2.007 Design and Manufacturing I
Spring 2009

Milestone 4

Design MCM and Build Final Car

Schedule for: week of 23 - 27 February.
Deliverable: 6-8 pages in your lab notebook turned in before next week's lab as scheduled

Week's Activities

The plan this week is to continue moving forward toward the **major milestone** of "Demonstrate MCM." Since the last day before spring break is Friday, March 27, you have four weeks to design, fabricate, test, and then demonstrate your MCM. This week you'll also build your final car, so as soon as your MCM is fabricated, you can mount it on your platform and drive with it.

"Demonstrate" means that, with your MCM mounted on your vehicle, you will drive out of the Starting Box and perform, according to your 60 second time line, the functions assigned to your MCM by your strategy and concept.

Then after vacation, you will complete and integrate your other modules, and refine your MCM, as appropriate to implement your complete strategy.

1. Design MCM

Since this is the first time you have been asked to do design in 2.007, it's worth dwelling briefly on what a design is. In a technical sense a design is simply that set of information necessary and sufficient to build a "product." As stated in last week's milestone, the level of information you provide to document your design should be sufficient so that a 2.007 classmate, one of the lab guys, could build the design and have it work without having to ask you questions like, "What is this material here?" or "I don't know what this dimension is," or "Hey, this doesn't fit." Of course you will fabricate your MCM yourself in 2.007, but typically in industry the prototyping and fabrication will be done for you. So it is essential that your design definition be a good piece of technical communication. In industry this set of information is often called a "Design Release."

From the process point of view, Design (sometimes called detailed design as we are using the term here) is the process of moving from the Design Specifications to the physical embodiment of the product which will meet these specification (or requirements) in as effective, efficient, and robust manner as possible.

You have many options from the materials and parts in 2.007, so this is a time to be very and imaginative. Again it's always good not to jump to conclusions, but to evaluate a number of possibilities? Think about different ways to implement the arm. Come up with multiple options and do a quick Pugh chart to compare and decide. Clearly you want a strong arm but at the same time a light arm to minimize rotational torque requirements, etc.

What are the materials and parts and actuators to be used? How are they to be cut, formed, transformed, joined, assembled, etc.? Now as you start homing in your design, you should simultaneously be doing the relevant calculations. For example as your arm design emerges, estimate its moment of inertia. Now you can calculate the torque to rotate it according to your specifications. Then you can calculate how you are going to get this torque from whatever actuator(s) you are using

Previously the kind of calculations we did were essentially feasibility calculations. For instance, it takes so much energy to lift this bale 20 cm, I have a motor that puts out ½ watt, so I can in principle lift this bale in n seconds. Now we need to calculate forces and torques. You will need to think about a) friction, b) the fact that the motor will not always operate at maximum power output, and c) safety factors. Engineering design always includes safety factors.

Start your design process by listing the basic design requirements, in a table for instance. For example, suppose in your conceptual design work you had compared a fork-lift structure, an arm with a grabber, and a rotating stacker, and had selected the arm via a Pugh chart. Write out the requirements for the arm.

Note: it's not a good engineering requirement if it can't be tested/demonstrated. Saying the arm pivot "has to be low friction" is an interesting comment, but it's not a requirement because there's nothing that be tested or analyzed. Stating friction should require no more than 20% of the applied torque is a useful specification, for instance.

Work out your design, doing calculations and experiments as necessary. Then prepare your design documentation.

2. Car (Platform) Fabrication

Last week you finalized your car design; so fabricate it this week. (You will demonstrate it next week.) You may want to take into account any last minute information from your MCM design to make changes, for instance, if your MCM turns out heavier than anticipated, you may want to carefully think through where it is mounted and the implications of this weight on driveability.

I'd like you to prepare a simple plan for the fabrication, i.e. a overview of the set of steps you will follow. Estimate times for these steps. Then keep track of the actual time it takes. (The ratio of these is an important metric, or predictor, for you.)

Milestone 2 Specific Deliverables

We are eager to see all peer groups up and running well. Those groups that did find time last week and met shared lots of good ideas, did some very interesting brainstorming, and got excellent feedback from their reviewers. Peer groups will prove to be a valuable resource for you, and I'm expecting all groups to be off and running.

1. MCM Design

1. Tabulate your design requirements as a start. 2. Provide a good sketch (no 1/8 pages sketches, please!) Show evidence how you got to the final design, i.e. alternatives considered, Pugh charts, decision criteria. Develop major properties of your design, ie weight, sizes, moments of inertias, etc. Show key calculations that you did, and the results, especially key parameters as piston bore (area), winch drum radius. 3. Provide your design release. Note: Since there have been a number of CAD lectures now, put these into practice by developing CAD (Solidworks) models of at least two key parts. Print these out and paste into your notebook.

2. Car Fabrication

Fabricate your car (platform) according to the design you completed last week. Report your car weight and both your planned implementation time and actual implementation time. What is the ratio of these?

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