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2.007 Design and Manufacturing I  
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## ME 2.007 SECTION 00

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### 1. REVIEW 2 - DESIGN SELECTION, ANALYSIS, DETAILED DESIGN, AND FABRICATION PLAN

On *Monday March 16<sup>th</sup>*, we will have informal presentations in which we will review the component(s) designed and fabricated thus far.

1.1. **Topics.** Recall that in our first review, we covered three things you should have completed in the *first* three weeks:

- (1) Your overall strategy for the competition
- (2) Key tasks or functions implied by these strategies
- (3) Preliminary design concepts to accomplish these tasks

Presentations in our second review are expected to cover four things you have worked on in the *second* three weeks:

- (4) **Selection of Design Concept(s)**
- (5) **Analysis and Detailed Design of the “Most Critical Module” (MCM)**
- (6) **MCM Fabrication Plan and Process**
- (7) **MCM Detailed Test Plan and Results**

The goal is to have *fabricated and tested the MCM by Spring Break*, the last week in March.

1.2. **Format.** Presentation format is up to you, and I suggest some content below. You must be able to discuss (4-7) in the allotted time (see “Schedule” below).

1.3. **Schedule.** Every student will get a *12 minute* slot to present, with *9 minutes* for presentation and at least *3 for questions/discussion*. I will allow a *maximum* of 9 minutes for presentation so that *some* discussion occurs. I will ask you to stop presenting at 9 minutes and if there are questions on what you have covered, these will be addressed.

On March 16<sup>th</sup> we will go by the following schedule:

- 1:05-2:00:** *Boston* (Ben, Steve, Toomas, & Vixit)  
**2:00-3:00:** *McCormick* (Kam, Rachel, Jon, Arin, & Arielle)  
**3:00-3:50:** *BC-KS* (Jamie, Emily, Vibin, & Dan)

Note that we will start *exactly* at 1:05. Be in lab and ready.

1.4. **Content.** The following is an outline of the content that will be required to address (4-7).

- *Selection of Design Concept.* Some of you have elaborated multiple concepts that will help you undertake your contest strategy. It is time to pick a single concept to move forward with. Select one design concept from your options in the most objective fashion possible. List out the expected benefits and concerns with each concept, and compare these against one another. A Pugh matrix will help organize this process. These were introduced in lecture and a variety of resources are available on the web; for example, at  
<http://www.isixsigma.com/library/content/c041108a.asp>  
 or <http://lssacademy.com/2007/06/19/the-pugh-matrix/>  
 or <http://web.archive.org/web/20080416235931/http://www.sixsigmafirst.com/PughMatrix.htm>

If you look at these sites (which I *strongly* recommend): We haven't done Quality Functional Deployment (QFD), but "user requirements" are, here, the specific functions/tasks your machine must accomplish. Regarding the "Voice of the Customer" (VOC), you are the customer, so ideally you know your "voice."

- *Selection of MCM.* Choose the component or assembly that you believe is *most critical* to the success of your machine concept, and design it in substantial detail. This criticality may come from the component's centrality to your strategy, or you may perceive this component as the most difficult to design and fabricate. Think carefully about your concept and what is most critical. Designing this component in substantial detail means choosing all dimensions and materials from the kit (see "Engineering Details" below). You need not build the MCM yet – that activity is scheduled over the next weeks and culminates in a demonstration on March 16<sup>th</sup>.
- *Engineering Drawings and Details.* Sketch the MCM clearly in "standard engineering fashion." That is, create a standard three-view drawing with top, front, and side views. Clearly identify all relevant dimensions, kit materials, fastening details, mechanism kinematics, etc. for the components and its sub-components. These can be symbolic labels (e.g.,  $h_1, h_2, \ell_1, w_1 \dots$ , etc) , with actual numeric values tabulated elsewhere. For example, symbolically label all dimensions and tabulate them in an Excel spreadsheet (I *strongly* recommend this approach, which will greatly help organize your analysis too). If you have correctly elaborated all details and drawings it is possible for a stranger to look at your documentation and re-create your object.

You may include an isometric view if you like, and this drawing does not need to be labeled unless there is some aspect of the design clearly demonstrated by this view and not the others.

If there are significant sub-components, these must be sketched in the same fashion. You do not need to sketch kit materials again, but reasonable sub-assemblies of kit materials should be drawn separately.

- *Analytical Modeling and Experimentation.* Make some analytical predictions about the performance of the MCM, as designed, and identify what decisions you have

made based on your calculations. Have you chosen a material because it will be strong enough or light enough? Have you chosen a particular dimension because it will generate a sufficient mechanical advantage? Have you picked one servo and not another because of a required torque output? You don't have to analyze every aspect of the MCM, just those aspects that most benefit from analysis. Please ask me if you are unsure about how to analyze some aspect of your design.

A few "universally" important questions are:

**Forces/Torques:** Draw free-body diagrams for your MCM in various stages of operation. What forces/torques are required for the MCM to accomplish its task? How will these be generated with the kit materials? How much mechanical advantage are you using?

**Energy:** How much energy will be consumed by the MCM for it to accomplish its key task? How much of your energy budget will be consumed by the MCM during one round of play?

**Motion:** What displacements (linear and/or rotational) are required in MCM mechanisms? How fast can these displacements be made?

**Failure:** Will any of your materials deform elastically? Plastically? Fail entirely? What is your factor of safety against these failure modes?

If you are unsure about how to undertake these analyses, you can ask me. You can also discuss this with your peer group, or other students in the class (properly referenced in your notebook).

Experiments (e.g. can crushing, friction measurements) can be very important in guiding your thoughts on these questions and providing needed parameters for your analysis. Clearly describe any experiments you have done to inform your design of the MCM. Expect to test the MCM itself (or sub-components) to validate your calculations.

1.5. **Brief Report.** Please prepare a brief report on (4-7) that you can hand out to your peer group and myself.

While there is no page requirement, I would guess about 2 pages of straight text, and 5-6 pages including (detailed) sketches. Being concise can help. The overall format is not important, so long as you present a convincing argument for your strategy and concepts. For example, you can photocopy pages from your lab notebook, as long as we can all follow the logic of your argument contained there.