ME 71 Final Project Guidelines
(Preliminary Version)

1 Overview and Bureaucratic Details

The goal of the final project is to give students a reasonably complete experience with the design process from initial concept to prototype. As discussed below, the final projects will fall into one of the following three categories:

- A *preapproved* project that is chosen from a list of projects. These projects have all been successfully attempted by previous ME 71 students. However, there are enough creative ways to approach these projects that there is ample room for your own innovation.
- A *sponsored* project that is chosen from a small list of projects. These project concepts are "sponsored" by outsiders who seek to have students build a prototype. As we have discussed in class, a prototype is meant to answer a question, and to reduce uncertainty.
- A *self-selected* project that is chosen by you or your team members. Given the limited time available such for the final projects, projects in the self-chosen category have additional constraints on timing of the key deadlines and the nature of the chosen project.

Note that none of the final projects have a competitive nature. First, you must choose the category that best suits your interest and schedule. Second, you need to determine the number of members in your "design team." Generally, we encourage people to work in teams of two. However, because of the small class size this year, there is ample shop time to support individual projects. Group projects involving more than two students are allowed with our consent. The quality of the group projects should be proportional to the number of students involved.

2 Final Project Time Schedule and Deliverables

The remainder of this section describes the key deliverables and timelines for the final project.

1) Preliminary Project Proposal. The preliminary project proposal is intended to describe your project concept in enough detail so that it can be evaluated for the purposes of project approval. This project proposal will consist of:

(a) A verbal description of your project and its intended operation. Accompanying conceptual sketches or cartoons to describe the operation of your device are a welcome addition.

(b) A discussion of the overall objectives of your project, including an objective tree. What are the principal criteria by which you can say that you have a good design?

(c) A list of the major functions and subfunctions required to meet your objectives.

(d) A 3-D perspective sketch of one possible design solution for your project, clearly identifying the major components of the mechanism and their relationship. Dimensions are not required. Note, your are not committed to using this design alternative for your final design.

This list of pre-proposal content is general, and certain components will be more or less important for each project category.

Due dates for the preliminary project proposal are:

- **Wednesday, May 18:** self-chosen projects (individual or team), and solo projects (sponsored or pre-approved).
- **Thursday, May 19:** all others.

NOTE, the act of submitting a pre-proposal that outlines a project of your own design DOES NOT automatically guarantee approval of your final project subject matter. We will notify you of acceptance of your project subject and project scope on May 19 (for pre-proposals turned in on May 18) or May 20 (for pre-proposals turned in on May 19). To facilitate fast turn-around of your project evaluation, it is imperative that you submit the email address of at least one of your team members, and make sure you check your email frequently during this period.

2) Project Conceptual Details. To follow up on the preproposal, you should next complete these items:

(a) A list of relevant specifications and constraints for the project's objectives and functions.

(b) A morphology chart that lists several alternative means to implement the functions and objectives specified in your project proposal.

(c) A brief evaluation of the merits and disadvantages of your morphology alternatives.

(d) A 3-D perspective sketch of your best candidate solution.

(e) A list of the materials required (e.g., aluminum stock, plexiglass, gears, dowel pins, etc.).

Due date for the project details:

- **Tuesday, May 24:**

3) Preliminary Design Review. All teams should prepare and present a poster describing their final project.

- **Thursday, May 26.**

The poster should describe your project idea, the basic objectives of your project, and a sketch of your best project idea to that date.

4) Engineering Drawings. All teams should submit a complete set of engineering drawings of major every part that is to be fabricated. Important tolerances should be noted. It is very likely that the geometry of some or all of your parts may change during the course of fabrication. However, John and Rodney *will not* let you fabricate any part in the machine shop unless you have a drawing for that part.

Due date for engineering drawings:

- Friday, May 27.

5) Major Piece Fabricated. At least one major fabricated piece must be demonstrated to John or Rodney. They will record your demonstration.

- **Due date:** Tuesday, May 31 2005.

6) Final Project Submission: The final project is due at 1:00 p.m. on the last day of finals (June 10, 2005). Your project should be left at the shop. Your final project submission will consist of:

1. your fabricated device.
2. your "design notebook." (see below for details)

There can be no exceptions to this due date. Students who do not complete the project by this date will receive a grade based on the portion of the project that is completed at that time. Incompletes may be given for valid reasons, but must be accompanied by a letter from the dean of students explaining why you deserve an incomplete. Students who do not complete the project because of poor planning will not be given the incomplete option.

Because the final project follows very tight deadlines, and because the grading and recording of your various submissions takes some time, it is highly desirable that your turn in photcopies of your submissions and keep the originals in your design notebook for reference.

3 The design notebook

To facilitate grading of the final projects and organization of your efforts, each team member is required to maintain a section in their design notebook that is dedicated to the final project. At the bare minimum, the notebook should catalog the essential information about your project. Preferably, the notebook should also record the significant evolutionary changes in your design. The final contents of the design notebook must include:

- An updated set of drawings showing final dimensions of your completed project.
- A final description of your project. You should note any significant changes from your original concept, and why those changes were necessary. You should discuss both the positive and negative aspects of your design, and how well it met your original objectives. If given more time to work on your project, how would you redesign your solution to improve its "value," and/or make it easier to produce.

Your notebook should also include:

- any calculations relevant to the design of your project.
- the records of any conceptual exercises that were carried during the design of your project.
- sketches or descriptions that help to describe the thought process behind evolutionary changes in your project.
- "fabrication notes:" notes on issues that arose during the fabrication of your project, and how you solved those issues.

4 Final Project Grading

Based on a total of 100% for the final project score, each of the activities described above will contribute as follows

- Pre-proposal: 2.5%.

- Project conceptual details: 2.5%
- Preliminary design review (poster): 5.0%.
- Engineering drawings: 5.0%
- Major Piece Fabricated: 5.0%
- The submitted final project: 70%. This grade is broken down as:
  - 40% for the completeness and thoroughness of the mechanical design. This will include: (1) quality and originality of design concepts; (2) appropriateness of your mechanical layout; (3) attention to detail.
  - 30% for the quality of the fabrication. This will include: (1) quality of the finish and appearance of your device; (2) smoothness of operation (for moving parts); (3) tightness of tolerances and interference for mated parts.
- Design Notebook: 10%. We are looking for documentation of the design process. Good notebooks will contain notes from brainstorming sessions, and adequate documentation of the evolution of the project design and fabrication process.

5 Final Project Materials

For your final project, you can use materials that are stocked in the M.E. shop. Some of you will need items which aren't maintained in the M.E. shop. Each student has a budget of up to $30 to obtain supplies from the central receiving warehouse. The cost of any components above the $30 limit will be born by the design team members, as will be the cost of any materials purchased outside of Caltech.

6 List of Pre-Approved Projects

Below are some suggestions for the final project. In each case, you are to design, build, and demonstrate a working device. The projects are loosely stated so as to leave sufficient leeway for individual creativity and initiative.

- **Can Crusher**: Design a human-actuated mechanical device to crush aluminum soda cans for recycling purposes. Quality designs will be visually appealing, require a minimum of human effort, be easy to use, take up a minimum of space, provide thorough and safe crushing of the can, and appear to be durable .
- **Multiple-speed transmission.** Design a transmission for the the drag wheel/motor combination used for the transmission design contest. You must design a transmission

that uses at least two different "speeds" (or gear ratios), or a variable speed transmission. The "gear shifting" behavior must be performed automatically by your device. That is, you can not manually change the speed ratio during operation. All of the contest rules will be in effect, except as follows. Because the automatic shifting mechanism may occupy significant space, your device need only fit inside a 6 inch $\times$ 12 inch $\times$ 12 inch volume. The critical 6 inch dimension is defined by the distance between the motor and wheel mounting shafts.

- **Fly-ball Governor**: Before the advent of electronics, the speed of steam powered engines was often regulated by simple mechanical devices, such as the fly-ball governor. As the rotation of the shaft increases, the centripetal acceleration of the rotating masses increases, causing the spring to shorten. The movement of the spring was coupled to a valve so that as the spring shortened, the valve closed, reducing the amount of steam into the engine cylinder, thereby decreasing the amount of power produced by the engine. Design and fabricate a fly-ball governor whose spring will deflect approximately one inch when the shaft is rotating at 360 rpm.

- **Card Shuffler.**

7 Self-selected Projects

Individuals or teams can select their own project concept, subject to the constraints outlined above. Some optional projects from previous years were: (1) Cam operated rock climbing aide; (2) one way clutch mock up; (3) adjustable and collapsible foot stool; (4) folding guitar stand; (5) sheet music stand; (6) a hand-pull golf cart.

Note, **we will not** approve any project which might potentially be used in a way which is harmful, illegal, or in violation of the Caltech honor code.

8 Sponsored Projects

These will be described in an upcoming handout.