CS148
Building Intelligent Robots

Week 1 : LEGO Design *Out: 2 Feb 2004*

Preliminary Tasks *before 4 Feb 2004, 9am*

The purpose of this week's lab and project is to get you acquainted with the subtleties involved in building structures with LEGO. Complete the following readings before coming to lab on Thursday:

- Martin, The Art of LEGO Design
- Martin, MIT 6.270 Notes, Chapter 4
- Baum, Chapter 4 (optional)

Lab 1: LEGO Design *4 Feb 2004*

After completing the readings, work through the following problems with your partner to gain some experience with the concepts presented there and to become familiar with the different LEGO pieces at your disposal.

0.1

Make sure you know the difference between the black and grey connector pegs. Connect two beams with a single grey connector peg and rotate one of the beams. Then do the same with a black connector peg: which one is more flexible?

Build a 40×2 beam. It should be very sturdy, and only give a millimeter or two when flexed in any direction.

0.2

Review the section 'Fundamental LEGO Lengths' from the MIT 6.270 notes. Spend time experimenting with the beams and connector pegs, using cross beams (and the 6:5 ratio) to make your structures sturdy. Now build a braced vertical structure that is at least 6×6.

Look at how diagonal beams can be used as supports. Build a right triangle using integral ratios (3:4:5, 9:12:15, etc). A piece that may be useful is the black connector that is 1.5 times the length of the standard connector.

0.3

We will be using gearing a lot throughout the semester. Two examples of its use are slowing down the speed of a motor and making the rotation sensor's measurements more precise. Spend a few minutes getting familiar with the different gears—how many teeth they have, how they mesh together, etc. Experiment with different vertical, horizontal, and diagonal spacings.

Program 1 on the RCX brick will run motor A straight forward. Attach a 24-tooth gear to the motor and then attach the motor to the brick. Run program 1 and observe how easy it is to stop the motor with your fingers.

Build a gear train that uses at least four different gear pairs and has a motor on one end and a tire on the other. Use the bushings and half bushings to secure the shafts that the gears rotate on, and make sure to support the beams well. Write down all of the gear reduction ratios and the final ratio. Now run the program again, and note how difficult it is to stop the tire.

0.4

Build the caster wheel in figure 28 of *The Art of LEGO Design*, noting which 'clichés' you use. Wheels like this can be useful in stabilizing your robot.

0.5

Making sure the RCX brick is firmly attached to your robot can be a little tricky sometimes. It is difficult to attach things to the grey bottom of the brick—pieces continually pop off. One way around this is to take advantage of the two small holes on either side of the brick to attach vertical beams which secure the brick to the base.

Build a platform with beams and attach the brick to it, using beams and the short grey connectors (they are about three-quarters of the length of the standard grey connector pegs).

Project 1: LEGO Design *due 11 Feb 2004, in class*

Specification: Now you will get a chance to practice building a fairly intricate mechanism, utilizing many of the special gears and small parts that are available. Your task is to build a gripper arm that could be used to grasp a typical paper coffee cup.

One design would be to have the arm close on to the cup, elevate it slightly, and then carry it to the final destination. Your arm does not have to be this sophisticated however; it can simply enclose the cup and drag it to the destination. Since this is purely an exercise in LEGO mechanics, you will not have to do any programming for this assignment. Your arm should meet the following specifications:

- The motion of the arm should be controlled by one shaft that you can rotate manually. If you were going to actually use this arm, you would attach it to a motor with this shaft, but you don't need to worry about that for this assignment. You are not allowed to apply any force to hold the gripper arm closed on any portion of the arm except this shaft.[1]
- The arm must have a gear train.
- The arm must be able to hold onto the cup without human assistance. The only place a human can apply force to is the control shaft, and this force can only be rotational.
- The gripping portion of the arm should be large enough to fully enclose a standard, coffee cup–sized paper cup,[2] but the overall arm should still be of a reasonable size. The robots you will build in this class are small, and an excessively large arm could easily over balance your robot.
- It should be robust. It should be able to withstand multiple openings and closings of the gripper as well as some general battering.

Paper Handin: This week's project is a chance for you to become comfortable building with LEGO and learn about the pieces available to you. In the future building will not be the focus so take advantage of this opportunity and spend time experimenting. It will be valuable later.

Your paper handin should include the following:

- Discuss the design decisions you made and the iterations that you went through. We are interested in the experimentation that you did, so include sketches of preliminary designs and failed attempts.

[1] Exercise in visualization: Pretend that you are, in fact, a tiny robot made of plastic bricks. Your hand is a little plastic motor. You, as a tiny plastic robot, cannot, for example, hold the gripper arm closed with your hands. No, this would be impossible.

[2] We're talking a normal coffee cup here, not a venti carmel macchiato or anything like that. A small Equal Exchange coffee cup would be a suitable test subject. The cup will definitely have a lipped rim.

- A detailed diagram of your final design. On the diagram, indicate the key components which drive the motion of your arm.
- A list of techniques, or ‘clichés,’ that you used. These can be from the readings or from online sources, but if they are the latter, please include references.

Grading: In class on Thursday we will expect a short demonstration of your gripper arm. Its design and structure will account for half of your grade, and the writeup will account for the other half.

in-class demonstration	
motion of gripper	30%
size	10%
robustness	10%
report	
discussion and sketches	30%
diagram	15%
list of techniques	5%