

# Programming Explorations

## Starting to write programs

### Introduction

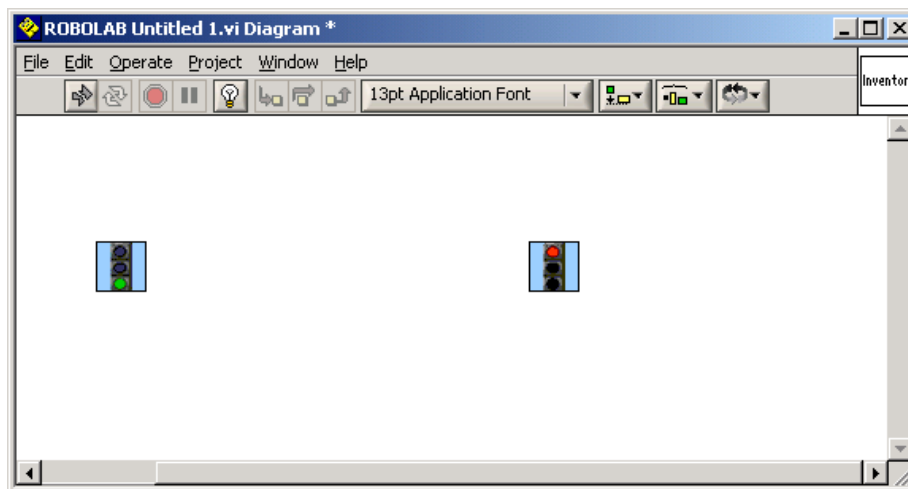
In this session you are going to explore how to write programs that can be run in a LEGO Mindstorms<sup>†</sup> model. The model you will start with is a simple windmill, controlled by a motor. Later on you will program a model that can move using two motors. All of the models you use will have a big yellow RCX brick to control them. The RCX contains the computer that you will be programming.

### Running ROBOLAB

ROBOLAB is the program you will use to write your own programs. If it is not already running on your PC:

- Start up the ROBOLAB program.
- Select the 'Run ROBOLAB' option.
- Select the 'Programmer' menu item.
- Select the 'Inventor 4' option (double-click on it).

Several windows will now open on the screen. Here is the ROBOLAB programming window you will see:



You are going to write programs for the LEGO models in this window.

### What ROBOLAB programs look like

All ROBOLAB programs start with a green traffic light and end with a red one. You can see these in the programming window.



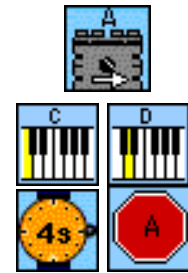
---

<sup>†</sup> LEGO is a registered trademark. MINDSTORMS, RCX and ROBOLAB are trademarks of the LEGO company.

In between the traffic lights you can place some programming symbols to show which bits of LEGO you have in your model, like a motor.

You can also make the RCX brick play music, using symbols like these:

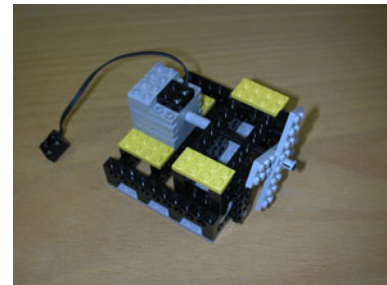
Some of the other programming symbols you will use look like this:



All the symbols you put in the window must be linked together with *the cotton reel tool* which draws a pink line between the pieces. Press the space bar several times in the programming window to see how to swap between the cotton reel cursor and an arrow cursor. The arrow is used to select the programming symbols. When a programming symbol is placed in the program window, it will sometimes be automatically joined with a pink line to the nearest symbol. This can speed up the process of linking the symbols together.

### Writing a program

What do you think the following program will do if it is run in the RCX brick connected to the windmill?



Try creating this program in ROBOLAB. Here are the steps you will need to take:

- Click on the title of the program window.
- There should also be another window on the screen called “Functions”. If it isn’t there, try selecting the “Windows” menu, and then the “Show Function Palette” option. If that doesn’t work, ask for help.
- In the Functions window, click on the symbol containing the motor with the letter “A” that you can see in the program above.
- Move the cursor back to the program window and place the symbol between the traffic lights.
- If it wasn’t joined up when you placed it, use the cotton reel to join the green light to the motor symbol and then the motor symbol to the red light. (Remember you might need to press the space bar to make the cotton reel appear.) Join the first two symbols by clicking the left mouse button over the green traffic light. Then drag the pink line to the motor symbol and click the left mouse button again. Repeat this process to join the motor symbol to the red traffic light.
- Your program should now look exactly like the picture above. If you have any problems with this, ask for help.

In order to try out the program, you will need a big yellow RCX brick and a windmill. Connect the wire from the model to position “A” on the brick. Now

the brick is ready to control the model. Before it can, though, you must send your program from the PC to the RCX brick.

## **Sending a program to the RCX brick**

Let's try sending your program to the RCX brick.

- Press the red ON-OFF button on the RCX brick so that its screen lights up.
- Make sure the front of the brick is near the 'tower' that is connected to your PC.
- Use the mouse to press the white-arrow button in ROBOLAB. It is just below the "Edit" menu item. This should copy the program from your PC into the RCX brick. When the program has been transferred, the brick plays a little tune.

Now the brick can use your program to control the windmill model.

Press the green RUN button on the RCX brick. What happens? Did the windmill do what you expected? Did the windmill stop once it had started? Why do you think that might be?

You can stop a program running by pressing the red ON-OFF button. The brick's display should turn off. Press the red button to turn it on again. Is the program still running? What happens if you press the RUN button again? Stop the program with the ON-OFF button again, and then turn the brick back on again.

## **Creating another program**

You should have seen that the windmill only stopped when you turned the brick off. This is not what we normally want – the RCX is a computer like a PC and you usually only turn a PC off when you shut it down at the end of the day. It would be better if you could change your program so that the windmill stops by itself after a few seconds, say. Here is how you can modify your program to make it work better, and you will learn about some more programming symbols as well.

First you should remove the second pink line from the first program – the one joining the motor symbol to the stop symbol.

- Use the space bar to make sure that the arrow cursor is showing.
- Select the second pink line by clicking on it with the left mouse button.
- Press the delete key and the line should disappear.

You are going to create a program that looks something like this:



You will need some more space in your program between the motor symbol and the red traffic light. Use the space bar to select the arrow cursor. Now

click on the traffic light and drag it to the right of the programming window to make a gap.

This new program uses two more programming symbols.

- In the Functions window click on the symbol that looks like a watch and a new small window should appear. This is the “Wait For” window.
- Click on the watch that has “4s” inside it.
- Place this symbol to the right of the motor symbol in the program window.
- Now go back to the Functions window by clicking on the up arrow at the top of the Wait For window.
- Select the red Stop sign containing the letter A and place it in the program window.
- Finally, use the cotton reel to make sure that the motor and the watch, the watch and the stop symbol, the stop symbol and the red traffic light are all linked together.

If your program doesn't look like the picture above then ask for some help. If everything looks right, make sure the LEGO brick is turned on and then send this program to it. Run the program on the brick. What happens this time?

If everything works correctly then the windmill should rotate for about four seconds (see the watch symbol) and then stop. Is that what happened? If not, ask for some help.

Here is how you might describe your program in words instead of symbols:

Start the program.  
Start motor A.  
Wait for 4 seconds.  
Stop motor A.  
Stop the program.

### **More about motors**

The motor symbol you have used so far runs the motor attached to position “A” in the forwards direction. There is another symbol that can be used to run that motor backwards:



Try using this new symbol in a program. Change your latest program so that the motor runs forwards for four seconds, then runs backwards for six seconds, and then stops.

Here is how you might describe your program in words instead of symbols:

Start the program.  
Run motor A forwards.  
Wait for 4 seconds.  
Run motor A backwards.  
Wait for 6 seconds.  
Stop motor A.  
Stop the program.

## Review

You have already written several programs, so let's review what you have learned before moving on.

- Programs are created in ROBOLAB by placing symbols between a pair of traffic lights.
- The symbols are joined together using the cotton-reel tool.
- A program is transferred from the PC to the RCX brick by the tower connected to the PC.
- The motor-symbol labelled A turns on a motor connected to position A on the RCX.
- The stop-symbol labelled A stops the motor connected to position A on the RCX.
- A program 'waits for' some time at a watch symbol.



If you look at the LEGO brick you will see that it has positions labelled "B" and "C" as well as "A". These positions are called 'output ports'. Can you find any symbols in the Functions Window that will control motors attached to these other positions?

Try changing the way that the windmill is attached to the RCX so that it is connected to output port B rather than output port A. Write a program so that it will run the windmill for four seconds attached to this new position.

If you have reached this point you have done really well! You have learned how to program LEGO models using ROBOLAB! Now you can learn about programming more complicated tasks.