Two sensor, line-following robot design using the LEGO® NXT Mindstorm® kit.
The RoboRAVE International is an annual robotics competition held in Albuquerque, New Mexico, for 3rd grade through 12th grade aged students.

www.roborave.org

This manual will walk you through programming this LEGO® NXT robot to follow a line with 2 T intersections, deliver balls to a tower, and return home.

This manual shows NXT Software v1.1.

RoboRAVE International is a program supporting the mission of “Making Research a Core Value.”

For more information, contact Inquiry Facilitators at 888-527-2007 or e-mail manual@gotoif.org.

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This manual will help you program a LEGO® NXT robot to follow a black line to a tower, deliver a payload of ping-pong balls, back up, turn around, and return to the starting position -- all in under three minutes!

We assume that you have already installed the Mindstorm NXT programming software.

If the Mindstorm NXT programming software has not been installed, please install before proceeding.

To begin, click on the “Mindstorm NXT” software icon.

In the pages that follow, the larger text size gives the basic instructions. The smaller text size is additional background information for adults or interested students.
If this is the first time you have used the software, look for the region labeled “Start New Program.”
If you are starting a new program, type its name in the box under “Start New Program.”

If you are working on a program that’s already been saved, navigate to it in the box under “Open Recent Program.”
This is the first screen you’ll see.

Click on the middle tab to see the “Complete” palette of icons.

Each of the tabs reveals another palette of icons. There is a list of all the commands on each of the palettes in the Appendix.
Click on the top icon to see the Common flyout.
Click on the Loop icon.
Drag the Loop command off the flyout.

All the programming commands will be entered the same way — finding the command and dragging it to the work area. A white box shows where the command will be placed.

Placing a command incorrectly can cause the program to crash and all your work to disappear. Save your work often!
Drag the Loop command to the “Start” box and release the mouse button.

Dragging the Loop command to the Start box begins the program. The first step of the program will be a set of instructions inside a loop. Those instructions will repeat over and over until a certain condition is met.
Be sure the Loop command is selected. You can tell if it is selected because the blocks are outlined in blue.

The Configuration Panel on the bottom left allows you to change information about a command. Here the Configuration Panel tells us that this Loop command will repeat forever. That’s what we want.

The bottom right window gives you information about the command and access to more help.
Go to the Common flyout (top green button) and drag a Switch to the Loop. The Loop will expand to fit the Switch command.

The white box shows where the command will drop. Be sure the white box is inside the Loop.
Drop the Sensor inside the Loop command.
Use the Configuration Panel at the bottom of the page to change the Touch Sensor to a Light Sensor.

Notice that the icon has changed from a hand to a light.
Click on the “Darker Than” button in the Compare section.

When you test the program, you may want to change the Threshold Value (the box that shows “50”) so the sensors of your robot more accurately sense the line.
Go back to the Common flyout and get another Switch command.
Drop the Switch command in the top part of the Light Sensor Switch.

If you need to move the work area, click on the hand icon above the work area. Be sure to click on the arrow before you continue programming.
Be sure the Switch is in the correct place.
Change the settings to:

Light Sensor
Port: 4
Compare: Darker Than
Drag another Switch to the lower part of the first Switch.

Change the settings to:

- **Light Sensor**
- **Port:** 1
- **Compare:** Darker Than

Switches are located in the top (Common) flyout OR on the Common palette. To use the Common palette, click on the green circle right above the Configuration Panel.
Go to the Common flyout and get a Move command.
Drop in the location shown.
Change the settings of the Move command to:

- Port: B and C
- Direction: Up
- Power: 35

Clicking in the circle in front of the Port letter or the Direction toggles the button on (orange) or off (white).
Change the Duration to Unlimited.
Drag two Loops to the location shown inside the top inner Light Sensor Switch.

Loops are in the top (Common) flyout.
Drag a Move command into the location shown.

Change the settings in the Configuration Panel to:

- **Power:** 35
- **Duration:** .25 Seconds
Go to the Action flyout and get a Motor command.

Move commands are found in the Command (top green circle) flyout.
Drag the Motor command inside one of the upper loops.
Change the settings to:
  Port: B
  Direction: Down
  Power: 45
Add two more Motor commands. Use the Configuration Panel to program each of the motors.

Port: C  
Direction: Up  
Power: 45

Port: B  
Direction: Down  
Power: 45
Add another Motor command. Change the settings to:
  Port: C
  Direction: Up
  Power: 45
Click on the first inner loop. The two sides of the loop should be outlined in blue. Change the settings to:
  Control: Time
  Unit: .25 (seconds)

This time setting will need to be changed based on the length of time the robot needs to find the line.
Select the second inner loop. Change the settings to:
Control: Sensor
Sensor: Light Sensor
Port: 4
Until: Darker than (click in front of left light)
Drag a Motor command to the bottom line of the top Light Sensor Switch. Change the settings to:

- Port: B
- Direction: Down
- Power: 45

The Motor command is in the Action (light green) flyout.
Drag another Motor command to the same line. Change the settings to:
- Port: C
- Direction: Up
- Power: 45
Drag a Motor command to the top line of the lower Light Sensor Switch. Change the settings to:

- Port: B
- Direction: Up
- Power: 45
Drag another Motor command to that line. Change the settings to:
  Port: C
  Direction: Down
  Power: 45
Select the outside Loop. Change the Control to Sensor.
Change the settings to:
   Sensor: Ultrasonic Sensor
   Port: 3
   Show: Centimeters (change this before changing the Distance)
   Distance: 12

This command instructs the robot to follow the instructions inside the loop until the ultrasonic sensor (which sends out an ultrasonic signal and sense how long it takes to bounce back) is within 12 cm of the tower.
Drag a Move command to the line outside the Ultrasonic Sensor Loop. Change the settings to:
   Port: A, B, and C
   Direction: None

This command stops the robot when it reaches the tower.
Drag a Motor command after the stop moving command. Change the settings to:

- Port: A
- Direction: Up
- Power: 45
- Duration: 6 Seconds
Drag a Wait command from the Common flyout to the end of the program.
Change the settings of the Wait command to:
Control: Time
Unit: 1.5 (Seconds)
Drag a Motor command to the end of the program. Change the settings to:
Port: A
Direction: Down
Power: 45
Duration: 6 Seconds
Drag a Move command to the end of the program. Change the settings to:
- Port: B and C
- Direction: Down
- Power: 45
- Duration: 1.5 Rotations
Drag two Loops to the end of the program. Insert a Motor command in the first Loop. Change the settings to:
- Port: B
- Direction: Down
- Power: 45

The Loop command is in the top (Common) flyout.
Insert another Motor command to the first Loop. Change the settings to:
Port: C
Direction: Up
Power: 45
Insert a Motor command in the second loop. Change the settings to:
- Port: B
- Direction: Down
- Power: 45
Insert another Motor command in the second loop. Change the settings to:
Port: C
Direction: Up
Power: 45
Click on the first Loop. Change the settings to:
Control: Time
Unit: .45 (Seconds)
Select the second Loop. Change the settings to:
  Control: Sensor
  Sensor: Light Sensor
  Port: C
  Until: Darker Than
Select the entire first Loop. Copy it by going to Edit and Copy or typing CTRL-C.
Paste the copy of the first Loop at the end of the program. You may need to drag it into the correct position.
Your robot has two light sensors, two motors, and one ultrasonic sensor.

When the robot goes forward in a straight line (Situation 1), both light sensors see white and both motors go forward.

When the line turns to the right (Situation 2), the right light sensor (light 2) sees black. The right motor (C) goes in reverse to make the robot turn right.

When the line turns to the left (Situation 3), the left light sensor (light 1) sees black. The left motor (B) goes in reverse to make the robot turn left.

When the robot comes to a T, both of the sensors see black. You need to program the robot to turn in the correct direction when it gets to the T.
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**Complete palette**

- **Common**
  - Move
  - Record/Play
  - Sound
  - Display
  - Wait
  - Time
  - Touch
  - Light
  - Sound
  - Distance
- **Action**
  - Motor
  - Sound
  - Display
  - Send Message
  - Motor* (RCX)
  - Lamp
- **Sensor**
  - Touch Sensor
  - Sound Sensor
  - Light Sensor
  - Ultrasonic Sensor
  - NXT Buttons
  - Rotation
  - Timer
  - Receive Message
  - Touch* (RCX)
  - Rotation* (RCX)
  - Light* (RCX)
  - Temperature * (RCX)
- **Flow**
  - Weight
  - Loop
  - Switch
  - Stop
- **Data**
  - Logic
  - Map
  - Compare
  - Range
  - Random Variable
- **Advanced**
  - Text
  - Number to Text
  - Keep Alive
  - File Access
  - Calibrate
  - Reset Motor