
  Lab.: α-prototype design

February 21: Robotic and Human Exploration (David Atkinson, NASA Headquarters)
  Lab.: α-prototype design

February 23: No Lecture, Nilton will be at the Phoenix Science Team Meeting in AZ
  Lab.: α-prototype design

February 26: Winter break (No Lecture)

February 28: Winter break (No Lecture)

March 2: Winter break (No Lecture)

March 5: TBD

March 7: No Lecture, α-prototype design
  Lab.: α-prototype design

March 9: No Lecture, Nilton will be at NRC Meeting in DC
  Lab.: α-prototype design

March 12: NG’s Space Exploration Program (Ray Haynes, Northrop Grumman)
  Phase II deliverables due
  Lab.: α-prototype design

March 14: No Lecture, α-prototype design

March 16: No Lecture, α-prototype design

March 19: Critical Design Review (CDR)

March 21: Critical Design Review (CDR)

March 23: Critical Design Review (CDR)
  Phase III deliverables due

March 26: No Lecture, Nilton will be at the Electrostatics Conference in Oxford, UK
  Lab: α-prototype fabrication

March 28: No Lecture, Nilton will be at the Electrostatics Conference in Oxford, UK
  Lab: α-prototype fabrication

March 30: No Lecture, α-prototype fabrication

April 2: No Lecture, α-prototype fabrication

April 4: No Lecture, α-prototype fabrication

April 6: No Lecture, α-prototype fabrication

April 9: No Lecture, α-prototype fabrication

April 11: No Lecture, α-prototype fabrication

April 12 (Thursday): Project Demonstration at the CoE Design Expo, Media Union

April 13: No Lecture, β-prototype design

April 16: No Lecture, Final project report and electronic files due
Phase IV deliverables due
April 20: Grades Posted

Project’s External Review Board (TBC): Pete Huseman (LMCO), Anna Paulson (LMCO), Lewis Peach (USRA), Andrew Baird (Cameron), Richa Jolly (Aerospace)