



# TeachEngineering

STEM Curriculum for K-12

## LINE-FOLLOWER CHALLENGE



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# Pre-Activity Quiz

- 1. How does a light sensor work? Does the light sensor detect white or black as a higher amount of light reflectivity? Absorbance?**
  
- 2. Can you think of a method to have the robot follow the line using turns? Describe how it would work.**

# Pre-Activity Quiz **Answers**

1. **How does a color sensor work? Does the color sensor detect white or black as a higher amount of light reflectivity? Absorbance?**

**A light sensor sends out light from one side and uses a sensor next to it to detect the light that comes back after being reflected by the surface the light hits.**

**White objects reflect most of the light whereas dark objects reflect very little light. Thus, a higher reading of the color sensor means that more of the light is reflected.**

**Looking at it another way, darker objects absorb more light so that less is available for being reflected. That is, more absorption means less reflectance.**

2. **Can you think of a method to have the robot follow the line using turns? Describe how it would work.**

**The two main program commands used are:**

- 1. If the light sensor detects a whitish color, program the robot to turn in a certain direction.**
- 2. If the light sensor detects a darkish color, program the robot to turn in the opposite direction.**

**With this technique, a robot can be made to follow the edge of a line.**

# Line-Follower Challenge

60 minutes

To have the robot follow a black line.

- First, let's review how the **light sensor** works.
- Then attach a light sensor using the instructions in the LEGO base set manual.
- Then, create a program that uses the light sensor to make it follow the black line.



# Understanding the light sensor

## Review: How does it work?

top: light sensor



bottom: lamp (sends out light)



## Do this:

- Connect the light sensor to the appropriate port on the NXT intelligent brick.
- Use the TRY ME option to detect the different light reflectiveness for each surface.



## Questions:

- What is the connection between color and light reflectivity?
- How would you use this information to program a solution to the line-follower challenge?

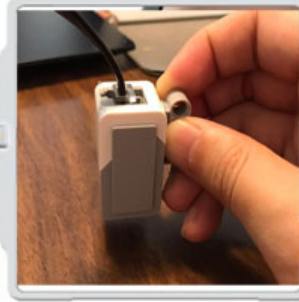
# Understanding the light sensor

## Review: How does it work?

With the sensor attached to the LEGO brick, use the VIEW command to go to the light sensor. Notice that in the “reflected light” mode, the sensor’s flood light or lamp (the bottom bulb) is turned on.



Select the Reflected light icon.  
Select the port in which you have placed the sensor.



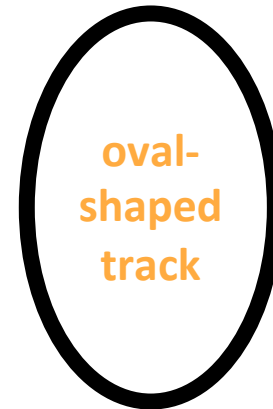
Hold the Light Sensor close to the different colors in your surrounding and see the different readings. You can use the color chart on page 66 of this guide or page 69 of the NXT Building Guide.



- **Higher numbers** indicate **BRIGHTER** light (as a percentage of light that the maximum the sensor can read)
- **Lower numbers** indicate a lower brightness of light.

# Line-Follower Activity

- Clear a **space on a smooth floor** where one or more oval-shaped tracks can be placed.
- Choose a floor area that is **light-colored**, not dark in color. If dark, then put a large sheet of white paper or wooden plywood over the floor to tape onto.
- Use **~5 feet of black tape** to create each oval track; like this →
- To test a line-follower program design, position the robot's light sensor over the line and start the program.



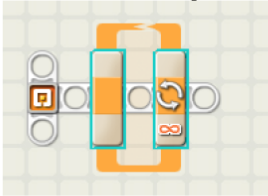
# Line-Follower Challenge Solution

## Description:

This program is for an NXT robot with the light sensor attached to the robot and connected to the NXT. The program will cause the robot to follow a black line on a white surface.

## Programming:

- 1) Click the “Loop” icon [second icon from the bottom] and drag and drop the loop command onto the sequence beam.



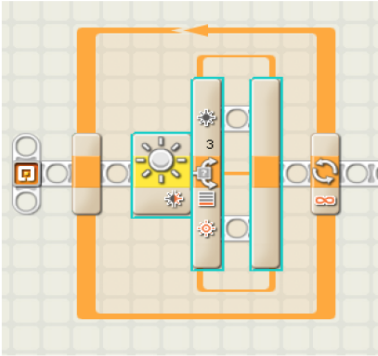
With the loop command highlighted, verify the loop control is set to forever in the control panel.



- 2) Click on the “switch” icon [the bottom most icon] and then drag and drop the switch command inside the loop.



# Line-Follower Challenge Solution



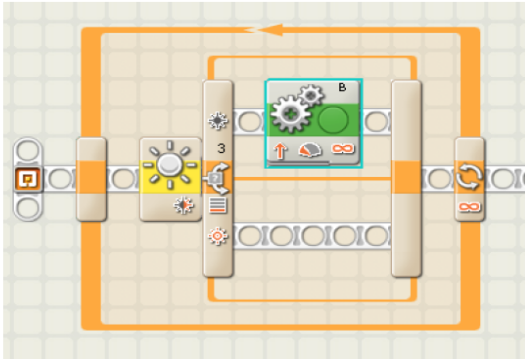
With the switch command highlighted, verify the following settings in the control panel.

- Control: Sensor
- Sensor: Light Sensor
- Port: 3 (or whatever port the light sensor is connected to)
- Compare: Light level is less than 40
- Generate light is checked



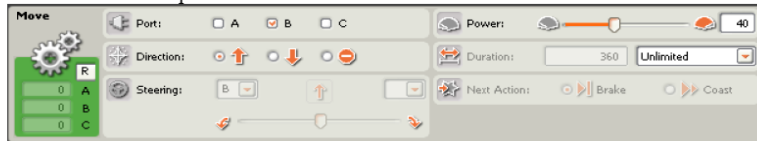
- Click the “move” icon [first icon from the top] and drag and drop the move command inside the top sequence of the switch statement.

# Line-Follower Challenge Solution



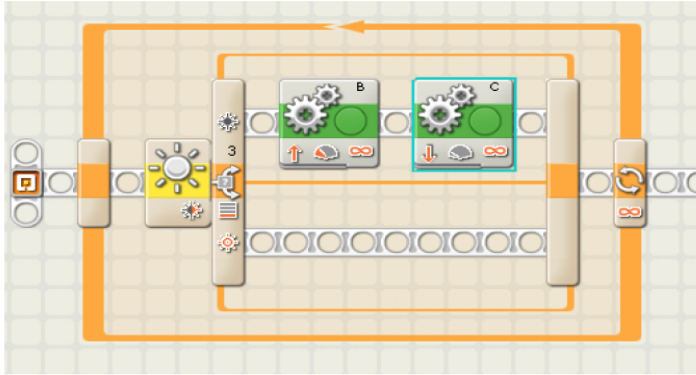
With the move command highlighted, verify the following settings in the control panel.

- Port: B selected
- Direction set to forward
- Power set to 40
- Duration drop down menu set to Unlimited



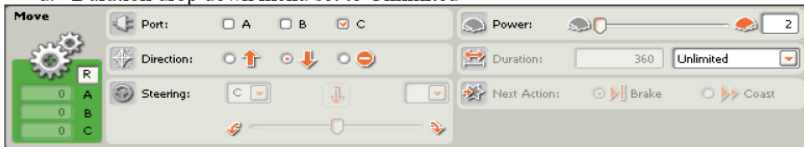
- Click the “move” icon [first icon from the top] and drag and drop the move command inside the top sequence of the switch statement to the right of the previous move command.

# Line-Follower Challenge Solution



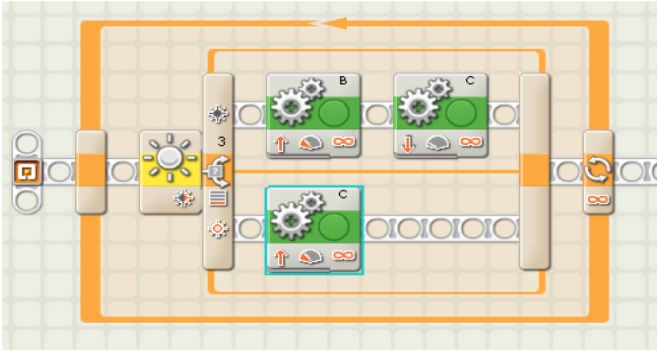
With the move command highlighted, verify the following settings in the control panel.

- Port: C selected
- Direction set to backward
- Power set to 2
- Duration drop down menu set to Unlimited



- Click the “move” icon [first icon from the top] and drag and drop the move command inside the bottom sequence of the switch statement.

# Line-Follower Challenge Solution



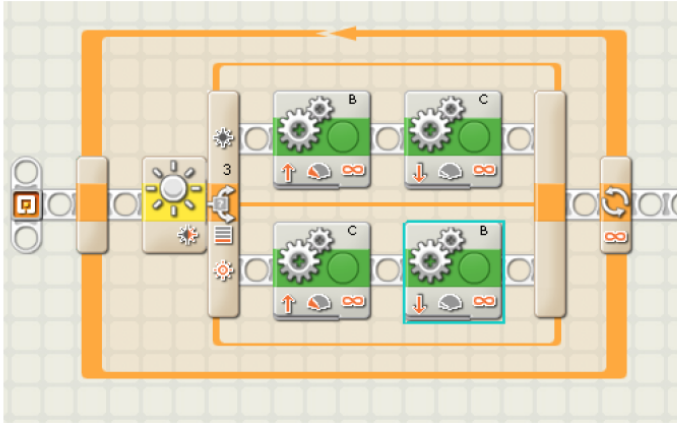
With the move command highlighted, verify the following settings in the control panel.

- Port: C selected
- Direction set to forward
- Power set to 40
- Duration drop down menu set to Unlimited



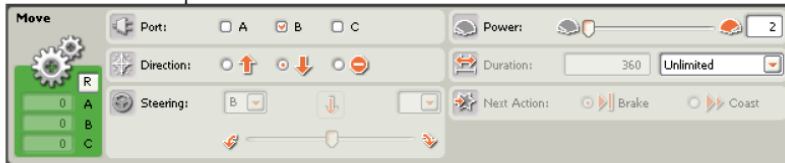
- Click the “move” icon [first icon from the top] and drag and drop the move command inside the bottom sequence of the switch statement to the right of the previous move command.

# Line-Follower Challenge Solution



With the move command highlighted, verify the following settings in the control panel.

- Port: B selected
- Direction set to backward
- Power set to 2
- Duration drop down menu set to Unlimited



# Troubleshooting Tips

If the robot does not follow a black line, check for these common problems:

- The black line may need to be thicker; if the line is very thin, the light sensor response time might be too slow.
- The light level used in the switch statement (step 2) might need to be raised or lowered, depending on the surface color/reflectivity of the black line. It is often helpful for debugging to view the output of the color sensor directly from the NXT, via the View menu option.
- Make sure the sensors/motors are connected to the correct ports.
- Read back through the instructions and make sure all the properties for the commands are set correctly.

# Post-Activity Quiz



1. Explain the logic you used in your line-follower program.
  
  
  
  
  
  
  
  
  
  
2. Where might “follow the line” logic be used in the real world?

# Post-Activity Quiz **Answers**

1. **Explain the logic you used in your “line-follower” program.**

**With the light sensor set to detect light reflectivity, it follows the edge of the line, directing the robot to turn one way when it detects more light reflectivity (whitish color) and turn the other way when it detects less light reflectivity (darkish color). By continuously doing this, sensor input and the programming come together to direct the robot to follow the tape edge.**

2. **Where might “follow the line” logic be used in the real world?**

**This idea can be turned into technology that is suitable for running buses and other mass transit systems and may end up as part of autonomous cars navigating freeways. Engineers are designing future highways where cars will travel in lanes without drivers; a Google car has been tested to do this. Smarter versions of line-follower robots are used to deliver mail in office buildings, move items through factory assembly lines, find and collect products in a warehouse, and deliver medications in hospitals.**



# Vocabulary

***design***: Loosely stated, the art of creating something that does not exist.

***engineering***: The use of science and mathematics to solve problems to improve the world around us.