

## Section Handout #1—Karel the Robot

Based on a handout by Eric Roberts

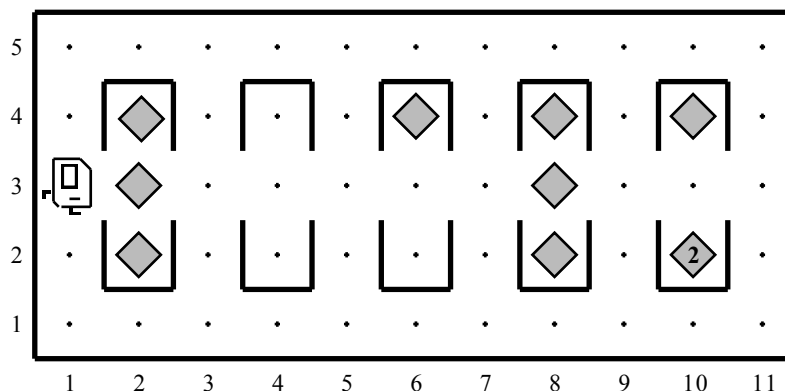
This week in section, your first priority is to meet your section leader and discover what sections in CS 106A are all about. Your section leader will therefore spend the first part of this week's session on introductions and telling you the things you need to know, such as where to get help and how to sign up for interactive grading. After the introductory material, the section will move on to cover some of the important material from class in a setting that is small enough for you to ask questions and thereby find out what you need to know. **Make sure that you get your section leaders email address in section, so that you can complete the Email portion of Assignment #1.** This week, your goal is to solve a Karel problem that involves stepwise refinement.

### Section problem. Karel defends democracy

After all the problems in the 2000 presidential election in Florida, most states eliminated the punch-card ballot problems that made *hanging chad* a household phrase at the end of 2000. The most common replacement is electronic voting machines—which have problems of their own, as we saw in several districts in the 2006 elections—largely because they do not generate any sort of voter-verifiable paper trail, making it impossible to conduct recounts or determine whether fraud has occurred.

Another possible (if fanciful) strategy for securing elections would be to retain the punch cards but to have a miniaturized robot—Karel, of course—check each of the ballots before it is counted to ensure that no unwanted chad remains. Karel's job is to move across the punch card ballot and make sure that no stray bits of the card remain in any of the ballot spaces in which the user has attempted to cast a vote.

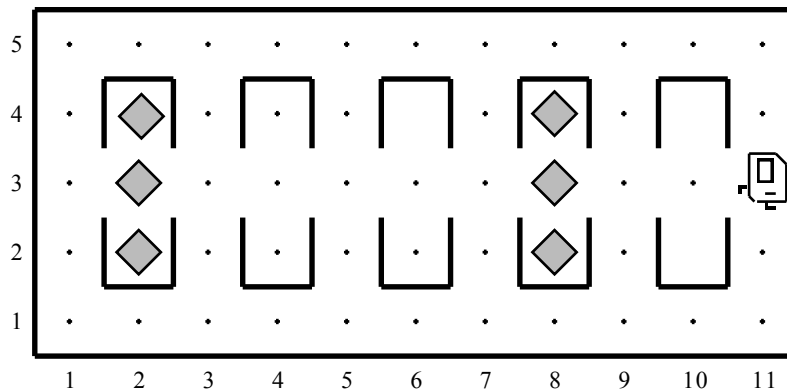
To make this task more concrete, imagine that Karel is sitting at the extreme left edge of a punch-card ballot that looks like this:



The partially enclosed rectangles in the interior of the card represent the areas of the ballot that voters must punch out to record their preferences. On the original ballot, these rectangles are completely filled with beepers, as shown in the ballot rectangles on 2<sup>nd</sup> and 8<sup>th</sup> avenues. Ideally, the voter will punch out all the beepers when casting a vote, leading to an empty rectangle of the sort shown on 4<sup>th</sup> avenue. Unfortunately, some bits of the

card—the chad—sometimes end up remaining in the hole, as shown on 6<sup>th</sup> avenue, where the beeper at the top of the rectangle is still attached to the ballot. The situation on 10<sup>th</sup> avenue, however, is even worse in that the punched out beeper from the middle of the rectangle has ended up in the bottom of the rectangle, leaving two beepers on that square.

Suppose that your state legislature has determined that the voter’s intent is indicated by the status of the square in the middle of the rectangle, which is where the stylus makes contact with the card. If there is a beeper in that position, Karel must assume that the voter did not intend to cast a vote in that column and move on to the next. If there is no beeper in the center square, Karel must check the other two squares in the ballot and remove any and all beepers so that the ballot can be counted correctly. Thus, the final configuration of the ballot after Karel completes the processing should look like this:



Karel may count on the following facts about the world:

- The world consists of a single row of ballot rectangles that appear on every even intersection, as shown in the sample world. The size of the ballot, however, may be different from the one shown in the example in the sense that it may contain any number of ballot rectangles. In any case, the card will begin one square to the left of the first rectangle and end one square to the right of the last rectangle.
- Every ballot rectangle is exactly one space wide and three spaces high, as shown in the diagram.
- Karel always begins immediately to the left of the first ballot rectangle, facing the hole that gives Karel access to the voting area along the center line of the rectangles.
- Karel must finish execution facing east at the rightmost edge of the ballot.

Write a Karel program to clean the chad from a ballot. Remember that your program should not work only for the example shown in the diagram, but for any ballot that meets these conditions.