ME 72(a,b): Engineering Design Laboratory
(Fall/Winter 2009-2010)

Instructors:

- **Instructor:** Joel Burdick, Thomas 319, 395-4139, jwb@robotics.caltech.edu,
- **Instructor:** John Van Deusen, Spaulding 024 (Sub-basement M.E. Shop), 395-4120, jvand@caltech.edu,
- **Instructor:** Noel du Toit, 310 Thomas, ndutoit@caltech.edu,
- **T.A.:** Mark McDuff
- **T.A.:** Nam Nguyem
- **T.A.:** Melissa Tanner

Course Web Site: *http://robotics.caltech.edu/∼me72/*

Goals of ME 72:

This year ME 72 has two main goals. First, we hope that ME 72 students experience a reasonably complete design process from initial concept, through analysis, to prototyping, testing, refining, and execution. This process is organized around a contest, whose description and rules will be found in a separate handout. Second, ME 72 will expose students to several technologies that are used in modern engineering practice: 3D rapid prototyping, laser cutting/engraving, CNC milling, and vacuum molding.

More concretely, this course also aims to:

- Give student teams the experience of solving an open ended electro-mechanical design problem.
- Introduce students to basic motor control technology.
- Review and extend basic design methodologies that were introduced in ME 71.
- Introduce a limited subset of the basic mechanical elements.
- Review conventional 3D computer-aided-design practice using SolidWorks.
- Introduce students to computer-aided manufacturing technologies such as 3D rapid prototyping, 3D CNC machining, and 2D laser cutting/engraving.

Class Format of ME 72:

ME 72 is a project class, and most of the learning in this class will take place during the process of building and fielding your contest design solution. Class time will be devoted to: (1) reviews of appropriate design issues and design methodologies, (2) reviews of relevant technical issues (electric motor modeling, motor control, fluid dynamics of propulsion, buoyancy and stability of ligher-than-air vehicles, basic linkage principles); (3) student project reviews (a poster session, a preliminary design review, and a critical design review), and reviews of 3D CAD/CAM technologies. Also, class time will be used for M.E. shop demonstrations on subjects that are relevant to the contest. During the last few weeks of each quarter, when students are intensively working on their projects, class lecture time will be limited so that students can devote more time to fabrication and testing.

Homework, Finals, and Grading:

The course work will consist almost entirely of a final project. There is no midterm or final exam in the traditional sense. However, the work of the final project will broken down into a series of tasks that involve milestones and intermediate deliverables, mock-ups, system analyses, simulations, drawings, and documentation–in addition to the actual physical construction of the project. The various activities and their timing are aimed to keep everyone on track to effectively compete on contest day–March 9, 2010. Additionally, each student must keep a "design notebook" throughout the two quarters. These notebooks will be checked at regular intervals, and a final grade will be assigned to the notebook at the end of each quarter.

The final grade for the first quarter will be computed as:

- 90% for the deliverables related to the final project. This year's final project deliverables, and their weighting in the overall grading, are as follows (the due dates are tentative, and subject to change):
  - 3%: Shop exercise.–Thursday, Oct. 8.
  - 5%: Structured design artifacts (objectives, functions, and constraints)–Thursday, Oct. 15.
  - 7%: Poster Session (initial concepts and their justification for the contest design, preliminary analysis, skeches of design candidates)–Tuesday, Oct. 20.
  - 15%: Preliminary Design Review (PDR), including device mock-up built using laser cutter, and development of critical objectives, functions, and design constraints–Tuesday, Oct. 27.
  - 23%: Mobility Demonstration: you must demonstrate a working vehicle (either aerial if your design includes a lighter-than-air vehicle, or a ground vehicle if your plan does not include a lighter-than-air component) in the Brown Gym–Tuesday, Nov. 17.

  - 17%: Critical Design Review (CDR), including calculations, simulations, and design plan based on the outcome of the mobility experiments–Tuesday, Nov. 24.
  - 20%: Demonstration of a scoring mechanism–Thurs., Dec. 10.
- 10% for the quality of the design notebook.

You will receive separate instructions, with more detailed guidelines and grading information, for each of these deliverables.

Note that all of the projects are done in teams. The grade assigned to the team on each team-based deliverable is the grade received by all team members. However, the course notebook and some of the intermediate deliverables will come from individual efforts. Thus, there is some room for individual effort to affect the final grade. The grading scheme during the second quarter will be similar, though there will be a component of the grade that relates directly to your performance in the final contest. However, only 20% of the final grade in the second quarter will be related to your contest entry's actual performance. The rest of the grade will be based on the quality and creativity of your design process (as evidence by the various design artifacts that you create throughout the quarter), and the quality of your final project's fabrication and operation.

Grading of design projects is often subjective. We will attempt to be as fair as possible and lay out the grading procedure for each deliverable in a handout which describes the details that make up each deliverable. Students are encouraged to ask questions when the grading procedure is not clear.

Course collaboration policy. We encourage students to discuss the competition and the intermediate milestones with other students and with the class instructors and T.A.s. Group projects by their nature involve collaboration. On individual homeworks or deliverables, while discussions with other class participants is encouraged, the submitted work should entirely reflect the effort of the individual.

Shop Materials and Tools

We will provide a ready supply of the basic contest materials that you need for most of the class activities. As described in the contest rules document, students may wish to buy additional battery packs, decoration supplies, bonding material, etc. that may be needed to efficiently design, build, and test their contest entries. Only one set of radio control modules and motors will be provided to each team. Damage radio control systems and motors must be replaced at your cost.

Basic hand tools are available for each student to use in the M.E. shop. We encourage those students who have not already done so to purchase their own basic set of measurement tools.

References

There is no text for this course. We will photocopy and distribute course material as necessary. We will try to keep copies of handouts on the course web site.

Tentative Course Syllabus

In addition to the subjects described below, some class meetings will be devoted to shop demonstrations of prototyping systems, mechanical fabrication methods, and common mechanical components. It is our intention to have a lighter lecturing schedule during the periods when prototypes are being constructed.

- Overview of this year's contest and review of shop layout and safety rules (2 lectures)
- Review of structured design methods (1 lectures)
- Simple modeling of motors and transmissions (2 lectures)
- Review of fluid dynamics of propulsion (1 lectures)
- Buoyancy and stability of lighter than air vehicles (1-2 lectures)
- Review of Solidworks (2 lectures)
- Review of CAM/CNC (1-2 lectures)
- Description of servomotor mechanisms and operation (1 lecture).
- Basic mechanism design and analysis (1-2 lectures)