

## Challenges

Below is a list of “challenges” that you will be asked to complete during the first 6 or 7 class meetings. You should document each of the challenges in your design journal.

### Challenge 1: Kinetic Sculpture

With one or two other partners, build a *very* simple kinetic sculpture out of Lego parts that is controlled by the Handy Board with a simple Handy Logo program. The control should involve at least one motor and two different kinds of sensors (e.g., switch, light sensor, reflectance sensor). For example, one sensor might turn the sculpture on while the other might turn it off. Or you might use the two sensors to control two different kinds of motors.

Include in your design journal a description of the sculpture (including a rough sketch) and the Handy Logo program.

Here, and for almost every other challenge in the course, you may need to go through several iterations before you achieve the behavior you desire. This is not a bad thing, but an expected aspect of the design process that offers rich opportunities for learning. In your design journal, you should document each iteration of a design, indicating what worked well, what didn't work so well, and what you learned from the experience.

### Challenge 2: How Does SciBorg Follow a Line?

The first menu selection on a SciBorg Handy Board is `follow-line`. Executing the program causes the SciBorg to follow a black line. The goal of this challenge is to figure out *how* it follows the line -- i.e. to determine the algorithm used by the `follow-line` program.

You should work in teams with two or three members. Each team should have one SciBorg, a sheet of large paper, and a black marker (you may need to share markers between teams). Perform experiments with the SciBorg to deduce the algorithm employed by `follow-line`. In your design journal, document your hypotheses, experiments, and conclusions. You should include an English description of the `follow-line` algorithm that explains all the behaviors you observe, including not only the line-following behavior but also the song-playing behavior.

Pay special attention to figuring out which sensors and actuators participate in the behavior. Recall that the analog sensor display mode (which you get by turning the knob on the Handy Board past menu item 7) is a particularly good way to monitor analog sensors. You might also want to experiment with different colors of markers and papers. Can SciBorg follow a red line? What happens if you place SciBorg on black paper? On the rug?

### Challenge 3: Simple SciBorg Modifications

Here you are asked to predict the consequences of some simple modifications to SciBorg. Think carefully about your predictions and record them in your design journal. Later (maybe even the next day), test your predictions on an actual SciBorg and record your observations. Explain any discrepancies between a prediction and an observation.

- a. **Changing the Blackness Threshold.** SciBorg's notion of what constitutes a black line is determined by a "blackness threshold". You can add 10 to this threshold via the `black+10` menu option and subtract 10 via the `black-10` menu option. (Each can be executed multiple times, and each indicates the threshold number that results from the operation.) Predict what will happen if the blackness threshold is set at the minimum value

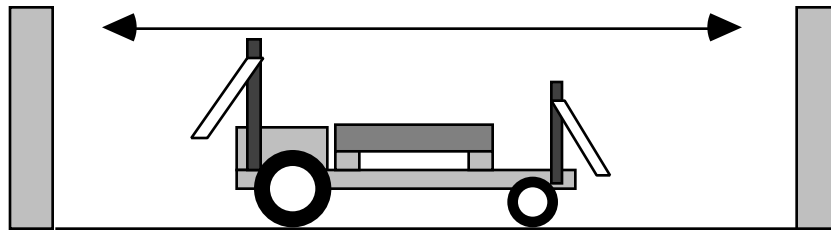
(0) and at the maximum value (250). When testing your prediction, record the range of blackness thresholds in which SciBorg exhibits the "normal" line-following behavior.

- b. Swapping Sensors** Assume that the blackness threshold is reset to its initial setting. Predict what will happen to the `follow-line` behavior if you swap the connectors in analog sensor ports 0 and 1.
- c. Swapping Motors.** Assume that the blackness threshold and sensor ports are reset to their initial settings. Predict what will happen to the `follow-line` behavior if you swap the connectors in motor ports A and B.

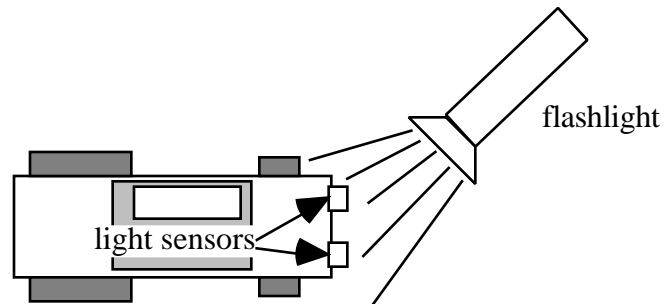
## Challenge 4: New SciBorg Programs

Below are specifications for the behavior of four new SciBorg programs. Working in teams of two or three members, implement (i.e. write Handy Logo code for) and test at least two of these programs and include the code in your design journal. You are encouraged to do more than two programs if time permits. Send your code by email to [fturbak@wellesley.edu](mailto:fturbak@wellesley.edu), so that Lyn can post the programs for others to view.

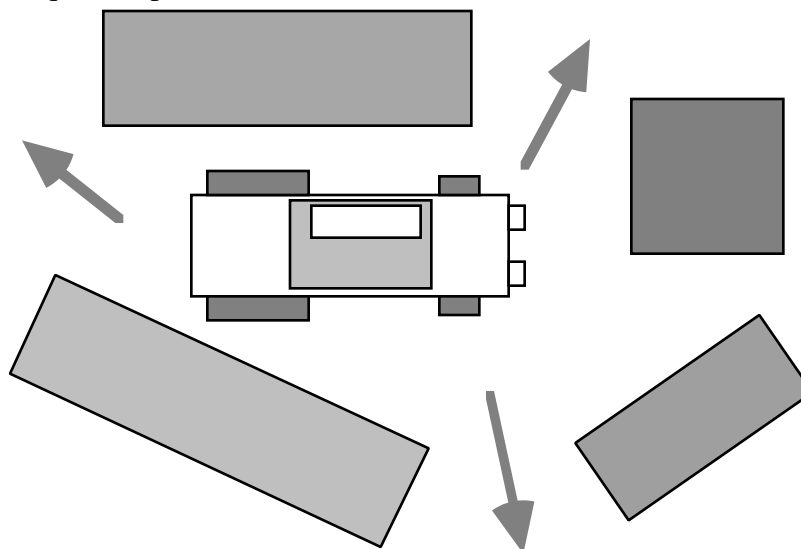
- 1. ping-pong:** Using the front and back bumper sensors, program SciBorg to bounce back and forth between two walls or obstacles.



- 2. follow-light:** Using the light sensors at the front of SciBorg, program SciBorg to follow a moving flashlight. *Hint:* test the difference between the two light sensor values. *Extra Challenge:* Have the SciBorg stop moving when there is insufficient light.



3. **escape:** Program SciBorg to find its way out of a field of obstacles. The random procedure is quite helpful here.



4. **sobriety:** SciBorg's line following algorithm causes it to zig-zag back and forth a lot. Modify the line following behavior to reduce the number of zig-zags. That is, try to make SciBorg go as straight as possible when following a straight line segment.

## Challenge 5: Sensor Interaction

On your own, or in a small group, write the following two Handy Logo programs, in which switches 7 and 8 independently control motors **a** and **b** (respectively). In both programs, the switches can be pressed in any order and any number of switches (zero, one, two) may be pressed at once. Do not use any concurrency commands (e.g. `launch`, `forever`, `when`, `every`). Test your programs to make sure they work, and include them in your design journal.

1. **ab-on-off:** Motor **a** is on when switch 7 is pressed and is off otherwise; motor **b** is on when switch 8 is pressed and is off otherwise.
2. **ab-toggle:** Pressing switch 7 toggles motor **a** and pressing switch 8 toggles motor **b**.

*Note:* `ab-on-off` is relatively easy, but `ab-toggle` is very hard. Programs like `ab-toggle` are an excellent motivation for the concurrency commands we will study next week (see Challenge 11).

*Hint:* use global variables for `ab-toggle`.

## Challenge 6: Indestructible Box

By yourself, build a Lego box that holds at least two red "weight bricks" and can be consistently dropped from a height of 6 feet without coming apart. Some of the idioms described in the handout on "Building Strong LEGO Structures" and also Fred Martin's "The Art of Lego Design" are particularly helpful in this challenge. Demonstrate your indestructible box to Robbie or Lyn and write up a brief description of your design in your design journal. As usual, you can expect to go through several iterations before you achieve the goal.

## Challenge 7: Single Motor Racing Vehicle

In a group with two or three members, design a vehicle with a single motor that can carry a 1.0 kg weight as fast as possible. You should use one of the gray rectangular motors that does *not* have

internal gearing. This will force you to experiment with building your own gear trains. It will be helpful to study the handout on “LEGO Gears and Motors” and also the section on gears in "The Art of Lego Design".

This is a non-trivial challenge that will require many design iterations on your part. You will have several days to work on this challenge. There will first be a test run in which you will pit your vehicle against others on a 2.5 meter course. On the following day final competitive event will be held. You should document each iteration of your design in your design journal.

## **Challenge 8: Communicating Crickets**

Following the guidelines the “Communicating With Crickets” handout, build your own “Dancing Crickets”. Record your experiences and observations in your design journal.

## **Challenge 9: Everyday Sensors**

Many sensors are embedded in machines, devices, pieces of equipment , etc. that you frequently use. In your design journal, make a list of ten sensors you can encounter on the Wellesley campus -- e.g., in your dorm, classrooms, common areas, outside, etc. You need not be able to see a sensor in order to deduce that it exists. Try to avoid listing simple switch-like sensors, such as light switches, mouse buttons, faucet handles, etc. The sensor may be embedded in a piece of equipment or machine, such as an automobile or photocopy machine.

## **Challenge 10: Animal Sensors**

Animals display an astonishing variety of behaviors. Many of these behaviors depend crucially on special-purpose sensors possessed by an animal. Find an animal sensor that intrigues you and write a few paragraphs in your design journal describing what the sensor is used for and how it works. Remember that humans are animals, too. You need not use more than one source of information, but you should list whatever sources you do use. It's OK to use newspapers, popular magazines and journals (e.g., Audubon, National Geographic, Natural History, Newsweek, Scientific American, Time, etc.) and articles posted on the Internet, but you are also encouraged to check more "serious" journals (e.g. Nature, Science) and books.

## **Challenge 11: Modularizing Behavior**

On your own, write the following Handy Logo programs. Use the concurrency constructs discussed in class. Appreciate how difficult the programs would be if you could not use the concurrency constructs!

- 1. ab-toggle:** Pressing switch 7 toggles motor **a** and pressing switch 8 toggles motor **b**. The switches can be pressed in any order and any number of switches (zero, one, two) may be pressed at once.
- 2. a-toggle-reverse:** Pressing switch 7 toggles motor **a** and pressing switch 8 reverses its direction.
- 3. ab-onfor:** Pressing switch 7 turns motor **a** on for one second and pressing switch 8 turns motor **b** on for one second. Each switch should be active even when the other motor is on.