PROGRAMMING RB5X USING ROBOT CONTROL LANGUAGE WITH SAVVY

STUDENT WORKBOOK

GENERAL ROBOTICS CORPORATION GOLDEN, COLORADO
Copyright 1986

Copyright 1986 General Robotics Corporation
All Rights Reserved

No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopy, recording, or otherwise, without the prior written permission of the publisher.

General Robotics Corporation
14618 W. 6th Avenue, Suite 150
Golden, Colorado 80401

The following are registered trademarks of the companies indicated:

RB5X -- General Robotics Corporation
RB5X: The Intelligent Robot -- General Robotics Corporation
Robot Control Language -- General Robotics Corporation
RCL -- General Robotics Corporation
Savvy -- Excalibur Technologies Corporation

TABLE OF CONTENTS

STUDENT WORKBOOK

Introduction: Laying the Foundation, i
Basic RCL Commands, i
How to Use These Activities, ii

Section A: Robot Movement, 1
Activity 1: Random Movement vs. Structured Movement, 1
Activity 2: Move in a Square, 3
Activity 3: Move in a Triangle, 3
Activity 4: Move in a Circle, 4
Activity 5: Robot Pathfinder, 5
Activity 6: Animal Charades, 6
Activity 7: Rock 'n' Roll Robot, 7
Activity 8: The Robot Waltz, 7
Activity 9: Square Dance Partner, 8
Activity 10: Robot Ballet, 9

Section B: Sensing Devices, 11
Activity 1: Respond When Any Bumper is Touched, 11
Activity 2: Respond When Front and Rear Bumpers are Touched, 12
Activity 3: Respond When This Bumper is Touched, 13
Activity 4: All of the Bumper Commands Together, 14

Table of Contents

Activity 5: Respond When Sonar Activated, 14
Activity 6: Measuring Sonar Distances, 15
Activity 7: Using Sonar and Bumpers Together, 16
Activity 8: Staying Out of the Way, 17
Activity 9: Exploring Infrared, 17
Activity 10: Find the Charger, 18

Section C: Audio-Visual Communication, 21
Activity 1: Sound Pattern #1, 21
Activity 2: Sound Pattern to Music, 22
Activity 3: Morse Code, 23
Activity 4: Light Pattern #1 or A Bright Idea, 24
Activity 5: Light Pattern #2, 24
Activity 6: The Festive Robot, 25
Activity 7: Putting Sounds and Lights Together, 26
Activity 8: Back to Morse Code, 26
Activity 9: New Year's Eve, 27
Activity 10: Sentry Robot, 27

Section D: Speech Programming, 29
Activity 1: Programming in Phonemes, 29
Activity 2: Repeating a Simple Sentence, 31
Activity 3: A Robot Introduction, 31
Activity 4: Deliver an Important Message, 32
Activity 5: The Robot Reminder, 33
Activity 6: The Alien Robot, 34
Activity 7: Robot Instructions, 34
Activity 8: A Conversation with Your Robot, 35
Activity 9: A Play for Robot and Two Actors, 36
Activity 10: The Robot Psychologist, 36
Phonemes, 38

Section E: The Robot Arm, 43
Activity 1: Exploring the Shoulder, 43
Activity 2: What is a Robot Elbow, 44
Activity 3: Wrist Wiggling, 45
Activity 4: Robot Grippers, 46
Activity 5: Find the Center, Find the Limits, 46
Activity 6: Eggs in the Basket, 47
Activity 7: A Robot Assembly-Line Helper, 48
Activity 8: Draw a Simple Geometric Form, 48
Activity 9: Robot Artist, 49
Activity 10: The Writing Robot, 50

Table of Contents

Section F: Putting It All Together, 51
Activity 1: Robot Patrol, 51
Activity 2: Robot Exercise Leader, 52
Activity 3: Robot Express, 53
Activity 4: Robot Vaudeville, 53
Activity 5: Robot Professor, 54
Activity 6: Robot Zoo, 55
Activity 7: Robot Butler, 55
Activity 8: Robot Host, 56
Activity 9: RB5X Says, 56
Activity 10: Multipurpose Robot, 57

Appendix 1: Robot Vocabulary, 59

Appendix 2: Phonemes, 61

ABOUT THE AUTHOR

Author Niki Delgado is General Manager of Rio Grande Robotics, Las Cruces, New Mexico. She is a former educator with a background in early childhood education, special education, bilingual education, and educational psychology.

INTRODUCTION

LAYING THE FOUNDATION

BASIC RCL COMMANDS

Certain RCL commands are important to all robot programs. Here is a list of these commands and how to use them. It is important to read these FIRST, before proceeding to the activities, because you use these commands from the very start.

1. **PREPARE THE ROBOT:** This command goes at the beginning of all new robot tasks and "wakes" RB5X up.

2. **WAIT:** This command asks you how many seconds the robot should wait before doing something else or repeating the task. **WAIT** is also helpful when using the sensing devices.

3. **WAIT RANDOMLY:** This command lets you select the maximum time the robot waits. If you select five seconds, the robot may wait no longer than five seconds, but may continue after some shorter time.

4. **CALL:** This command asks for a name that must begin with a quotation mark. It tells the robot where to start over in the task when it has finished the original program.

5. **JUMP:** This command asks for a name that must begin with a quotation mark and must be the same as the name you selected in **CALL.** It tells RB5X to look in its memory for that spot in the program and to go back to that part of the program.

6. **BUILD AND LOAD:** Use this command when you have finished writing a robot task and want to see how it works. When you see the computer's ready message, type in **BUILD AND LOAD.** The computer asks you for the name of the task. Once you have entered the name, the computer translates your English commands into the Tiny BASIC that RB5X understands. When the task is ready for the robot, a message appears on the screen. Be sure the RS-232 cable is plugged into the robot and that the power is on. Follow the instructions given by the computer.

7. **BEGIN A LOOP:** A loop is a set of robot instructions that RB5X repeats some number of times. This command specifies where the repeated instructions start. The program gets out of the loop through an EXIT instruction some place in the loop.

8. **REPEAT THIS LOOP:** This command tells the robot where the loop ends and instructs it to go back to the beginning of the loop.

9. **BEGIN A COUNTED LOOP called (1) beginning at (2) and ending at (3):** A counted loop repeats a set number of times. You insert the loop name at point (1), tell the robot where to start counting by putting a number value at (2), and tell the robot when to stop with another number value at (3). Variable (2) can be any number, but (3) must be larger than (2) or an error occurs. Each time the loop is repeated, a "loop counter" value is increased by 1. The program gets out of the loop through an **EXIT** instruction or when the count gets to value (3).

10. **REPEAT A COUNTED LOOP:** This command tells RB5X where the counted loop ends and instructs the robot to go back to the beginning of the loop.

HOW TO USE THESE ACTIVITIES

There are two ways to use these activities. They are divided into five sections that address a specific type of robot ability with a sixth section that combines all of the different abilities to allow RB5X to perform more difficult tasks. Each section contains ten activities and each group

of activities is arranged in order of difficulty or complexity, with Activity 2 building on what you have learned in Activity 1.

You may complete each section before going on to the next or you may complete Activity 1 in each of the six sections before going on to Activity 2 in each of the six sections. In the latter case, you may want to use commands from other sections.

You will want to save on diskette most of the tasks you create because this gives RB5X many useful and entertaining things to do as well as making your future programming of the robot faster and easier. As you proceed through the activities, you will see how this works.

SECTION A

ROBOT MOVEMENT

ACTIVITIES

1. Random Movement vs. Structured Movement
2. Move in a Square
3. Move in a Triangle
4. Move in a Circle
5. Robot Pathfinder
6. Animal Charades
7. Rock 'n' Roll Robot
8. The Robot Waltz
9. Square Dance Partner
10. Robot Ballet

ACTIVITY 1:
RANDOM MOVEMENT VS. STRUCTURED MOVEMENT

What is random movement? Movement that seems to have no purpose or reason -- it just happens.

2 / Section A: Robot Movement

What is structured movement? Movement with a purpose. For RB5X, it is movement that you have programmed that makes RB5X do a certain task.

When would you want the robot to use random movement? When you don't want the robot to seem to pick favorites, when you want it to explore its environment, or if you want the robot to appear to be "doing its own thing."

When would you want the robot to use structured movement? When you have an exact place that you want the robot to go or a special set of movements you want the robot to do.

New Robot Vocabulary

1. MOVE RANDOMLY
2. MOVE TIMED FORWARD
3. MOVE TIMED BACKWARD
4. PIVOT ON LEFT CLOCKWISE
5. PIVOT ON LEFT COUNTERCLOCKWISE
6. PIVOT ON RIGHT CLOCKWISE
7. PIVOT ON RIGHT COUNTERCLOCKWISE
8. STOP ALL MOTION

Let's Practice

BUILD AND LOAD the program called X BETA. See what RB5X does.

Let's Experiment

DEFINE a task using the eight commands above and any commands from the Introduction that you think you need. Using BUILD AND LOAD, see what RB5X does. Do you like X BETA or your own task better?

Let's Experiment Some More

Rearrange the movement commands in your task. See how many different ways you can make the robot move.

ACTIVITY 2: MOVE IN A SQUARE

RB5X can move in any pattern you like. Let's think about how we would get the robot to move in a square. What do we know about squares? All four sides are the same length and all corners are 90 degree angles.

New Robot Vocabulary

1. MOVE DISTANCE BACKWARD for this many feet:
2. MOVE DISTANCE FORWARD for this many feet:
3. SPIN CLOCKWISE this many degrees:
4. SPIN COUNTERCLOCKWISE this many degrees:
5. SPIN LEFT 90 DEGREES
6. SPIN RIGHT 90 DEGREES

Let's Experiment

Decide how big a square you want the robot to make. If you want to check for accuracy, you can either make the square on the floor or draw it on a large piece of paper. Now DEFINE a task using commands that let RB5X make a square pattern. Did the robot do what you wanted?

Let's Experiment Some More

EDIT the square task. Have RB5X retrace its path, only by moving backward. (What other commands do you need?) Once your robot is moving forward and backward accurately, add commands to let it move to a different position before each square movement.

ACTIVITY 3: MOVE IN A TRIANGLE

Now RB5X can move in a square forward or backward. Let's see if you can make the robot move in a different pattern. Try a triangle. For this pattern, you can use the same robot vocabulary used for the square.

Let's Experiment

DEFINE a new task for the triangle. Try an equilateral triangle first, where all three sides are the same length. How many degrees does the robot have to spin at each corner to arrive back where it started?

Let's Experiment Some More

Now that the robot can make a triangle over and over in the same place, after each complete triangle, have the robot move so it can make the following pattern:



How do you change the degrees for each new part of the pattern?

A New Approach

Write a program that lets RB5X make a triangle that has sides of different lengths. What happens to the degrees at each corner or angle?

ACTIVITY 4: MOVE IN A CIRCLE

This job requires some thinking. There are several ways to have RB5X move in a circle. Before you start, stop and think how RCL with Savvy works. It might make the job more efficient. To check for accuracy, draw a large circle on a BIG piece of paper. You use the same robot vocabulary you used to make the square and the triangle.

Let's Experiment

DEFINE a new task for your circle. Put the robot on a point of the circle you have drawn. Experiment with the commands to make the robot follow the line. Does it seem to take a lot of commands?

If it does, there is an easier way. Think about how RCL works again. Also, think about the ways in which you can use loops within your program.

Let's Experiment Some More

Now that the circle is easy for RB5X to make, combine the tasks for circle, square, and triangle in any order you like to have the robot make an interesting pattern. If you used JUMPs and CALLs, you have to do some editing of each task. Also, think how many times you really need to PREPARE THE ROBOT.

NOTE: Figuring out how many degrees the robot should spin is really quite simple. You know there are 360 degrees in a circle. All you need to do is decide how smooth you want the circle to be. The more small spins you include, the smoother the circle. Find a number that divides evenly into 360 (8, 10, 20, 40, etc.). The remainder (45, 36, 18, 9, etc.) is the number of degrees the robot needs to spin each time. The size of the circle depends on how far you tell RB5X to move forward between each spin.

ACTIVITY 5: ROBOT PATHFINDER

Robots don't have to go in symmetrical patterns all the time. Sometimes you might want a robot to go from one place to another and that's all. So let's send RB5X on an errand.

Let's Experiment

On a very large piece of paper (at least 10' x 10') draw the floor plan of your house, a map of the streets you use to go to the nearest store, or a map of some other place with which you are familiar. RB5X needs to get from one side to the other without going through walls or running into obstacles. Now DEFINE a new task and using the commands you already know, write a task that lets the robot get where it is supposed to go. Did RB5X make it without "running into" anything?

Let's Experiment Some More

Now that the robot knows how to get where it's going, add to your task so that the robot can safely come back to the starting point. You might want to add a WAIT between the two parts of the task.

ACTIVITY 6: ANIMAL CHARADES

You know how to teach the robot to go from place to place and to make several patterns. Let's teach the robot to imitate some different animals. (Try to pick animals that have very distinct types of movements, such as a snake or a duck.)

New Robot Vocabulary

1. PICK A RANDOM DIRECTION

Let's Experiment

Think about the first animal you picked. How does it move? What are its most distinctive movement patterns? How does it move when it gets excited? What commands that you already know can you use to make the robot move most like the animal? Why would you want to use the command PICK A RANDOM DIRECTION? Remember the very first part of Activity 1 in this section? DEFINE a task and try out your ideas. When you are satisfied with your first animal, DEFINE tasks for all of the other animals.

Let's Experiment Some More

When you are satisfied with all of your animals, put the tasks together the same way you did with the patterns. Try them out on your friends to see if they can guess what RB5X is doing. You might want to put a WAIT after each set of animal movements so your friends have a chance to guess what animal is represented by each task.

ACTIVITY 7: ROCK 'N' ROLL ROBOT

If RB5X can imitate different animals, why can't it dance? Let's see if you can turn the robot into a really flashy dancer. Rock 'n' roll dancing gives you the opportunity to let the robot use a lot of free movement since there is really no one, right way to do it.

New Robot Vocabulary

1. SPIN AROUND CLOCKWISE this many times:
2. SPIN AROUND COUNTERCLOCKWISE this many times:

Let's Experiment

Pick some music that you think you and RB5X will like. Think about the way people who are really good at dancing to rock 'n' roll music look. What kinds of movements do they make? Now think how these movements go with the music you have picked? You might want to close your eyes and imagine how RB5X would look moving to the music you are using.

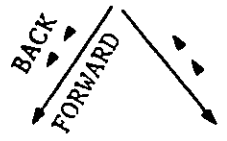
Now DEFINE a task and start programming your "steps." You will probably want to use WAITs to help the robot keep time to the music. Be sure to try the new commands. They will add a lot of flash to RB5X's routine.

ACTIVITY 8: THE ROBOT WALTZ

You can see that RB5X has some talent as a dancer! So do you, for that matter -- you're the one who is teaching it. Now let's teach the robot a dance that is a little more structured. Suppose RB5X is transported back in time. The robot finds itself at a grand ball in honor of the king and queen. To keep from seeming out of place, RB5X needs to know how to waltz right along with the other guests.

Let's Experiment

Pick some waltz music, the kind that has a very strong 1---2,3 count. Remember that when people waltz, they usually make one long movement to the front or side and two short ones back to where they started. You might want to draw a pattern on a piece of paper:



Sometimes people add some spins to the waltz, all the time keeping to the 1---2,3 beat. You could have RB5X do these too. Now that you have your music and your pattern, think about how far the robot should go to follow the pattern and keep time with the music. Remember that WAITs and SPINs can help you keep RB5X in time with the music.

DEFINE a task, put the movements in, and see if your calculations are right. Would RB5X fit right in at the royal ball or would it stand out like a sore thumb?

ACTIVITY 9: SQUARE DANCE PARTNER

It's time that you put RB5X to practical use. Why not have it be your square dance partner? If you know something about square dancing, you can use some steps that are authentic. If not, just invent your own. Remember that there is a lot of moving forward and back, and a lot of turning.

Let's Experiment

Pick out some music. The best would be a piece of square dance music that includes the calls. If you don't have any, just pick some lively music that has a "country" flavor to it.

Plan the figures that you and RB5X will perform. It is easiest to draw these on a piece of paper. Count the music to see how long the robot needs to perform each move. Remember, the robot can't change its mind in the middle of a pattern. Only you can do that.

Now DEFINE a task and program in the commands that allow the robot to execute the figures. Have RB5X perform its part to the music. See if it is in time. Adjust your program where needed. Now are you ready to try square dancing with RB5X? How did it turn out?

ACTIVITY 10: ROBOT BALLET

Now you know all of the major movement commands that RB5X learned before it left the factory. You are ready to teach the robot something quite spectacular. Let's "choreograph" a ballet for RB5X. If you like, you can even make the robot a costume to wear for its performance.

Let's Experiment

Pick out some music. It can be lively or serene, whichever you and RB5X prefer. Now, think of your stage as being 5' x 5'. Listen to the music and visualize your robot as the star performer, moving gracefully to the music. It may help to draw the patterns you see on a piece of paper before you start to write the program.

Using all of the techniques you have learned, DEFINE a task for the robot. Try to use as many movement commands as you can, and try out your task at several stages to see if it is really what you want. There might even be a place for some random movements, since ballet dancers seem to wander around the stage aimlessly from time to time.

Remember that you may be able to incorporate some previous tasks in the ballet. When you are finished and are satisfied with RB5X's performance, invite some friends to enjoy the dance concert with you.

SECTION B

SENSING DEVICES

ACTIVITIES

1. Respond When Any Bumper is Touched
2. Respond When Front and Rear Bumpers are Touched
3. Respond When This Bumper is Touched
4. All of the Bumper Commands Together
5. Respond When Sonar Activated
6. Measuring Sonar Distances
7. Using Sonar and Bumpers Together
8. Staying Out of the Way
9. Exploring Infrared
10. Find the Charger

ACTIVITY 1:
RESPOND WHEN ANY BUMPER IS TOUCHED

Robots are designed to help people. Robots should know how to use good manners and not just run around doing things out of control. You need some ways to tell the robot when it should start to do something and when it should stop. Here is one way to help RB5X behave.

New Robot Vocabulary

1. EXIT IF ANY BUMPER TOUCHED
2. BEGIN A LOOP
3. REPEAT THIS LOOP

Let's Experiment

Combining some movement commands, try to get the robot to perform these movements only when a bumper is touched. Think about where you should put the new commands in your robot task. Be sure to precede the command with START A LOOP and to follow it with REPEAT THIS LOOP. See if RB5X does what you expected.

Let's Experiment Some More

Now you have the robot doing its job only when it is told to. See if you can use the same command to also make the robot stop doing its job when it is told to. (HINT: EDIT the same task and decide how many times you should use the commands and where the commands should go. The WAIT command can be very helpful here.)

ACTIVITY 2: RESPOND WHEN FRONT AND REAR BUMPERS ARE TOUCHED

RB5X uses its bumpers in a variety of ways. It would be nice to tell the robot to do something only if a certain event occurs. Here is one command that allows you to do this.

New Robot Vocabulary

1. EXIT IF FRONT+REAR BUMPER PRESS

Let's Experiment

EDIT the task that you used in Activity 1, "Respond When Any Bumper is Touched." Replace one of the EXIT IF ANY commands with the new EXIT command. Which command would be the most logical to replace? Remember that you must touch the front and rear bumpers at the same time for RB5X to fully understand you.

Let's Experiment Some More

Using the same task again, add some more to it (other movements). At some point, use the STOP ALL MOTION command and then have RB5X wait to have the front and rear bumpers pressed before it continues. What kind of an effect does this give? Imagine what some good uses of this command might be.

ACTIVITY 3: RESPOND WHEN THIS BUMPER IS TOUCHED

Here is a way to tell RB5X to do something specific only if a certain bumper is pressed. This can be very helpful in writing robot tasks. It makes RB5X seem to be thinking about different things to do and making choices of behavior on its own.

New Robot Vocabulary

1. EXIT IF THIS BUMPER is touched: (#)

Let's Experiment

As you have noticed, RB5X has eight bumpers, which are numbered one through eight if you start with the bumper under the sonar and count in a clockwise direction.

You can use the new command to address any of the bumpers. You can have each bumper call up a different robot activity. EDIT the task used for Activity 2, "Respond When Front and Rear Bumpers are Touched." In each of the places where you call for bumpers to be pressed, substitute the new command and select a different bumper for each robot activity. See what happens.

Let's Experiment Some More

Now that you see how this works, add enough different activities to use all eight bumpers. What kind of an effect does this give? What are the limitations of this command?

ACTIVITY 4: ALL OF THE BUMPER COMMANDS TOGETHER

Now you know how each of the bumper commands works. Is it possible to use any or all of these commands together? There are some things to consider as you start to use many different kinds of bumper commands in one task. It is important that you use the commands in a logical order and that you use different commands for different kinds of robot behavior.

Let's Experiment

Think of the things you have already done. What is the basic command that puts RB5X on its best behavior? Which command is the least likely to be figured out by someone unfamiliar with the robot? How did you make the robot appear to decide on different kinds of behavior? Now how could all of these commands be put to good use in one task.

Design a series of activities for RB5X, with each activity starting with a bumper command. Decide which kind of bumper command is best for which activity. Write your task and see how the robot performs. It might be helpful here to have your robot task displayed on the screen while you watch the action. After you have used your task for a while, decide if there are ways it could be improved. Make any changes and try again.

ACTIVITY 5: RESPOND WHEN SONAR ACTIVATED

RB5X's sonar can detect objects and movement in front of the robot, allowing the robot to avoid them. This saves

wear and tear on RB5X, you, and the furniture! It also allows RB5X to move with more intelligence and to perform jobs like sentry duty.

New Robot Vocabulary

1. EXIT IF SONAR distance value is less than:

Let's Experiment

DEFINE a new task. Let's see if you can use the new command to make RB5X a sentry robot. How could the robot tell us if something had moved in front of it? (Remember that the sonar can be programmed to scan different distances: the value 95 is about 14-1/2" in front of the robot. Values smaller than this aren't as accurate.)

The use of the new command is similar to the bumper commands, but the results are different. See if you can find out how they are different. Follow your program closely while watching what the robot does.

Let's Experiment Some More

Now, use the sonar as a collision-avoidance aid. You can either DEFINE a new task or EDIT one of your previous tasks that includes forward movement. Use the commands that allow RB5X to "see" what is in front of it.

ACTIVITY 6: MEASURING SONAR DISTANCES

Now you have an idea of how RB5X "sees" objects in front of it. Different numerical values allow the robot to see things closer or farther away. Discovering what those values are is up to you.

Let's Experiment

Try setting the SONAR DISTANCE VALUE in your last program with different numbers. Try both smaller and larger numbers. Have something move in front of the robot and

measure where the robot "sees" the movement. Make notes of these different numbers and what they mean.

Let's Experiment Some More

Now you know what makes RB5X "see" things at different distances, find out what kinds of things RB5X can see. Can the robot see something move in front of it that is as small as a human hair? Can it see something as large as a chair? Can it see things that are transparent? When can it see these things? How do you think you can use this ability in other tasks?

ACTIVITY 7: USING SONAR AND BUMPERS TOGETHER

How can we combine sonar and bumpers to have RB5X respond to its environment in a more intelligent way? It would be nice if the robot could respond in the same manner regardless of whether it "sees" or "feels" something. There is a way to do this with the commands you already know.

Let's Experiment

Think of the ways you have used the EXIT commands. How could you use these commands in a robot task to get RB5X to respond either to an object in front of it or to touching something? Think about the way you have already used LOOP commands.

What would happen if you used more than one type of EXIT command between BEGIN A LOOP and REPEAT THIS LOOP? Either EDIT one of your previous tasks or DEFINE a new task and try using this arrangement. How does RB5X respond?

Let's Experiment Some More

If you didn't use the EXIT IF THIS BUMPER command in the task you just wrote, use it now to change the way RB5X performs that task. Which way do you like it best?

ACTIVITY 8: STAYING OUT OF THE WAY

It would be very handy for both you and RB5X if the robot could move around an area freely without running the risk of bumping into walls, funiture, or other moving objects. You have already learned how RB5X's sensors can help in getting around safely. What more needs to be added to create a program that lets RB5X stay out of the way in a busy place?

Let's Experiment

Think of the last robot task you wrote. Did RB5X have any problems using sonar and bumpers to avoid running over or into things? Can you think what needs to be added to be sure the robot can move around freely? What important commands are missing? EDIT your previous program and add the commands that are needed to help RB5X move around an unknown area easily. (If you have tried any voice/sound synthesis programming, you might have the robot say something like "Excuse me" when it detects something in its way.) Do you think this is a useful task for a robot?

ACTIVITY 9: EXPLORING INFRARED

RB5X has an infrared sensor or detector on its undercarriage. This allows the robot to tell the difference between light and dark places on the floor as it passes over them. Using this sensing capability, you can program RB5X to find a contrasting tape pattern on the floor, which you can provide for a variety of reasons. One reason might be to allow RB5X to find its battery charger on its own by following the tape.

New Robot Vocabulary

1. TURN ON INFRARED LED
2. TURN OFF INFRARED LED
3. EXIT IF THE TAPE IS SENSED
4. FOLLOW TAPE
5. MOVE FORWARD TIL TAPE NOT SENSED

Let's Experiment

With strongly contrasting tape, make a straight line on the floor. The robot was set at the factory to look for a white tape on a dark floor. (See Section E, "Getting A Charge," in the RB5X Reference Manual for instructions on accurately setting this LED or if you want to change the default to dark tape on a light floor.) If your floors are inbetween colors, you might want to use a large piece of dark paper or fabric and put white tape on it, for this experiment.

Using the new commands, DEFINE a new task that allows RB5X to move until it finds the tape and then to follow the tape to the end where the battery charger is. It might be helpful here to look at the detail of the commands listed in the RCL Programmer's Guide to see what is included in each task. This can help you decide which vocabulary you need.

Let's Experiment Some More

Now that your robot can find a straight tape, let's see if you can teach RB5X to find a tape that makes another pattern. In addition to the commands in this activity, you may need some commands from Section A, "Robot Movement." Can RB5X find the tape pattern? Could RB5X follow tape that made a more complex pattern?

ACTIVITY 10: FIND THE CHARGER

RB5X has the ability to know when it is running low on battery power, and to start searching for its charger to "plug" itself in and charge up. RCL has tasks already written to help RB5X find its charger. You may want to use these or you may want to try writing your own.

New Robot Vocabulary

1. EXIT IF BATTERY IS LOW
2. EXIT IF THE CHARGER IS TOUCHED
3. MAINTAIN CHARGE
4. X CHARGER FINDER

Let's Experiment

Besides the new robot vocabulary, you need commands from Activity 9, "Exploring Infrared." Read the detail of the tasks (commands) listed above in your RCL Programmer's Guide and see what each of these tasks tells RB5X to do. Try combining the tasks you think are needed to tell the EXIT IF BATTERY IS LOW command because the robot should ignore this if its battery is not low.)

See if RB5X can get to the charger and make proper contact. Once you have done this, think how and when you would use these tasks in other, larger tasks. Do you need to include a charger-finder routine in every program you create for the robot or only in some?

SECTION C

AUDIO-VISUAL COMMUNICATION

ACTIVITIES

1. Sound Pattern #1
2. Sound Pattern to Music
3. Morse Code
4. Light Pattern #1 or A Bright Idea
5. Light Pattern #2
6. The Festive Robot
7. Putting Sounds and Lights Together
8. New Year's Eve
9. Back to Morse Code
10. A Sentry Robot

ACTIVITY 1: SOUND PATTERN #1

Now you know something about how robots move and how they sense their environment. Robots can communicate with the world in other ways, too. Using sound is one way. RB5X has a horn that it can honk for different lengths of time.

New Robot Vocabulary

1. TURN ON THE HORN
2. TURN OFF THE HORN

Let's Experiment

DEFINE a new robot task for sound. Using the new vocabulary and some commands from the Introduction, write a program that lets the robot sound its horn for one long and two short beeps. Write the task so the robot can do this over and over. What commands from the Introduction are needed to make this work?

Let's Experiment Some More

Now that you know how to have the robot sound its horn in some sort of pattern, go ahead and EDIT your task to create a more complicated pattern that repeats over and over. You might want to try something like this: long, short, long, long, short, short, medium, medium, long, short, medium, long, long, long. Or make up your own.

ACTIVITY 2: SOUND PATTERN TO MUSIC

What else could the robot do with its horn? Why not have RB5X honk its horn in time to some music?

New Robot Vocabulary

1. Honk the horn for this many seconds:

Let's Experiment

Pick out a piece of music that has a nice repeating rhythm. Listen to the beat to see how many long and short shounds it has. Make notes of the pattern. Now DEFINE a task and using the new vocabulary, write a program that lets RB5X honk in time to the music. Think about how you solved Activity 1, "Sound Pattern #1." Can you use the same technique for this activity?

Remember that if you put a period, or decimal, in front of the number for seconds, you will get parts of seconds instead of whole seconds. What kind of musician is RB5X?

Let's Experiment Some More

Now that RB5X can keep the beat, try to teach the robot to honk with the melody. This will take some careful planning. Listen closely to the timing of the melody and jot down the pattern. DEFINE a new task or EDIT the previous task to include the proper commands. Don't forget that WAIT might be a useful command in this task. How does RB5X sound?

ACTIVITY 3: MORSE CODE

Morse code has been used for communication in many different ways over the years. It consists of combinations of short and long sounds or dots and dashes that stand for letters. A new way to use Morse code is to involve the robot. Do you think that RB5X can sound out a code message?

Let's Experiment

Morse code has been used many times by people who were in distress. Here are the symbols for the phrase, "S.O.S. Robot in distress!":

(B -...,D -..,E .,I ..,N -.,O - - -,R .-.,S ...,T -)

DEFINE a task and write a program that allows RB5X to use the horn to communicate the message.

Let's Experiment Some More

Find a book on Morse code at the library or look in an encyclopedia. Select some messages for RB5X to transmit and write the appropriate programs. Once you are satisfied with the results, invite some friends to figure out what the robot is trying to communicate.

ACTIVITY 4: LIGHT PATTERN #1 OR A BRIGHT IDEA

You have learned one way to have RB5X communicate. Here is another method. The lights under the robot's dome are its LEDs (light-emitting diodes). You can use the lights to signal the beginning or end of parts of robot tasks or you can use them just to make the robot appear happy and friendly.

New Robot Vocabulary

1. TURN ON THE FLASHING LIGHTS
2. TURN OFF THE FLASHING LIGHTS

Let's Experiment

DEFINE a task that is a lights routine. You've seen the cartoons that show a light bulb in a balloon when someone has a "bright idea." Well, let's write a program that gives the impression that RB5X is thinking for a while and then has a bright idea. Very short bursts of lights flashing could indicate thinking while a long period of flashing lights could indicate a great idea. Arrange it to suit yourself. What kind of effect does it give?

Let's Experiment Some More

Using one of the movement tasks you previously wrote, add the flashing lights at appropriate spots to make RB5X appear to be thinking about what is to be done next.

ACTIVITY 5: LIGHT PATTERN #2

There are other things you can do with the LEDs besides making them flash. There are five LEDs that can be switched on and off independent of each other. You can use these to create many different effects.

New Robot Vocabulary

1. TURN ON LED (#)
2. TURN OFF LED (#)

Let's Experiment

To learn which number corresponds to which LED, DEFINE a new task. Have the robot switch on each LED from one to five, then have RB5X switch off each LED in the same order. Remember which number goes with which LED and make a note of it.

Now you know how to switch on and off the LEDs you want. Let's create a more complicated pattern. Work out a pattern on paper, marking which LEDs are to be on at each step. EDIT your LED task and program in the pattern. Does it look the way you expected it to? Try as many patterns as you wish.

ACTIVITY 6: THE FESTIVE ROBOT

You know how to use all of the lights commands so let's put them together to make RB5X sparkle. You can have your robot imitate a Christmas tree, a neon sign, or a mini-fireworks display just by combining different light patterns.

Let's Experiment

Using your imagination, pick something festive you would like the robot to imitate. Decide how to combine the commands to let RB5X give the best possible imitation. DEFINE a task and write the program. Can someone else guess what the robot is supposed to be?

Let's Experiment Some More

RB5X has had a lot of excitement with all of the festivities. Now it's time to wind everyting down and let the robot drop off to sleep. DEFINE a new task. Start out with lots of flashing lights, then work out a pattern where

fewer lights flash, slower and slower, until none are flashing. You can use this task as a general utility in other robot tasks to give RB5X some of its own personality.

ACTIVITY 7: PUTTING SOUNDS AND LIGHTS TOGETHER

Now that you know how to use the commands for both the horn and the LEDs, let's combine the two sets of commands to produce more complex effects. The horn and LEDs can be helpful in alerting people to the robot's whereabouts.

Let's Experiment

Let's add sound and lights to one of your previous movement tasks. You can pick any task you think will be improved by this addition. Decide on the effects you want to create. (You did a little of this by adding "A Bright Idea" to the "Square" task.)

Once you have decided on the task, EDIT the task and add the commands for horn and LEDs in the most logical places. Does this improve the appearance of the task? Could you add more flourishes for an even better effect?

ACTIVITY 8: BACK TO MORSE CODE

You have used the horn to sound out messages in Morse code. Now let's be sure that those messages are communicated in a noisy room as well as one where the horn can be heard. We can do that by adding long and short light flashes to the task we created in Activity 3, "Morse Code."

Let's Experiment

EDIT the task you created in Activity 3, "Morse Code." Before you add the LED commands, you need to decide if you want RB5X to use the horn all through a message and then change to the LEDs, or if you want to use horn and LEDs together for each separate letter. Choose the method that

you like best. What kind of effect does the combination of lights and horn give? Can your friends decode the message?

ACTIVITY 9: NEW YEAR'S EVE

Whatever the season, RB5X likes to share in the excitement. The robot can do an excellent job of helping you celebrate the arrival of the New Year. The lights and horn are perfect for this. Let's write a program that lets the robot participate right along with everyone else.

Let's Experiment

First, write a script that shows when RB5X is going to flash its LEDs and when it is going to sound the horn. Decide how long you want each of these activities to last. Think of some of the other tasks you have written. Are there parts from these that you could use in this task? What is helpful about this idea?

Once you have decided what to do and how to proceed, DEFINE a new task and enter the commands in the proper order. Try out your task. Does RB5X look like it is celebrating at a New Year's Eve party? Make any additions or changes you like. Now your task is ready when that time of the year comes.

ACTIVITY 10: SENTRY ROBOT

RB5X can put its horn and LEDs to real, practical use by alerting you if anyone or anything enters a room. The robot can either sound its horn or flash its lights or both. This can be very helpful. Imagine, for example, that it's been raining and someone lets the dog in. The dog heads for the nice, clean carpet in the living room to shake and roll. It would be nice to know this in time to catch the dog and save the carpet. RB5X can help out there.

Let's Experiment

First, decide where RB5X can best be put to work. Then decide how the robot is going to help alert you. How much time do you need from the time the robot alerts you to the time you can do something about the warning? How do you want the robot to signal you -- with horn, with LEDs, or with both?

Now you are ready to DEFINE a task. You need some commands from Section B, "Sensing Devices," since RB5X needs to use sonar to sense the presence of the object. Once your task is written, check to see if the sonar responds the way you want it to. When it does, put RB5X in the proper location and wait for results.

SECTION D

SPEECH PROGRAMMING

ACTIVITIES

1. Programming in Phoemes or
   What We Write Isn't What We Say
2. Repeating a Simple Sentence
3. A Robot Introduction
4. Deliver an Important Message
5. The Robot Reminder
6. The Alien Robot
7. Robot Instructions
8. A Conversation with Your Robot
9. A Play for Robot and Two Actors
10. The Robot Psychologist

ACTIVITY 1: PROGRAMMING IN PHONEMES OR WHAT WE WRITE ISN'T WHAT WE SAY

RB5X can say anything you would like it to. The trick is to think exactly how you say the same words. What we write on paper is not really what we say. Think of a simple short word like "I," "my," or "have." Say the word out loud. Listen to how many different sounds the word actually

has. "I" has two sounds (i-ee), "my" has three sounds (M-i-ee), and "have" has four sounds (h-a-u-v). The sounds are different from the spelling.

To make RB5X understandable, you have to teach it all of the sounds, or phonemes, in the right order for each word. A phoneme is the smallest, single, utterable speech sound. RB5X uses 61 phonemes, two kinds of pauses, and one very important command, STOP. As you enter a phoneme into the voice program, follow it by a period to tell the robot where each phoneme ends. For example: "I" = AH.E.E.STOP., "my" = M.AH.Y.STOP., "have" = H.H.AE1.AE.V.STOP. If we want RB5X to say "I have," we would enter the phonemes like this: AH.E.E.PA1.H.H.AE1.AE.V.STOP. PA1 is the pause between words. With practice, you will learn how to have RB5X say what you want with ease.

New Robot Vocabulary

1. PREPARE THE VOICE
2. LOAD THE PHRASE called "_____ with the phonemes "_____
3. SPEAK the phrase called "_____

Let's Experiment

Decide on a word you would like RB5X to say. Pick something different from the words given in the explanation. Think about each sound in the word. To select the right phonemes, study the phoneme list at the back of this section and in the section called Appendix 2 at the back of this book. Now that you have the phonemes selected, DEFINE a new task using the new vocabulary. You must use the new robot vocabulary in the order shown above.

At first, you probably want RB5X to say the word over and over so you can decide if it sounds right. Use any of the techniques you have learned to do this. How does your word sound? How could you fix it to sound better?

Let's Experiment Some More

Now that you see how to develop speech for the robot, think of a few more words you would like RB5X to say. Work out the phonemes. Add these words to your previous task. Make notes of the phonemes used for each word.

ACTIVITY 2: REPEATING A SIMPLE SENTENCE

You can see that RB5X has no trouble saying things once you figure out how to enter the phonemes. Why not have RB5X repeat a simple sentence every time it is told to?

Let's Experiment

Decide on a sentence you would like RB5X to be able to say over and over. Work out the phonemes for each word. Remember that when you enter a whole sentence into LOAD THE PHRASE, you should use PAls between each word to make the speech easier to understand. Remember the programming technique that will make RB5X wait to be told to perform. Now DEFINE a new task and enter your program. How does it work?

Let's Experiment Some More

How could you take the same sentence and make it sound different? You could use PAls to change the rate at which the robot says the sentence or you could change the phonemes to put more or less emphasis on certain words. Try to make the sentence in the previous task sound different. Experiment to find out which you like best.

ACTIVITY 3: A ROBOT INTRODUCTION

Let's put RB5X to work. Why not have the robot explain to your friends what it can do instead of your having to do it. All RB5X needs is more vocabulary.

Let's Experiment

Decide what you want the robot to be able to tell your friends about itself. Write out the script and pick the phonemes you need for each word. Decide if you want to

load all of the phonemes in one phrase or if you would rather use separate, shorter phrases. (One of these methods is easier than the other for correcting any mistakes in the phonemes.) Also, decide if you want RB5X to give the introduction on command or on its own.

Now DEFINE a task and enter your program. When you are happy with the way the robot sounds, try it out on your friends.

Let's Experiment Some More

Now that you have all of the phonemes for the introduction, let's have the robot take on a new personality. Instead of giving all of the information at once, have RB5X wait for a prompt from you for each part of the introduction. If you loaded the sentences into separate phrases, you are all ready. If not, you want to do this first.

EDIT the previous task and, using the LOOP command, arrange the task so RB5X only says the next sentence when you press a bumper. Does this give RB5X a different personality?

ACTIVITY 4: DELIVER AN IMPORTANT MESSAGE

Since RB5X can give such a good introduction of itself, certainly it can perform other useful jobs. Why couldn't RB5X deliver an important message to someone?

Let's Experiment

Think of an important message that you would like to send to someone. Also think of a way that the robot can let someone know that it has an important message to deliver. Select the vocabulary and the proper phonemes for both. DEFINE a new task that lets RB5X alert someone and then deliver the message on command. At this point, you may have to pretend that you know where the person is who is to receive the message. Write your task and see if it works.

Let's Experiment Some More

Now that RB5X can deliver the message, how could the robot let you know that the message has been delivered? This takes some careful thinking. You need commands from the previous activities. There are many ways to do this. Let your imagination be your guide. What is going to tell you that someone has received the message?

ACTIVITY 5: THE ROBOT REMINDER

If RB5X can deliver an important message, surely it can also serve as a daily reminder of jobs that need to be done. What a nice way to help you remember because you know that RB5X will never get mad at you!

Let's Experiment

Think of some jobs that you have to do today or jobs that you have to do regularly, but sometimes forget to do. Make a list of these. Decide how you want the robot to remind you of each. Write a script and pick out the correct phonemes for each word.

DEFINE a task and enter your program. Try it out. When you are satisfied with it, use it for a while to see if it helps to have a robot reminder.

Let's Experiment Some More

Sometimes we know what we have to do, but we get sidetracked doing the least important jobs first and then running out of time for the more important jobs. Organize your jobs by order of importance.

You can either EDIT the previous task or DEFINE a new one. Write your program so the robot reminds you of only one thing at a time and waits to remind you of the next until you ask.

ACTIVITY 6: THE ALIEN ROBOT

RB5X can really say anything at all. Not only can the robot learn to speak English, but RB5X can speak foreign languages or a language of your invention. All you need to do is to select the proper sounds.

Let's Experiment

Select a phrase in a language other than English. You may know some yourself, or you can find one in a book or on a tape. All you need to know is how it sounds. Pick the phonemes that you think will come closest to sounding like the words in the phrase.

DEFINE a new task or EDIT your repeating-sentence task and program in the phonemes. How does RB5X sound? Would the robot pass for a visitor from another country?

Let's Experiment Some More

It would be fun to have a code language that only you and your robot can understand. You can invent your own words and give them meanings or you can use something like "Pig-Latin."

If you invent your own, write a dictionary as you go so you won't forget what RB5X means when it speaks to you. You can save these words and phrases to be used in future robot tasks if you like. How easily can you understand what RB5X says? Can anyone else figure out your "robot language"?

ACTIVITY 7: ROBOT INSTRUCTIONS

RB5X can use its speech for some very helpful jobs. Suppose you know how to do something that you need to teach to someone else, but you can't be there when the other person needs the information. Have RB5X do it.

Let's Experiment

First decide on the task to be done. Just as an example, let's have RB5X teach someone how to make a good sandwich. What are all of the steps involved in making a sandwich? Besides the actual making of the sandwich, do you need to tell someone where to find the ingredients or do they already know? Should you have RB5X wait after each instruction, should the robot give all of the information at once, or should the "student" ask RB5X for each step when ready? These are all things you need to decide before you write the program.

List all of the steps on a piece of paper. Check to see that you have included all the important points. Select the proper phonemes and write your program. Once you think it sounds right, try to follow the instructions yourself. If you think you need to change anything, do so and then let someone else try to follow the instructions.

ACTIVITY 8: A CONVERSATION WITH YOUR ROBOT

You can see that RB5X's speech abilities are useful for many different situations. The robot can explain, deliver messages, speak foreign languages, and give directions. Now how about sitting down and having a friendly conversation with someone?

Let's Experiment

It is time to have RB5X use its social nature. Robots can be very friendly. Your job is to select the right phrases to let RB5X show your friends just what good companions robots can be.

First you need to decide who should take the lead in the conversation. It will probably work best if the robot does, but this is up to you. Then decide exactly what the robot is going to say and select the phonemes you need.

Once this part is done, you need to decide if the robot is going to just WAIT a given amount of time before saying the next phrase or is going to need a prompt to say the next sentence. When you have all of this under control, you are ready to DEFINE a new task and to enter your program.

Try out the conversation. How realistic does it sound? Have other people try holding a conversation with RB5X.

ACTIVITY 9: A PLAY FOR ROBOT AND TWO ACTORS

If RB5X can have a conversation with you and your friends, certainly the robot can take part in a play. What character would suit RB5X best? Will the robot need a costume? Should the setting be in the past, the present, or the future? Do you want to write the script yourself or to use a prepared script? How long should the play be?

Let's Experiment

Once you have answered the questions above, you are ready to continue. Select the speaking parts for RB5X. Pick the phonemes for all that the robot says. Decide when and how the robot should move. DEFINE a new task. LOAD THE PHRASEs with the correct phonemes.

Now that you are ready to write the main part of your task, decide if you want someone to prompt RB5X for each line or if you want to time the conversation by the other actors and just tell RB5X how long to WAIT before it says each line.

Once your task is written, rehearse the play. When you are satisfied with everyone's performance, invite some friends to attend the premier.

ACTIVITY 10: THE ROBOT PSYCHOLOGIST

RB5X can really do a great many different tasks. Why not have the robot act as a friendly psychologist, willing to listen to what's been bothering you for a while, eager to be a friend.

Let's Experiment

Computers have acted as psychologists for a while now. There are several programs for microcomputers that could

give you ideas for the kinds of things you might want RB5X to say in response to your problems. You can also write your own.

Think of people you know who are considered "good listeners." What do they say to keep someone else talking? Write your script and DEFINE a new task. LOAD THE PHRASEs with the correct phonemes for each sentence. Now, decide if you want to prompt RB5X for each sentence or if you want a timed WAIT. Write your program and try it out. When RB5X performs to your satisfaction, let others share the benefits of RB5X's soothing nature.

PHONEMES

STOP
Use after each finished phrase.

PA0
Use to double letter sounds, for inflection or emphasis.

PA1
Use after each word to create a short pause; more PA1s create longer pauses.

A
As in is or limit (longest of A group).

A1
As in hiccup.

A2
As in bit (single) or mitten (shortest of a group).

AE
As in at.

AE1
As in animal or and.

AH
As in arise or alarm.

AH1
As in a dog, similar to father but not quite the same.

AH2
As in hot (several), single is short. Use in combination for complex vowel sounds, as in vowel.

AW
As in father or abuelo.

AW1
As in hawk or haul.

AW2
As in harbor or aardvark. The A sound before R.

AY
As in inside (several) or it (single).

E
As in seem (several) or eat (single).

E1
As in eliminate (several) or seat (single).

EH
As in elevator (single).

EH1
As in wretched (several) or wretched (single).

EH2
As in esta (several) or chile (single).

EH3
As in went (several) or intelligent (single).

I
As in integral (several) or hit (single).

I1
As in limit (single).

I2
As in nip (sngle) or ear and irregular (several).

I3
As in which (several) or ditch (single).

IU
As in what (several) or ink (single).

O
As in orange (several) or carrot (single).

O1
As in cooperative (several) or doubt (single).

O2
As in onion (several) or honey (single).

OO
As in robot (several) or robot (single).

OO1
As in como (several) or como (single).

U
As in look (several) or useful (single).

U1
With a long E sound in front, useful (several) or other (single).

UH
As in unless (several) or what (single).

UH1
As in gum (several) or up (single).

UH2
Very short sound for emphasis or as in a.

UH3
Use as a short sound in combination with other vowels.

Y
As in seat (several) or ready (single).

Y1
As in teepee (several) or wheat (single).

B
As in boy (single).

CH
As in chew (several) or church (single).

D
As in ditch (single); very short and soft.

DT
As in dentist (single) and other DE combinations.

ER
As in stir or dinner (single).

F
As in first (several) or after (single).

G
Sounds like IK or like program (single).

H
As in help (several) or ahum (single).

J
As in tsh (several) or ts (single); use with D for gent.

K
As in cat, quiet, and take (single).

L
As in trouble (single) or like (several).

M
For all M sounds, correct vowel sounds important.

N
As in name (several) or sound (single).

NG
As in song (several) or angle (single).

P
As in put (single).

R
As in run (single).

S
As in hiss (several) or its (single).

SH
As in shovel (several) or sheep (single).

T
As in cat (single).

TH
As in through (several) or sheath (single).

THV
As in seventh (several) or this (single); must use carefully, not a good sound.

V
As in very (several) or voice (single).

W
As in forward (several) or went (single).

Z
As in snake (several) or tallest (single).

ZH
As in buzz (several) or atchoo (single).

SECTION E

THE ROBOT ARM

ACTIVITIES

1. Exploring the Shoulder
2. What is a Robot Elbow?
3. Wrist Wiggling
4. Robot Grippers
5. Find the Center, Find the Limits
6. Eggs in the Basket
7. A Robot Assembly-Line Helper
8. Draw Simple Geometric Forms
9. The Robot Artist
10. The Writing Robot

ACTIVITY 1: EXPLORING THE SHOULDER

The robot arm has features similar to the human arm, constructed as it is with a shoulder, a forearm, a wrist, and a hand. Examine your own arm and think about how it moves. The robot arm moves in similar ways, but is much slower than a human arm. To make the robot arm do what you want it to, think carefully about how you use your own arm to do the same things.

NOTE: Be sure RB5X's batteries are fully charged before you start these arm movement activities. The robot uses a lot of energy to move its arm around. Begin these activities with RB5X's arm in a full resting position, inside the robot.

New Robot Vocabulary

1. MOVE THE ARM FROM THE SHOULDER (UP,DOWN,IN,OUT) _____ for this many degrees _____

Let's Experiment

Examine the way the arm is located inside the robot. Which direction does the shoulder have to move first as the robot begins extending its arm? DEFINE a task that extends the shoulder to the place where it can use its full range of movement. See if it works.

Let's Experiment Some More

Now you have the arm out of the robot where it can be used fully. EDIT your task to allow the robot to move its shoulder in all possible directions and then fold itself up inside again.

ACTIVITY 2: WHAT IS A ROBOT ELBOW?

A robot elbow is much like a human elbow except it is more flexible. A human elbow can move in and out in only one direction, while a robot elbow can move in and out in two directions. This means that you have to think a little differently about using the robot elbow (or forearm, as it is called in RCL) when deciding how the robot performs certain tasks. How can you use degrees to allow for movement in two directions?

New Robot Vocabulary

1. MOVE THE FOREARM (IN,OUT): ___ for this many degrees: ___

Let's Experiment

Using the task you wrote in Activity 1, "Exploring the Shoulder," EDIT the task to include the new command after the shoulder is fully extended. Try to visualize a movement that would be helpful, and select the direction and number of degrees you think are needed. Load the task to see if you were right. Modify the movement until you are satisfied.

Let's Experiment Some More

You now know enough commands to have RB5X touch the floor and raise its arm in the air. Modify your task to allow the robot to do a few calisthentics before RB5X puts its arm away.

ACTIVITY 3: WRIST WIGGLING

The robot wrist moves in the same way that the human wrist does. As you move your own wrist, think about what humans use this movement for. How will this movement help RB5X perform useful jobs?

New Robot Vocabulary

1. TURN THE WRIST (LEFT,RIGHT): ____ for this many degrees: ____

Let's Experiment

DEFINE a new task. Using the commands you already know, have the robot extend its arm so the wrist is visible. Include the commands that let RB5X wiggle its wrist back and forth several times. Then have the robot put its arm away.

Let's Experiment Some More

EDIT the task where the robot touches the floor and raises its arm. Have RB5X wave hello by using the wrist-wiggling commands. You can decide where in the movements you would like the robot to wave. Maybe you would like it to wave more than once.

ACTIVITY 4: ROBOT GRIPPERS

The robot hand is quite different from the human hand, especially in appearance. It moves much the way the human hand moves when people are picking up little sticks. Notice that there are only three "fingers." This means that the robot cannot do as many things with its hand as people can. As you experiment, you will notice other differences. The robot arm is not as strong as the human arm -- RB5X can only lift between 12 and 16 ounces. The fingers have to be positioned just right to be able to pick up and hold something.

New Robot Vocabulary

1. MOVE THE HAND (OPEN,CLOSE): ____ for this (1-100) %:

Let's Experiment

EDIT your first wrist-wiggling task. Use the new command to have the robot open its hand at some point in the task. Try different percentages to see what each will hold.

Let's Experiment Some More

EDIT your complete arm-movement task. Select some object for RB5X to pick up from the floor. Add the proper commands to allow the robot to grasp and hold the object. (HINT: You may need to add some basic movement commands to allow the robot to get a proper hold on the object.) See how well your task works. Experiment with different objects.

ACTIVITY 5: FIND THE CENTER, FIND THE LIMITS

It is important to know how to teach the robot to find certain places. To do this, we need to know how many degrees or in what direction each part of the robot arm must move to be in a specific relation to other parts of the robot. This way, we know where to tell the robot to put its

arm if it is going to touch something in front of it or off to one side.

Let's Experiment

DEFINE a new task. Using what you have already learned, give the robot instructions that let it extend its arm as far as possible straight in front. Make notes of the degrees you used.

Let's Experiment Some More

From the center position, see how far in each direction you need to move the arm for it to reach the limit of its movement. Make notes of the degrees used. Now experiment to see how many degrees you need to make the arm move half-way between the center and the limit of each direction. Once you have mastered this, you are ready to put the arm to work.

ACTIVITY 6: EGGS IN THE BASKET

Now you understand the basics of arm movement. Let's begin to put these basics to use. In industry, robot arms are often used for "pick-and-place" activities -- where they select a specific object from a group, pick it up, move it to another location, and put it down. The arm is programmed to repeat this movement over and over. Its movements must be accurate enough so that the robot arm does not break or damage anything with which it is working.

Let's Experiment

Think of a simple object that RB5X can pick up and move to another location. It might be blocks or small, light-weight boxes. (You'd better not start with real eggs!)

Find a container for the robot to put these objects in. Decide where the objects will be to start and where you will put the container. Then think about the exact arm movements needed to reach the object and place it in the container. (Remember the Hint in Activity 4 of this section.)

Now DEFINE a task and enter the commands needed to move the arm. Once you have this task working to your satisfaction, try having RB5X "pick and place" other objects.

ACTIVITY 7: A ROBOT ASSEMBLY-LINE HELPER

Since RB5X can use its arm to do pick-and-place types of activities, why not have the robot help you as part of an assembly line? Think how nice it would be if you didn't have to keep reaching for an object before you could do something else with it. You could do routine jobs much faster.

Let's Experiment

Think of some jobs that call for the same movements over and over. Now, decide on a job that has, as a part of it, some movements that RB5X can do while you are doing some other part of the job.

An example might be getting a bushel of fresh corn ready to eat or put in the freezer. You have to reach in the basket, pick up an ear of corn, move it over a container, peel of the husk, and put it in a pot of boiling water. Where could RB5X help you out best in an operation like this? Would you need to change anything about how this job is organized to make it easier for the robot to help?

Once you have decided on the job and the part that RB5X plays, figure out the exact movements and distances RB5X must move its arm. DEFINE a task and write the commands. How does it work? What other jobs could RB5X help you with?

ACTIVITY 8: DRAW A SIMPLE GEOMETRIC FORM

By now you have gotten quite good at programming the arm to move to specific places. Do you think you can teach RB5X to draw?

RB5X can move its arm in all of the proper directions, but you need to figure out how to get the robot to hold on

to a pencil or piece of chalk tight enough to draw continuous lines on paper or a chalkboard. You may even want to design a special board or easel for RB5X to use.

Let's Experiment

Decide on how to have RB5X hold the writing tool. Decide where you are going to place the writing surface (paper or chalkboard). Will it be on the floor, or on a stand in front of RB5X? Vertical or on a slant? You need all of this information before you write the commands.

Now, pick a geometric shape for the robot to draw. Think about the ways in which RB5X can move its arm. What movements are involved in drawing the figure?

DEFINE a task. Write the commands in the proper order. Try out your task. Did RB5X draw what you thought it would? Once RB5X can draw the first figure to your satisfaction, DEFINE tasks for other geometric figures.

ACTIVITY 9: ROBOT ARTIST

RB5X has learned to draw a few basic shapes. Perhaps the robot has the talent to be a real artist. Why not find out?

An artist must decide on the subject for a picture, and on the materials and the medium to be used. For RB5X's first attempt, chalk (or pastels) would be a good choice for medium.

Let's Experiment

Select the materials you need (paper, chalk, etc.). RB5X can use the same positioning as it used in the Activity 8, "Draw a Simple Geometric Form." Decide on the subject for the drawing. You might want to draw some sample pictures yourself so you know exactly what you are going to tell RB5X to do.

Once you know what the drawing will look like and what movements the robot must make to draw it, you are ready to DEFINE the task. Enter the commands in the proper order. If

the robot is going to draw several different objects (such as hills, trees, clouds, buildings, etc.) in one picture, you might want to make each of these a different task so that later RB5X can draw many different pictures.

When your picture task is complete, have RB5X draw. Are you ready to open a "Robot Art" gallery?

ACTIVITY 10: THE WRITING ROBOT

Now RB5X can draw only a few shapes, but pictures as well. The final step is to teach RB5X how to write or print.

Let's Experiment

There are several elements you need to think about before you start to compose this task. You need to decide on the style of the letters RB5X makes. Will the robot write or print? Will the letters be curved or square? Would it be helpful if you made each letter a separate task?

You can use the same approach for writing tool and writing surface you used in the last two activities. Figure out the arm movements that are needed to make each letter. DEFINE a new task (or tasks). Enter the necessary commands that allow RB5X to make the letters. Try out each letter as you go to be sure they are the way you wanted them to be.

If you are using separate tasks for each letter, what could you do to keep the robot from making one letter on top of another? Once you have figured out the answer to this, why not have RB5X write its name? Now, that is one smart robot!

SECTION F

PUTTING IT ALL TOGETHER

ACTIVITIES

1. Robot Patrol
2. Robot Exercise Leader
3. Robot Express
4. Robot Vaudeville
5. Robot Professor
6. Robot Zoo
7. Robot Butler
8. Robot Host
9. RB5X Says
10. Multipurpose Robot

ACTIVITY 1: ROBOT PATROL

You have had RB5X performing sentry duty already. It would be very useful if the robot could really patrol an area and sound an alarm or give a verbal warning. By combining commands and techniques learned in earlier sections, you can do just that.

Let's Experiment

Decide on an area you would like RB5X to patrol. Work out the path the robot is to follow much like you did in "Robot Pathfinder" (Section A, Activity 5). Decide if you want RB5X to give you an "OK" from time to time, so you know it is still on the job. Then decide how close something should be to the robot before it detects it. What kind of alarm do you want RB5X to give?

You should use techniques from "Respond When Sonar Activated" (Section B, Activity 5), "Morse Code" (Section C, Activity 3), and "A Sentry Robot" (Section C, Activity 10); from Section D, "Speech Programming;" and whatever other commands you wish.

DEFINE a task and enter the commands. Try out your task to see that it works properly. Then put RB5X to work.

ACTIVITY 2: ROBOT EXERCISE LEADER

Remembering to get your daily exercise can sometimes be a problem, especially if you exercise alone. Why not let RB5X keep you company, and remind you what to do next and when? Robots need to keep in shape too!

Let's Experiment

If you already have a regular exercise program, make a list of the exercises you do and the time you spend on each one. If you don't already have a program, get some ideas from a friend or find a book in the library on exercise.

Once you have decided on a program, think how RB5X can best help you stick to the routine. What kind of encouragement would you like to receive? What movements can RB5X use to remind you of what you should be doing? Do you want the robot to count each exercise for you, or to give you a cue when you are almost finished?

Write a script for the robot, including speech, movement, time, and other aids in the order you want them done. You can use techniques from all of the previous

activities to make RB5X a first-class exercise leader. Test each exercise as you go to be sure it does what you want. When you are finished, invite some friends to join you and RB5X for your daily practice.

ACTIVITY 3: ROBOT EXPRESS

A robot that can run simple errands and deliver messages or objects from one place to another can be quite helpful. Suppose you are working on something and are at a point where you can't leave, but you need something or need to tell someone something. Let RB5X do it for you. With what you have already learned, you can write many utility tasks that send the robot to different known places, ask for or deliver information, and carry small objects back and forth.

Let's Experiment

Pick a location where you spend a lot of time doing many things. Using the ideas in "Robot Pathfinder" (Section A, Activity 5), make maps of the routes you would like RB5X to follow to reach certain places. Using ideas from "Deliver an Important Message" (Section D, Activity 4), you can have the robot carry information to these places. You can also equip RB5X with a basket or carrying box that can take written notes to or from different places along with small objects.

Decide how you want the robot to do these things. DEFINE a separate task for each location and write your programs. You will soon see just how helpful RB5X can be.

ACTIVITY 4: ROBOT VAUDEVILLE

You already know that RB5X is quite a show-stopper. It would be nice if the robot had several different routines it could perform for different occasions. RB5X might have a special set of songs, dances, and jokes or sayings for birthdays, another set for Valentine's Day, and a different

routine for Halloween. Once these performances are developed, you and RB5X are ready for whatever may come along.

Let's Experiment

You really need to use your imagination here. You can use ideas from all of the activities you have worked on so far to make up these routines. First, you need to write a robot script for each special occasion that includes just what RB5X is going to do and when. You may find that you can use tasks you have already written as parts for some of the new tasks.

When you have your script, DEFINE a task for each occasion and enter the proper commands. It is a good idea to try these out on someone else before RB5X performs for a group to be sure that the first "real" performance is perfect.

ACTIVITY 5: ROBOT PROFESSOR

Here is an excellent opportunity to see how easy it is to create new activities for RB5X once you have developed a lot of smaller tasks. You have created, in previous activities, all of the tasks you need to let RB5X put on a really complete lesson on what it can do. You can use only those tasks you have already written or you can add more.

Let's Experiment

Start with the task you wrote for "A Robot Introduction" (Section D, Speech Programming). After RB5X speaks each phrase, insert another task you have already written that lets RB5X show off each capability after it is described. If you feel you left something out of the original introduction task, now is the time to add it.

Select the proper phonemes for the new things that you want RB5X to explain, then add the action tasks. Did you remember to modify any tasks that included such elements as PREPARE THE ROBOT and extra CALLs and JUMPs? When you are finished, RB5X should be able to show your friends just how many things it can do.

ACTIVITY 6: ROBOT ZOO

You had RB5X imitate the movements of different animals in "Animal Charades" (Section A, Activity 6). By adding all of the robot's other capabilities, you can have RB5X do an even better job. You may already have some tasks written that can be included to create more meaningful animal imitations, such as arm movements, horn and LED routines, and sensing tasks.

Let's Experiment

As you did in "Animal Charades," decide on the types of animals you would like RB5X to imitate, remembering to pick animals that have distinct, identifiable characteristics. Think about all of RB5X's abilities and decide which of these are suitable for each animal. Use your imagination. You might have RB5X use its arm to give the appearance of an elephant's trunk, for example.

Decide if you want to put all of the animals in one task (it may get too big, however) or if you want to make each animal a separate task that can later be arranged in order in a larger task. DEFINE your task and write the commands. RB5X can do a good job of entertaining your friends at a party with these antics.

ACTIVITY 7: ROBOT BUTLER

A personal butler is something very few people can have. You can have your own with RB5X. You can write several tasks that allow RB5X to perform useful chores. These tasks can be arranged in many different ways for future use, depending on what you need done at a certain time. You might have a task that has RB5X greet guests at the door and take their coats to a certain spot, and another that asks guests if they would like refreshments and then to alert someone who can serve them.

Let's Experiment

Think about all of the useful jobs RB5X could do for

you. Decide which jobs you would like to have tasks for now. Write a script for each task. Remember that if a task is going to have the robot go to a special place, you need to know the distance and angle of that location as you did in "Robot Pathfinder" (Section A, Activity 5).

Once you have selected the tasks, the phrases RB5X will say, and the other capabilities each task will use, DEFINE and write the programs for each separate task. To get the effects that you want, put the separate tasks together in a larger task and see what kind of personal butler RB5X is.

ACTIVITY 8: ROBOT HOST

Besides acting as a butler, RB5X can help you take care of a group of visitors. The robot can move around a room, stopping to make small talk with different people who are visiting. You may have some good phrases already written in "A Conversation with Your Robot" (Section D, Activity 8). Try writing others.

Let's Experiment

There are several things you will want to decide. What do you want RB5X to talk about? How many things do you want the robot to say before it moves on to someone else? How will the robot decide to move and how will it decide to stop again? Do you want to include arm movements for effect? What tasks that you have already written can you include in this task?

Once you have made all of the decisions, DEFINE a task and write the program. If you are not expecting a group of visitors right a way, invite a few friends over to see how well RB5X does with a group.

ACTIVITY 9: RB5X SAYS

RB5X can play games with people, too. Almost everyone knows how to play "Simon Says," so why not let your robot play "RB5X Says"? You can add some things to the routine

that will convince the players that the robot can see just who is following instructions and who isn't.

Let's Experiment

Remember that in "Simon Says" the leader tells the players to do many different, simple things. The only things that the players are supposed to do are the things that start out with "Simon says..." Doing anything not starting out with "Simon says..." disqualifies the player.

Decide what people can do that RB5X can do, such as turning around, facing front, facing back, opening your hand, or wiggling your wrist. Then select what the robot is going to say and when it will say "RB5X says..." Also, write some phrases for the robot like, "Someone is not paying attention" or "Did I say to do that?" You can use these randomly throughout the program. Remember that if RB5X doesn't "say" to do something, the robot doesn't do it.

Once you have worked out the game on paper, DEFINE the task and enter the commands. This is a task you will use over and over along with all of the other games you create for RB5X.

ACTIVITY 10: MULTIPURPOSE ROBOT

You have learned how to have RB5X do a little of everything. You have taught RB5X how to work, to play, and to just be good company. It would be nice to have the robot be able to show off its versatility by writing one, large task. Here is another easy way to use many of the smaller tasks you have created.

Let's Experiment

Do you remember the command "EXIT IF THIS BUMPER is touched"? You can use this command to have RB5X be ready to fill many different roles at once. Decide what you want the robot to do when each bumper is pressed. You can even paste identifying labels on each bumper if you like so others can choose what the robot will do. Just remember not to get the overall program so big that it does not fit into the robot's memory.

You might have RB5X wave when one bumper is touched, think when another is touched, perform a movement pattern with another bumper, give instructions on a signal from a fourth, and so on. Experiment with this idea to see just how many things RB5X can remember at one time.

APPENDIX 1

ROBOT VOCABULARY

The following is a complete list of the robot vocabulary used in the activities contained here. The commands are listed in order of their appearance in this book.

PREPARE THE ROBOT
WAIT
CALL
JUMP
BUILD AND LOAD
BEGIN A LOOP
REPEAT THIS LOOP
MOVE RANDOMLY
MOVE TIMED FORWARD
MOVE TIMED BACKWARD
PIVOT ON LEFT CLOCKWISE
PIVOT ON LEFT COUNTERCLOCKWISE
PIVOT ON RIGHT CLOCKWISE
PIVOT ON RIGHT COUNTERCLOCKWISE
STOP ALL MOTION
MOVE DISTANCE BACKWARD
MOVE DISTANCE FORWARD
SPIN CLOCKWISE
SPIN COUNTERCLOCKWISE

SPIN LEFT 90 DEGREES
SPIN RIGHT 90 DEGREES
BEGIN A COUNTED LOOP
REPEAT THIS COUNTED LOOP
PICK A RANDOM DIRECTION
WAIT RANDOMLY
MOVE BACKWARD
MOVE FORWARD
SPIN AROUND CLOCKWISE
SPIN AROUND COUNTERCLOCKWISE
EXIT IF ANY BUMPER TOUCHED
EXIT IF FRONT+REAR BUMPER PRESS
EXIT IF THIS BUMPER
EXIT IF SONAR
TURN ON INFRARED LED
TURN OFF INFRARED LED
EXIT IF TAPE IS SENSED
FOLLOW TAPE
MOVE FORWARD TIL TAPE NOT SENSED
EXIT IF BATTERY IS LOW
EXIT IF CHARGER IS TOUCHED
MAINTAIN CHARGE
X CHARGER FINDER
TURN ON THE HORN
TURN OFF THE HORN
HONK
TURN ON THE FLASHING LIGHTS
TURN OFF THE FLASHING LIGHTS
TURN ON LED
TURN OFF LED
PREPARE THE VOICE
LOAD THE PHRASE
SPEAK
MOVE THE ARM FROM THE SHOULDER
MOVE THE FOREARM
TURN THE WRIST
MOVE THE HAND

APPENDIX 2

PHONEMES

OVERVIEW

The following is a list of the phonemes you use to program speech for RB5X.

STOP
Use after each finished phrase.

PA0
Use to double letter sounds, for inflection or emphasis.

PA1
Use after each word to create a short pause; more PA1s create longer pauses.

A
As in is or limit (longest of A group).

A1
As in hiccup.

A2
As in bit (single) or mitten (shortest of a group).

AE
As in at.

AE1
As in animal or and.

AH
As in arise or alarm.

AH1
As in a dog, similar to father but not quite the same.

AH2
As in hot (several), single is short. Use in combination for complex vowel sounds, as in vowel.

AW
As in father or abuelo.

AW1
As in hawk or haul.

AW2
As in harbor or aardvark. The A sound before R.

AY
As in inside (several) or it (single).

E
As in seem (several) or eat (single).

E1
As in eliminate (several) or seat (single).

EH
As in elevator (single).

EH1
As in wretched (several) or wretched (single).

EH2
As in esta (several) or chile (single).

EH3
As in went (several) or intelligent (single).

I
As in integral (several) or hit (single).

I1
As in limit (single).

I2
As in nip (single) or ear and irregular (several).

I3
As in which (several) or ditch (single).

IU
As in what (several) or ink (single).

O
As in orange (several) or carrot (single).

O1
As in cooperative (several) or doubt (single).

O2
As in onion (several) or honey (single).

OO
As in robot (several) or robot (single).

OO1
As in como (several) or como (single).

U
As in look (several) or useful (single).

U1
With a long E sound in front, useful (several) or other (single).

UH
As in unless (several) or what (single).

UH1
As in gum (several) or up (single).

UH2
Very short sound for emphasis or as in a.

UH3
Use as a short sound in combination with other vowels.

Y
As in seat (several) or ready (single).

Y1
As in teepee (several) or wheat (single).

B
As in boy (single).

CH
As in chew (several) or church (single).

D
As in ditch (single); very short and soft.

DT
As in dentist (single) and other DE combinations.

ER
As in stir or dinner (single).

F
As in first (several) or after (single).

G
Sounds like IK or like program (single).

H
As in help (several) or ahum (single).

J
As in tsh (several) or ts (single); use with D for gent.

K
As in cat, quiet, and take (single).

L
As in trouble (single) or like (several).

M
For all M sounds, correct vowel sounds important.

N
As in name (several) or sound (single).

NG
As in song (several) or angle (single).

P
As in put (single).

R
As in run (single).

S
As in hiss (several) or its (single).

SH
As in shovel (several) or sheep (single).

T
As in cat (single).

TH
As in through (several) or sheath (single).

THV
As in seventh (several or this (single); must use carefully, not a good sound.

V
As in very (several) or voice (single).

W
As in forward (several) or went (single).

Z
As in snake (several) or tallest (single).

ZH
As in buzz (several) or atchoo (single).