

LEGO Engineering Conferences™
ROBOLAB and MINDSTORMS Education
Version 4.5 – March 2008

**NXT-G Software Book I: Introductory
Robotic Activities for use with the NXT**

NXT-G Software Book I: Introductory Robotic Activities for use with the NXT

This purpose of this book is to help you develop a basic understanding how to write simple NXT software programs that involve with motors and sensors. Each program will use the common Palette the NXT- G software package. Each activity in this book contains a learning objective, and step-by-step building and programming instructions that illustrate a different programming feature of the NXT-G software. Additional pertinent information will be found at the end of the activity.

The first three activities will walk you through using the basic programming blocks in NXT-G software. The fourth activity in this book will introduce you to some of the more advanced blocks available in common NXT-G software palette. The activities build off the materials presented in the previous activities, expanding on the instruction already presented. The Open-Ended activities are less detailed programming activities, should you want addition practice NXT-G programs.

<u>Activities</u>	<u>Level</u>	<u>Page</u>
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Going the Distance	1	I - 12
Stopping on Command	2	I - 21
Velociraptor	2	I - 33
Marathon-Bot	Open Ended	I - 38
Volleymobile	Open-Ended	I - 41
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Building Instructions for NXT

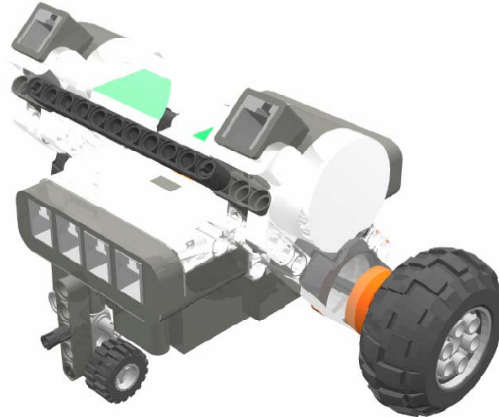
Section A	NXT - 1
Section B	NXT - 9
Section C	NXT - 11
Section D	NXT - 13
Section E	NXT - 15

Level 1

Getting Going

Learning Objective:

Building a robotic LEGO car and program the car to drive a certain distance.



NXT Car

Student Challenge:

Build and program a two-motor car to drive forward in a straight line for 2.5 meters. The car should be programmed to start moving when you press the start button and stop (by itself) after it has moved 2.5 meters.

Building Procedure:

Step 1: Build a NXT 2-motor car.

(See Building Instructions for NXT - Section A.)

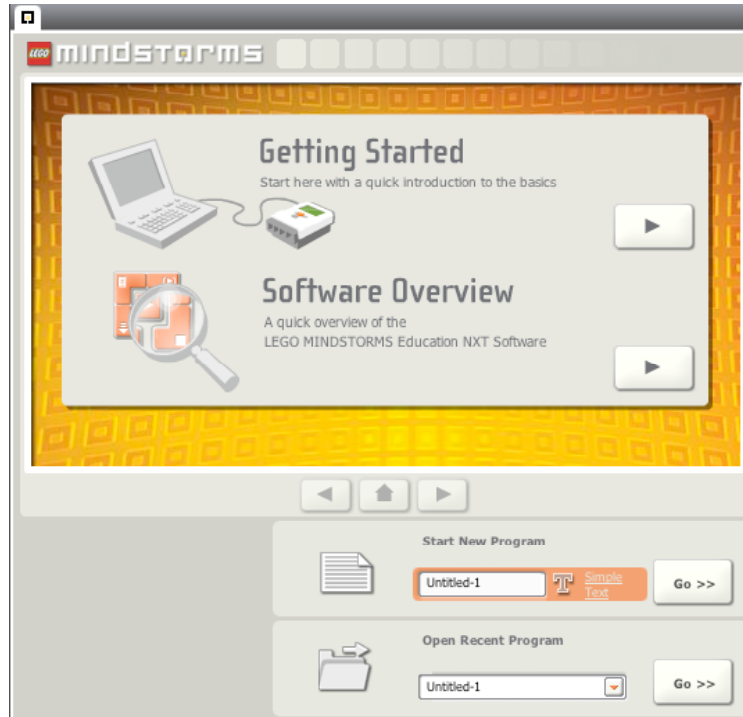
Step 2: Connect one motor to Output Port B and another motor to Output Port C.

NXT Wiring Diagram

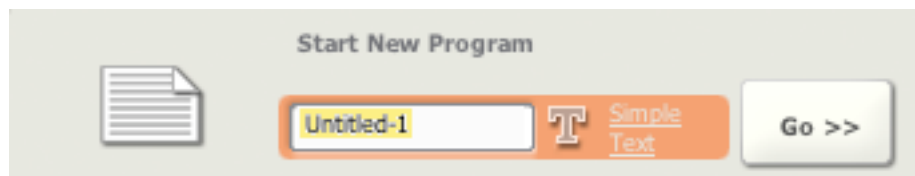
Output Port	Hardware	Input Port	Sensor
A	NONE	1	NONE
B	Motor	2	NONE
C	Motor	3	NONE
		4	NONE

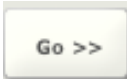
Programming Procedure:

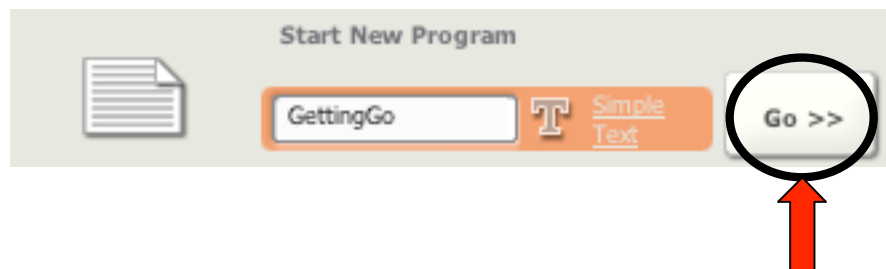
Step 1: Start the LEGO MINDSTORMS program. The menu below should appear.



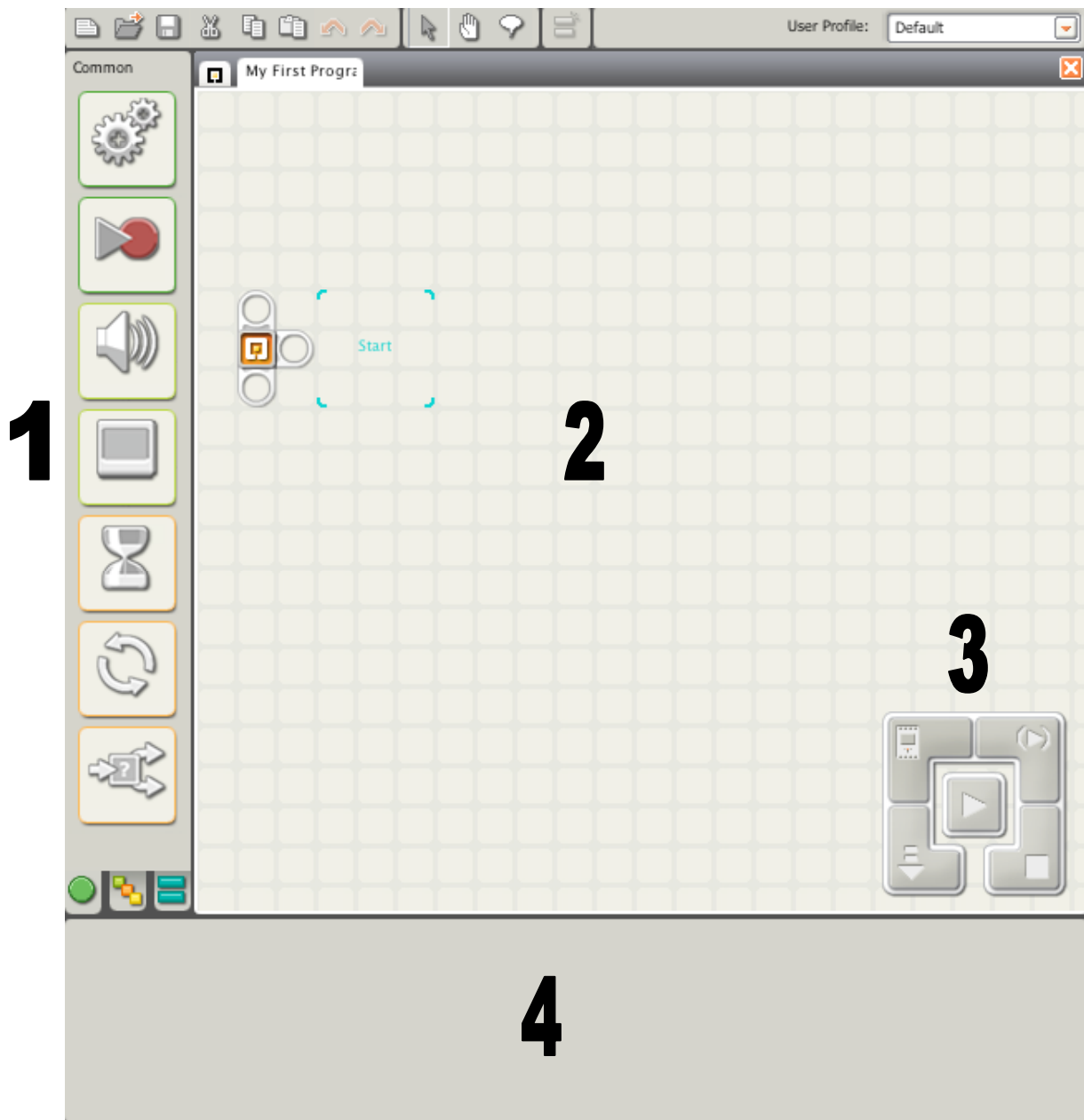
Step 2: In the MINDSTORMS NXT-G start screen, type into the orange *Start New Program* title box the name your program - *GettingGo*.



Step 3: Click the  button to the right of the orange *Start New Program* title box.



Step 4: MINDSTORMS NXT-G should open the following screen, which is the main work area for your NXT-G programs.



Area 1: The Common Block Palette.
Area 2: The NXT Workspace.
Area 3: The NXT Download Control.
Area 4: The Configuration Panel

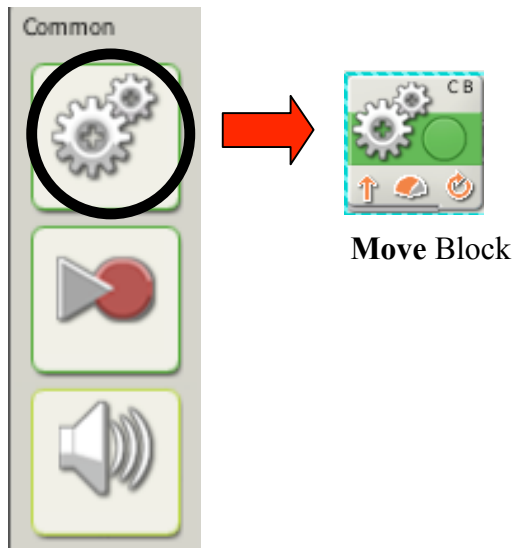
Step 5: Create a 1-block program by selecting the **Move** Block from the Common Block Palette and dragging it into the NXT-G workspace.

When adding programming blocks to the workspace, place the first programming block after the NXT-G start bar (pictured to the right). Each block added into the program will follow the proceeding block - forming a continuous line of blocks.



NXT Start Bar

The **Move** Block is selected by clicking on the top block in the Common Block Palette.



Move Block

Your 1 block program for **Getting Going** should, initially, look the picture below



Step 6: Next, the 1 block program needs to be configured to make your vehicle move forward, in a straight line, for 5 seconds.

When you select the **Move** Block, a corresponding Configuration Panel appears at the bottom of the screen.



Default Configuration Panel for the Move Block

For the purposes of this workbook, the configuration panels for each block will be presented in a chart form to clarify the settings selected for each program.

1 Move		Port: <input type="checkbox"/> A <input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power: 75
		Direction: <input checked="" type="radio"/> Forward <input type="radio"/> Backward <input type="radio"/> Reverse	Duration: 1 Rotation
		Steering: <input type="checkbox"/> C <input checked="" type="checkbox"/> B	Next Action: <input checked="" type="radio"/> Brake <input type="radio"/> Coast

Chart form of the Default Configuration Panel for the Move Block

NOTE: The configuration panel has a different setup for every block.

NOTE: Choosing specific settings will prevent you from modifying other areas. In the example above, you are unable to change the *Steering* setting unless two or more ports are selected in the *Port* area.

The **Getting Going** program should be configured to look as shown on the next page.

Step 11: The ‘Downloading to NXT...’ window will appear. The program will be completely downloaded when this window disappears and the NXT brick beeps.



Step 12: To run your program, press the **Select** (orange) button on the NXT brick four (4) times.

Additional Information:**Guide to NXT Brick**

Output Ports – 3 Ports (A, B, and C) where motors are connected to the NXT brick

USB Port – Port where USB wire is attached to connect the NXT to a computer

Display Screen – Area where all the information about the NXT is presented in various menus - including the programs stored in the NXT's memory and sensor values.

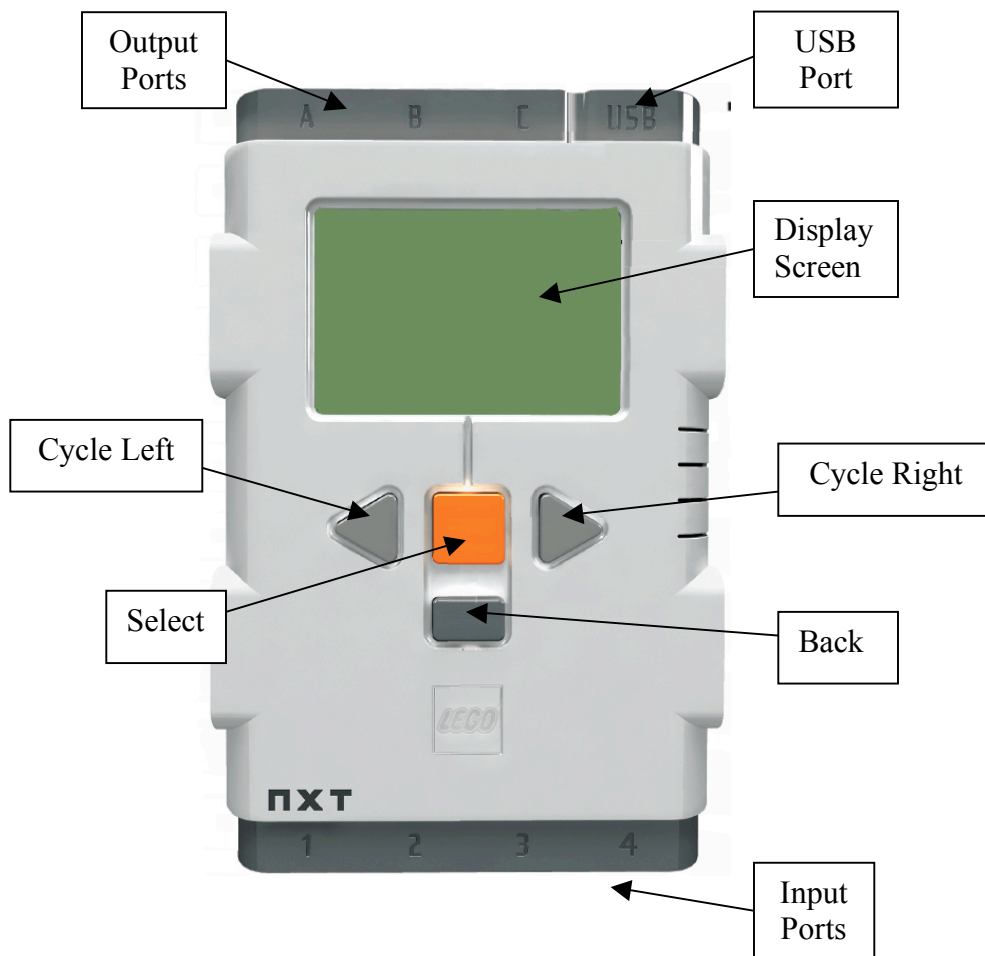
Cycle Left – Grey arrow used to cycle left through the various options presented in the NXT menus

Cycle Right – Grey arrow used to cycle right through the various options presented in the NXT menus

Select – Orange button used to select the menu option highlighted in the Display Screen. Also, when the NXT is off, pressing the orange button will turn the NXT on.

Back – Dark gray button that will step back (or deselect) to the previous options menu. When in the main options menu, pressing this button will give you the option to turn off the NXT.

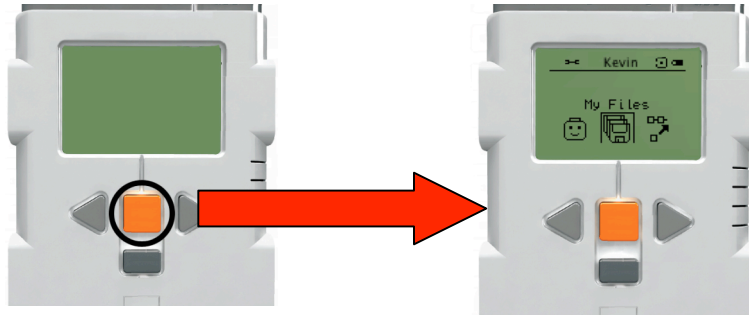
Input Ports – 4 Ports (1,2,3, and 4) where sensors are connected to the NXT brick.



Procedure to start a program stored on your NXT brick

If you've already stored a program to your NXT brick, follow these directions to run the program without having to re-download it from your computer.

Step 1: Turn the NXT on by pressing **Select** (orange) button.



Step 2: Select the *My Files* option by cycling through the menu with the **Left Cycle** and **Right Cycle** (gray arrow) keys. When *My Files* is highlighted, press the **Select** (orange) button to enter this option.



Step 3: In this new menu of the types of files stored on your NXT, use the **Left Cycle** and **Right Cycle** buttons to highlight the *Software Files* option. Once this option is highlighted, press the **Select** button.



Step 4: In this new menu of programs on your NXT, highlight the name of your program and press the **Select** button. In this example NXT menu, the program named *rbl* is highlighted.



Step 5: Highlight the *Run* option from this menu and use the **Select** button to start your program.



Step 6: Your program should now be running and the following image should now be displayed on the NXT screen



Additional Information:

In the Classroom

Age level: 7+

LEGO NXT building: beginner

Materials

NXT car

Tape measure

Tape that is a different color than the floor

Stopwatch

Level 1

Going the Distance

Learning Objective:

Program an NXT car to collect data that will allow you to graph the vehicle's velocity.



Student Challenge:

Program a two-motor car that will travel in a straight line. Your final objective is to accurately predict how long it will take for your car to travel a certain distance. You will measure how far your car travels over various periods of time and then use this information to graph and calculate the velocity of your vehicles.

PART 1:

Building Procedure:

Step 1: Build a NXT 2-motor car.
(See Building Instructions for NXT - Section A.)

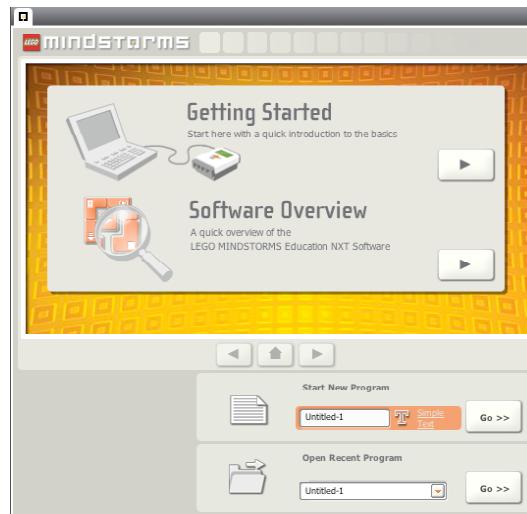
Step 2: Connect one motor to Output Port B and another motor to Output Port C.

NXT Wiring Diagram

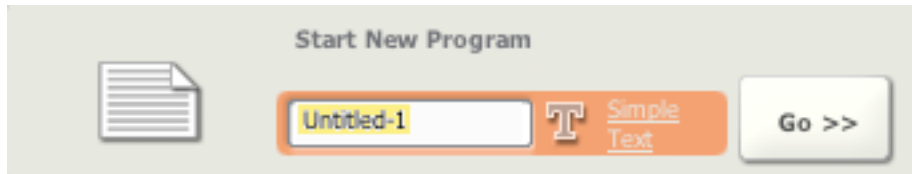
Output Port	Hardware	Input Port	Sensor
A	NONE	1	NONE
B	Motor	2	NONE
C	Motor	3	NONE
		4	NONE

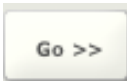
Programming Procedure:

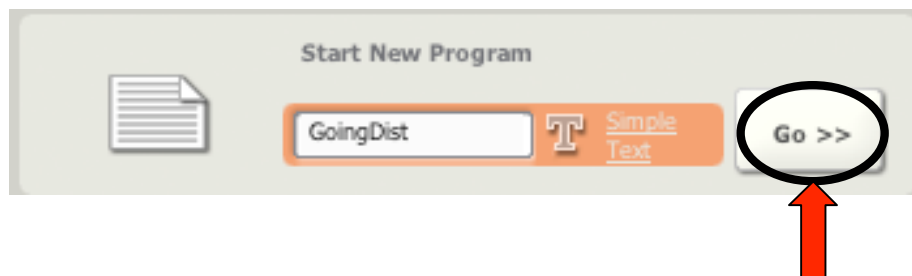
Step 1: Start the LEGO MINDSTORMS program.



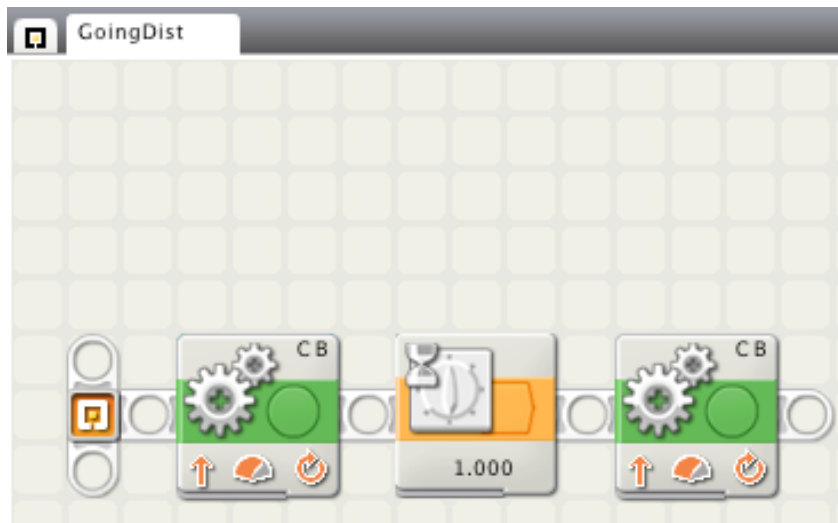
Step 2: In the MINDSTORMS NXT-G start screen, type into the orange *Start New Program* title box the name your program - *GoingDist*.



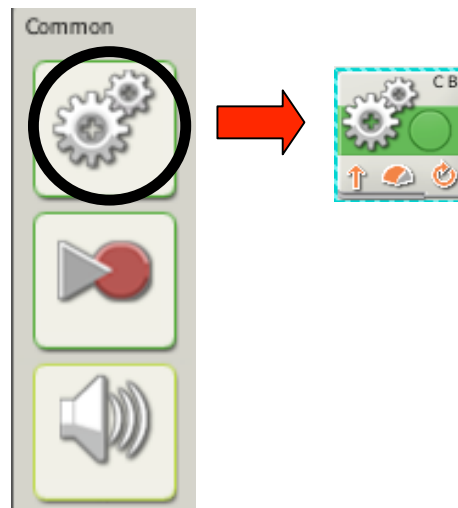
Step 3: Click the  button to the right of the orange *Start New Program* title box.



Step 4: Select blocks from the Common Block Palette to create a 3 block NXT-G program that matches the one below. These blocks will be modified in Step 5 into our final program for **Going the Distance**.



The **Move** Blocks are selected from the top block in the Common Block Palette.



The second block in this program is the **Wait For** Block, which is selected from the fifth block down on the Common Tool Palette. This block opens a submenu of five (5) possible options – but you want the **Wait For Time** Block, the first one in the menu.

The **Wait for Time** Block will cause your program to wait a number of seconds before moving onto the next block.

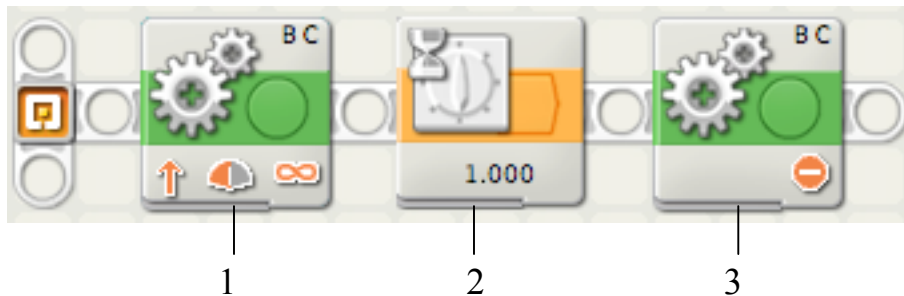
Wait For Time **Touch** **Light** **Sound** **Distance**



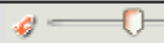

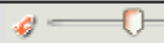

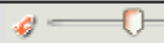








NOTE: The **Wait For** Block does not pause the NXT-G program, but prevents any new commands in the NXT-G program from occurring. Any unfinished commands *before* the **Wait For** Block will continue to run while the NXT-G program waits for a specific condition to occur.

Step 5: The 3-block program now needs to be configured to make your vehicle move forward for 1 second before stopping.

Sample Configuration for Going the Distance

This sample program will result in a 2-motor LEGO car that starts moving (block 1), waits for a period of time specified by the **Wait for Time** Block (block 2), then stops moving (block 3).



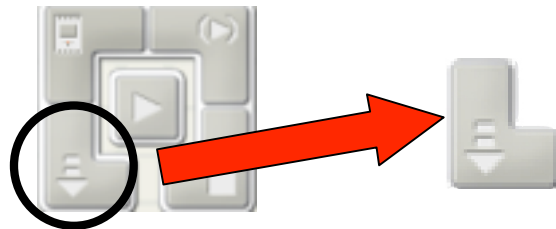
<i>Block #</i>	<i>Block</i>	<i>Configuration</i>												
1 Move		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td>50</td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td>Unlimited</td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	50	Direction:		Duration:	Unlimited	Steering:		Next Action:	
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	50											
Direction:		Duration:	Unlimited											
Steering:		Next Action:												
2 Wait for Time		<table border="1"> <tr> <td>Control:</td> <td colspan="3">Time</td> </tr> <tr> <td>Until:</td> <td>Seconds</td> <td colspan="2">1</td> </tr> </table>	Control:	Time			Until:	Seconds	1					
Control:	Time													
Until:	Seconds	1												
3 Move		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td></td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td></td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td> Brake</td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:		Direction:		Duration:		Steering:		Next Action:	 Brake
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:												
Direction:		Duration:												
Steering:		Next Action:	 Brake											

NOTE: The **Move** block is used in two different ways, due to differences in each block's configuration panel. The first **Move** block (block 1) starts motors B and C moving forward for an unlimited period of time. The other **Move** block (block 3) stops motors B and C, by taking priority over the first **Move** block.

Step 6: Using the long adaptor cable in your NXT kit, attach one end to your NXT robot and the other end to a USB port on your computer.

Step 7: Turn your NXT brick on.

Step 8: Locate download control (in the bottom right corner of the NXT workspace) and click on the *Download* button.



NXT Download Control Download Button

Step 9: The ‘Downloading to NXT...’ window will appear. The program will be completely downloaded when this window disappears and the NXT brick beeps.



Step 10: To run your program, press the orange button on the NXT brick four (4) times. Your program should be named *GoingDist*.

Step 11: Run this program and measure how far your car travels from start to finish. Record the measurements in the chart below (under Distance).

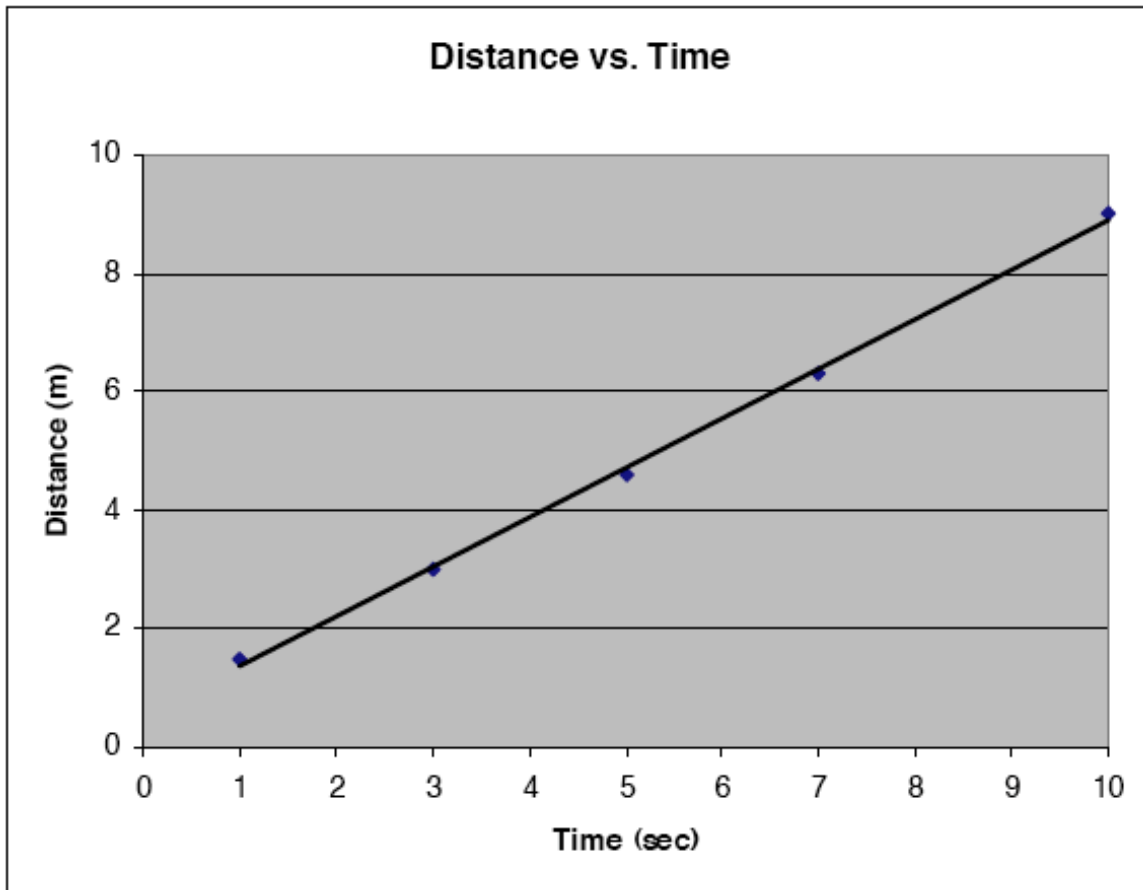
Step 12: Repeat steps 4 through 11, changing the amount of time that the **Wait for Time** block (blocks 2) waits until for each run. Continue repeating these steps until the chart below is completed.

Step 13: Plot a graph of Distance vs. Time.

Sample Data Table:

Run #	Time	Distance
1	1	1.5m
2	3	3m
3	5	4.5m
4	7	6.2m
5	10	9

Sample Graph:

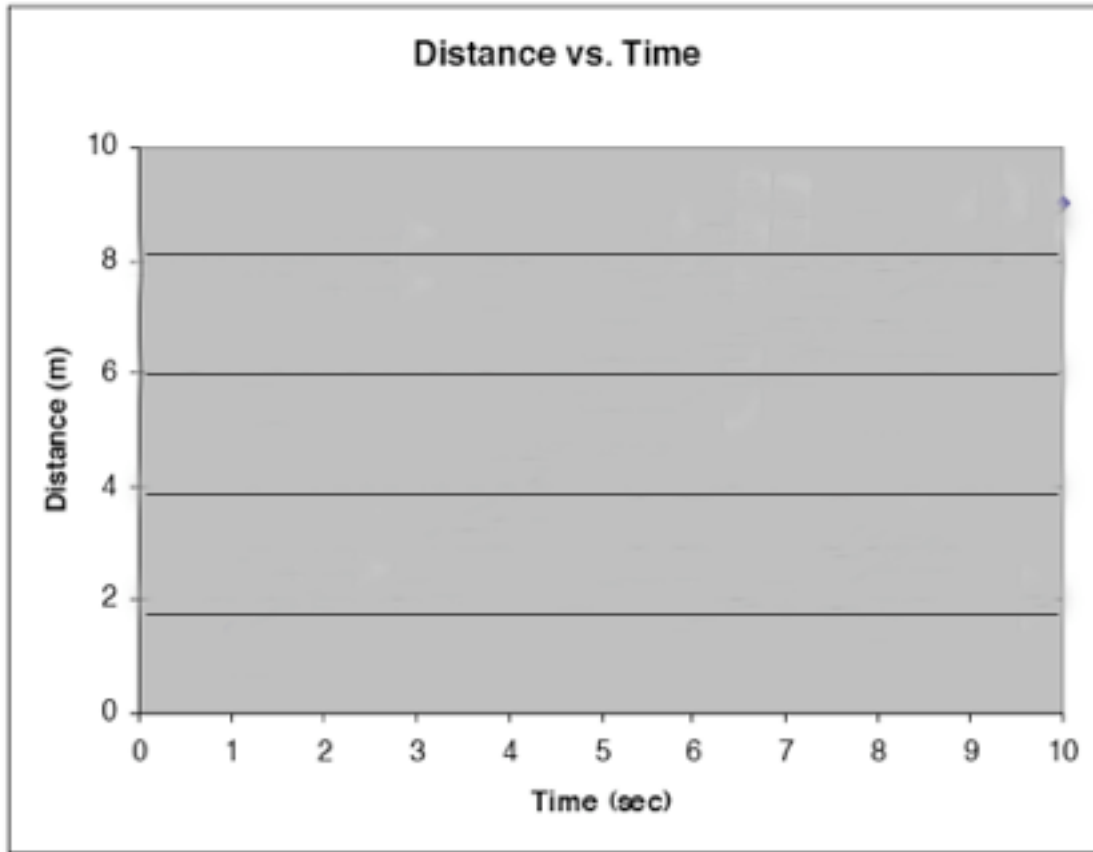


Your Data Table:

Run #	Time	Distance
1		
2		
3		
4		
5		

NOTE: The intervals you choose for your time can be as large or as small as you like. You can take more or less data than the spaces in your chart. However, the more time you have, the more accurate your graph will be. You should also run a particular time interval more than once to ensure that your car will travel that distance each time.

Your Graph:



PROCEDURE FOR PART 2:

We will tell you how far we want your car to go. Based on your graph, you will set a time for however long you think it will take to travel that distance. You get ONE SHOT to travel the specified distance – so your graph should be as accurate as possible. Whoever comes closest to the specified distance without going over will be declared winner.

Step 1: Using your graph, program the car to go the measured distance for a specific amount of time. The result is your estimated time to travel.

Step 2: Run the car and see if it stops at the specified time.

Step 3: Record the actual time it takes to travel the given distance.

Distance to Travel	Estimated Time to Travel Distance	Actual time to Travel Distance

Additional Information:

In the Classroom

Age level: 8+

LEGO NXT building: beginner

Materials

NXT car

Tape measure

Tape that is a different color than the floor

Stopwatch

Level 2

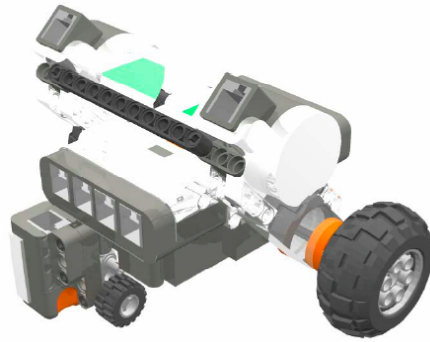
Stopping on Command

Learning Objective:

You will program your LEGO car to use touch and light sensors to stop.



NXT Vehicle with Touch Sensor



NXT Vehicle with Light Sensor

Student Challenge:

Using a two-motor car, program your LEGO vehicle to stop with a touch sensor and then with a light sensor.

PART 1 – Touch Sensor:

Building Procedure:

Step 1: Build a NXT 2-motor vehicle with a Touch Sensor.
(See Building Instructions for NXT – Section C.)

Step 2: Connect one motor to Output Port B and another motor to Output Port C.

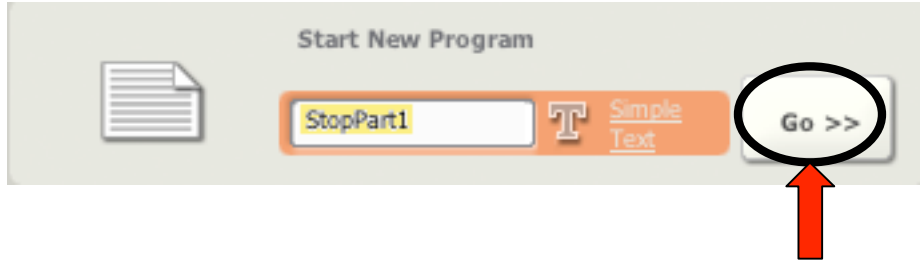
Step 3: Connect a Touch sensor to Input Port 1.

NXT Wiring Table – Touch Sensor

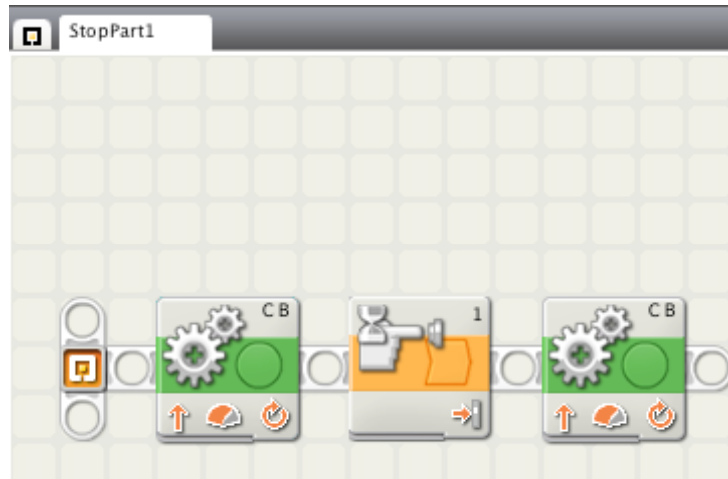
Output Port	Hardware	Input Port	Sensor
A	NONE	1	Touch Sensor
B	Motor	2	NONE
C	Motor	3	NONE
		4	NONE

Programming Procedure:

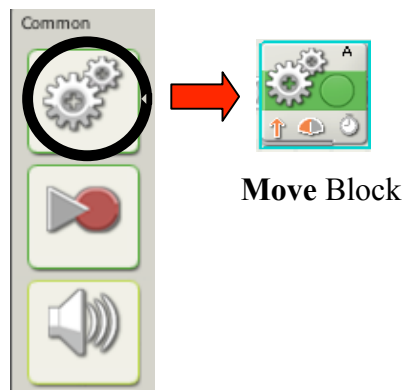
Step 1: Open MINDSTORMS and start a new program named *StopPart1*. (See previous sections for details.)



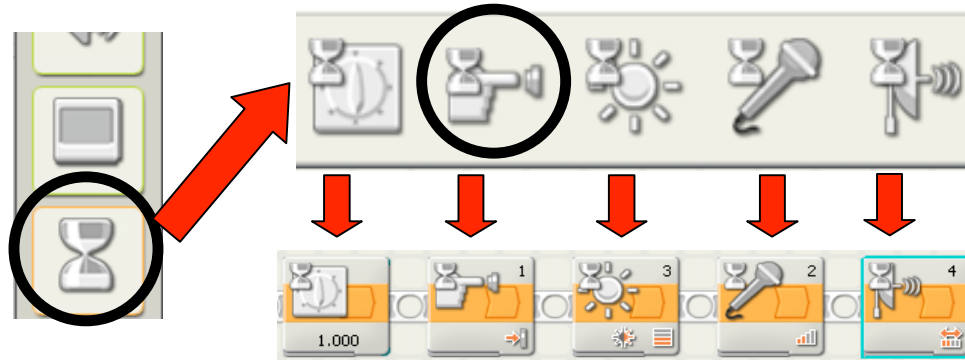
Step 2: Select blocks from the Common Block Palette to create a 3 block NXT-G program that matches the one below. These blocks will be modified in Step 3 into our final program for **Stopping on Command: Part 1**.



The **Move** Blocks are selected from the top block in the Common Block Palette.



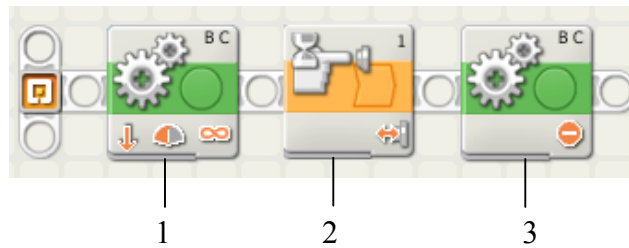
The **Wait for Touch** Block is selected from the same block in the Common Block Palette as the **Wait for Time** Block used in the *Going the Distance* activity.



Step 3: Configure the blocks in your program to start your vehicle moving and then stop when the touch sensor is pressed.

Sample Configuration for Stopping on Command – Part 1

This sample program will result in a 2-motor LEGO car moving (block 1), waiting for the touch sensor to be pressed (block 2), and then stopping (block 3).

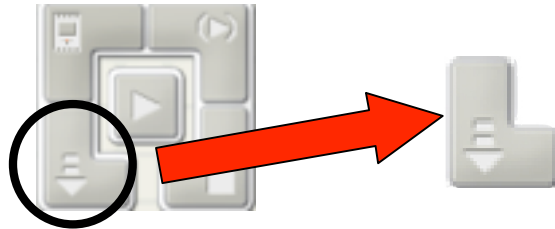


Block #	Block	Configuration												
1 Move		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td>50</td> </tr> <tr> <td>Direction:</td> <td>↓</td> <td>Duration:</td> <td>Unlimited</td> </tr> <tr> <td>Steering:</td> <td>↔</td> <td>Next Action:</td> <td></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	50	Direction:	↓	Duration:	Unlimited	Steering:	↔	Next Action:	
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	50											
Direction:	↓	Duration:	Unlimited											
Steering:	↔	Next Action:												
2 Wait for Touch		<table border="1"> <tr> <td>Control:</td> <td>Sensor</td> <td>Port:</td> <td>1</td> </tr> <tr> <td>Sensor:</td> <td>Touch Sensor</td> <td>Action:</td> <td>Bumped</td> </tr> </table>	Control:	Sensor	Port:	1	Sensor:	Touch Sensor	Action:	Bumped				
Control:	Sensor	Port:	1											
Sensor:	Touch Sensor	Action:	Bumped											
3 Move		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td></td> </tr> <tr> <td>Direction:</td> <td>⊘</td> <td>Duration:</td> <td></td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td>Brake</td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:		Direction:	⊘	Duration:		Steering:		Next Action:	Brake
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:												
Direction:	⊘	Duration:												
Steering:		Next Action:	Brake											

Step 4: Using the long adaptor cable in your NXT kit, attach one end to your NXT robot and the other end to a USB port on your computer.

Step 5: Turn your NXT brick on with the **Select** (orange) button.

Step 6: Locate download control (in the bottom right corner of the NXT workspace) and click on the *Download* button.



NXT Download Control Download Button

Step 7: The ‘Downloading to NXT...’ window will appear. The program will be completely downloaded when this window disappears and the NXT brick beeps.



Step 8: To run your program, press the **Select** (orange) button on the NXT brick four times. Your program will be named *StopPart1*.

PART 2 – Light Sensor:

Building Procedure:

Step 1: Build a NXT 2-motor vehicle with a Light sensor.
(See Building Instructions for NXT – Section B.)

Step 2: Connect one motor to Output Port B and another motor to Output Port C.

Step 3: Connect one Light Sensor to Input Port 2.

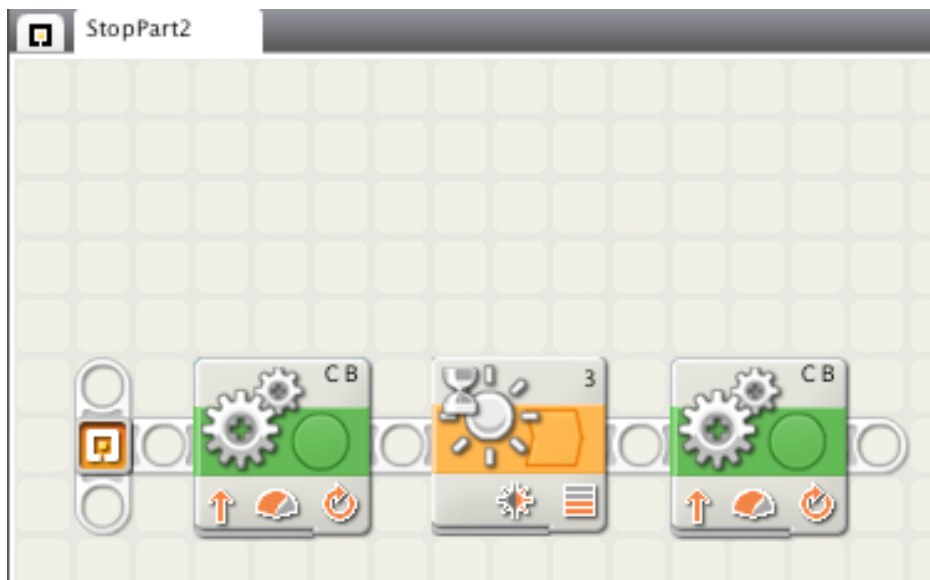
NXT Wiring Diagram – Light Sensor

Output Port	Hardware	Input Port	Sensor
A	NONE	1	NONE
B	Motor	2	Light Sensor
C	Motor	3	NONE
		4	NONE

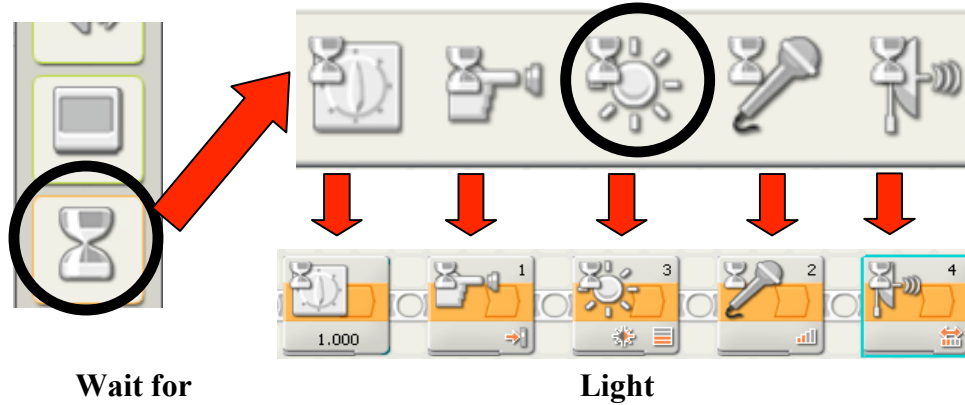
Programming Procedure:

Step 1: Open MINDSTORMS and start a new program titled *StopPart2*. (See previous sections for details)

Step 2: Select blocks from the Common Block Palette to create a 3 block NXT-G program that matches the one below. These blocks will be modified in Step 3 into our final program for **Stopping on Command: Part 2**.



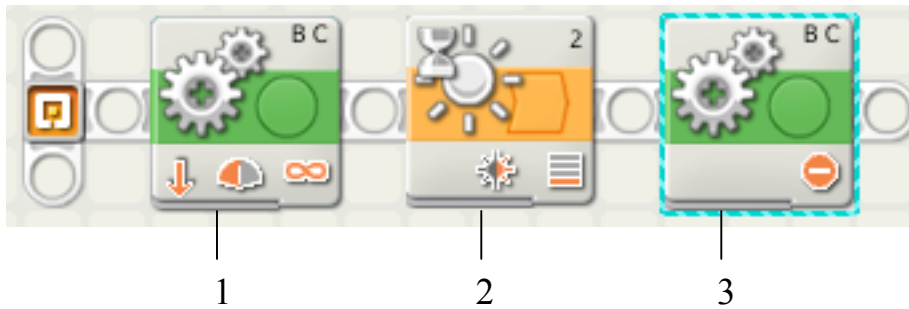
The **Wait for Light** Block is selected from the same block in the Common Block Palette as the **Wait for Touch** Block.



Step 3: Configure the blocks in your program to start your vehicle moving and then stop when the light sensor detects darkness.

Sample Configuration for Stopping on Command – Part 2

This sample program will result in a 2-motor LEGO car moving (block 1), waiting for the light sensor to detect something dark (block 2), and then stopping (block 3).



(Step Continued on Next Page)

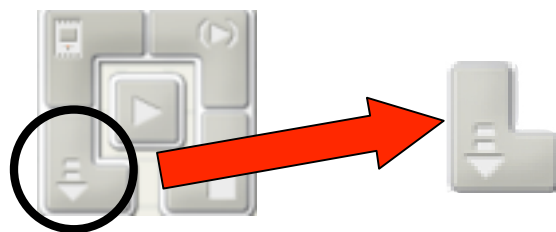
<i>Block #</i>	<i>Block</i>	<i>Configuration</i>												
1	Move	<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td>50</td> </tr> <tr> <td>Direction:</td> <td>↓</td> <td>Duration:</td> <td>Unlimited</td> </tr> <tr> <td>Steering:</td> <td>↔</td> <td>Next Action:</td> <td></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	50	Direction:	↓	Duration:	Unlimited	Steering:	↔	Next Action:	
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	50											
Direction:	↓	Duration:	Unlimited											
Steering:	↔	Next Action:												
2	Wait For Light	<table border="1"> <tr> <td>Control:</td> <td>Sensor</td> <td>Port:</td> <td>2</td> </tr> <tr> <td>Sensor:</td> <td>Light Sensor</td> <td>Until:</td> <td>< 35</td> </tr> <tr> <td>Function:</td> <td><input checked="" type="checkbox"/> Generate light</td> <td></td> <td></td> </tr> </table>	Control:	Sensor	Port:	2	Sensor:	Light Sensor	Until:	< 35	Function:	<input checked="" type="checkbox"/> Generate light		
Control:	Sensor	Port:	2											
Sensor:	Light Sensor	Until:	< 35											
Function:	<input checked="" type="checkbox"/> Generate light													
3	Move	<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td></td> </tr> <tr> <td>Direction:</td> <td>⊘</td> <td>Duration:</td> <td></td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td>⏸ Brake</td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:		Direction:	⊘	Duration:		Steering:		Next Action:	⏸ Brake
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:												
Direction:	⊘	Duration:												
Steering:		Next Action:	⏸ Brake											

NOTE: The light level in the *Until* section of **Wait for Light** (block 2) configuration panel may need to be modified from 35 to another value - based on how light or dark the room you work in is. (See page II-30 to view procedures for viewing sensor reading on the NXT brick.)

Step 4: Using the long adaptor cable in your NXT kit, attach one end to your NXT robot and the other end to a USB port on your computer.

Step 5: Turn your NXT brick on by pressing the **Select** (orange) button.

Step 6: Locate download control (in the bottom right corner of the NXT workspace) and click on the *Download* button.



NXT Download Control Download Button

Step 7: The ‘Downloading to NXT...’ window will appear. The program will be completely downloaded when this window disappears and the NXT brick beeps.



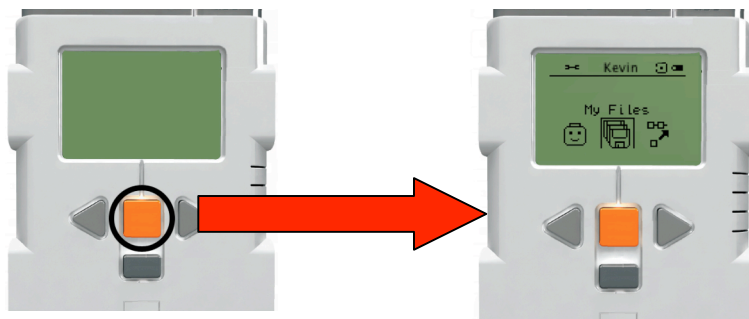
Step 8: To run your program, press the **Select** (orange) button on the NXT brick four times. The program will be named *GoingPart2*.

Alternative Procedure to view a sensor reading on your NXT brick

In **Stopping on Command – Part 2**, you need to program your NXT brick to stop when the NXT light sensor detects dark. You may need to adjust the light level in the program to accommodate the light level in your classroom.

This procedure will show you how to get sensor readings to display on the NXT brick. In this example, a light sensor is attached to port 1 on the NXT. The same steps would be followed to display readings for other NXT sensors.

Step 1: Turn the NXT on, by pressing **Select** (orange) button.



Step 2: Select the *View* option by cycling through the menu with the **Left Cycle** and **Right Cycle** (gray arrow) keys. When *View* is highlighted, press the **Select** (orange) button to enter this option.



Step 3: In this new menu of the sensor values you can view, use the **Left Cycle** and **Right Cycle** buttons to highlight the *Ambient Light* option. Once this option is highlighted, press the **Select** button.

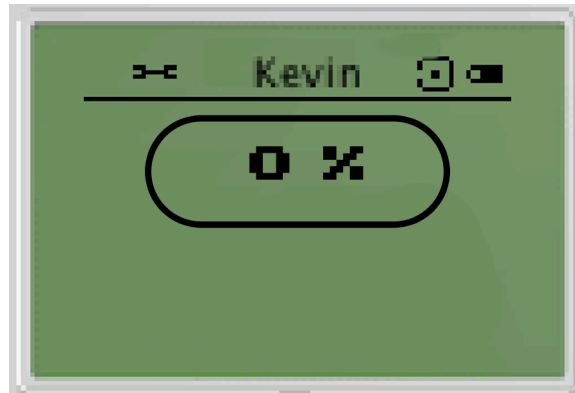


Step 4: In the new menu, highlight the port that your NXT sensor is attached to and press the **Select** button. In this example, the light sensor is attached to port 1.



NOTE: The NXT brick does not automatically differentiate between different types of sensors. The NXT brick will attempt to read values from whatever sensor is attached to the port you select in this step.

Step 5: The sensor values being read from the sensor will now be shown in the display screen of your NXT brick. The values returned is dependant on the sensor attached to your NXT. In this example, the ambient light level is returned as a percentage (%) of the maximum amount of light the NXT light sensor can detect.



NOTE: The NXT brick will not indicate what specific type of sensor that the values are being read from.

NOTE: You can stop the NXT from displaying sensor values or running a program at any time by pressing the **Back** (dark gray) button on the NXT brick

Additional Information:

In the Classroom

Age level: 7+

LEGO NXT building: beginner

Materials

NXT car

Tape measure

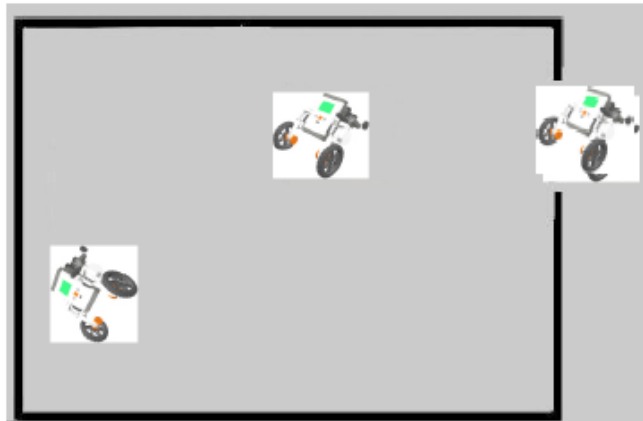
Tape that is a different color than the floor

Flashlight or Light Source

Level 2 Velociraptor

Learning Objective:

You will program your LEGO vehicle to use a light sensor and loop to avoid a black line.



Student Challenge:

A “box” made of black electrical tape will be laid down on the workshop floor. One section is open. Your robot will have to demonstrate that it can detect where the wall of the box is missing and escape the box.

Building Procedure:

Step 1: Build a NXT 2-motor vehicle with a Light Sensor.
(See Building Instructions for NXT – Section B.)

Step 2: Connect one motor to Output Port B and another motor to Output Port C.

Step 3: Connect one Light Sensor to Input Port 2.

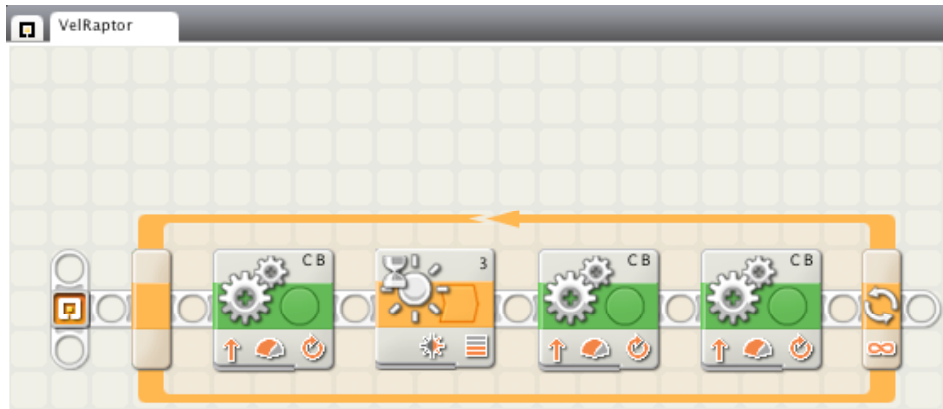
NXT Wiring Diagram

Output Port	Hardware	Input Port	Sensor
A	NONE	1	NONE
B	Motor	2	Light Sensor
C	Motor	3	NONE
		4	NONE

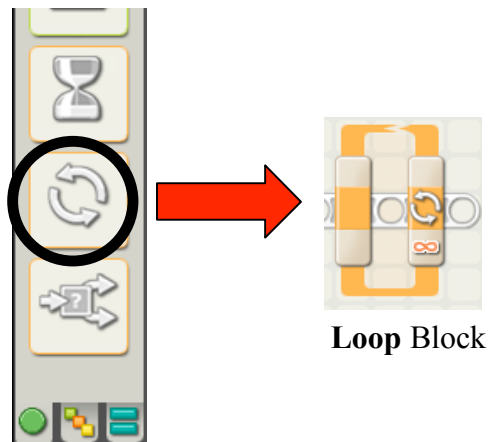
Programming Procedure:

Step 1: Open MINDSTORMS and start a new program called *VelRaptor*. (See previous sections for details.)

Step 2: Select blocks from the Common Block Palette to create a 5 block NXT-G program that matches the one below. These blocks will be modified in Step 3 into our final program for **Velociraptor**.

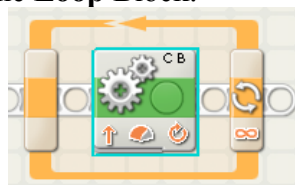


The *Velociraptor* program uses the **Loop** Block to make all (or a part) of a program run multiple times. The **Loop** Block is selected from the second to last block in the Common Block Palette.

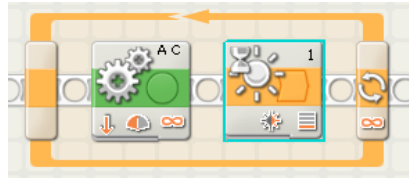


Loop Block

The **Loop** Block is different from the blocks previously discussed in this workbook. When using a **Loop** Block you place program blocks between the grey and yellow bars of the **Loop** Block.



The **Loop** Block will lengthen to accommodate each block, as shown below.

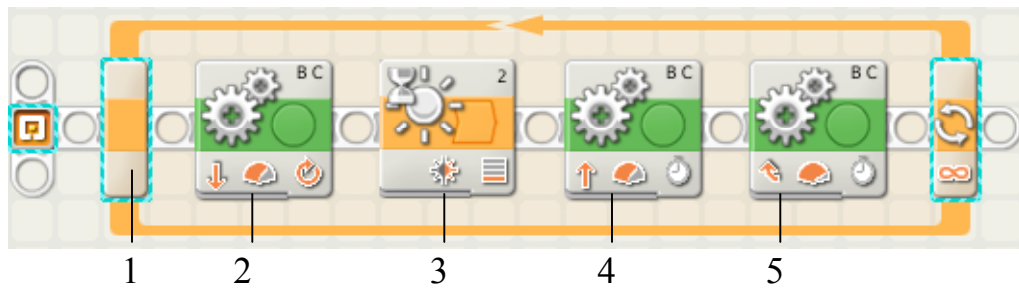


The blocks within the **Loop** Block will run normally. When the program reaches the last block in **Loop** Block, the program restarts with the first block within the loop.

Step 3: Configure the blocks in your program to start your vehicle moving, until it detects the dark ‘wall’ of the box on the floor. When the wall is detect, the car backs up and reorientates itself before driving forward again.

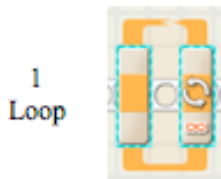
Sample Configuration for Velociraptor

This sample program makes the car move forward (block 2) until the light sensor detects dark (block 3). The car then briefly drives straight backwards (block 4) before veering to the right (block 5). The program repeats (block 1) until the car can drive forward without detecting the electric-tape ”wall“.



Block # Block

Configuration



Control:	Forever
Show:	

2
Move










Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	50
Direction:	↓	Duration:	Unlimited
Steering:	← →	Next Action:	





(Continued on next page)

Block # Block

Configuration

3 Wait for Light		Control: Sensor	Port: 2
		Sensor: 	Until: < 35
		Function: <input checked="" type="checkbox"/>  Generate light	

4 Move		Port: <input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power: 75
		Direction: 	Duration: 0.2 Seconds
		Steering: 	Next Action: <input checked="" type="radio"/>  Coast

5 Move		Port: <input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power: 100
		Direction: 	Duration: 0.4 Seconds
		Steering: 	Next Action: <input checked="" type="radio"/>  Coast

NOTE: The last **MOVE** block (Block 5) in this program has the steering slider shifted all the way to the left. This configuration allows your vehicle to turn before going forward again. Without this configuration, your vehicle would just keep running into the same wall over and over again.

Step 4: Download this program to your NXT brick. (See previous programs for details.)

Step 5: Run this program and see if your Velociraptor can escape the box.

Additional Information:

In the Classroom

Age level: 10+

LEGO NXT building: beginner

Materials

NXT car

Tape measure

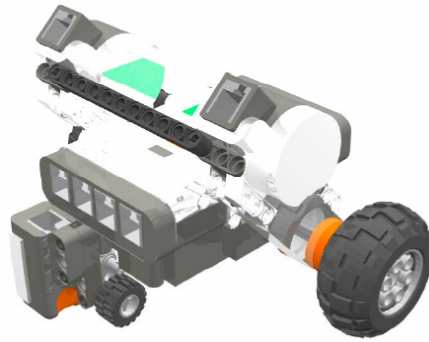
Tape that is a different color than the floor

Open-Ended Activity

Marathon-bot

Learning Objective:

You will program your LEGO car to move at different speeds throughout a race.



NXT Vehicle

Student Challenge:

Using a two-motor car, program your LEGO vehicle to move at different speeds through a race, driving at speed 20 for 1 second, 40 for 1 second, 60 for 1 second, 80 for 1 second, and then 1 for 1 second.

Building Procedure:

Step 1: Build a NXT 2-motor vehicle.

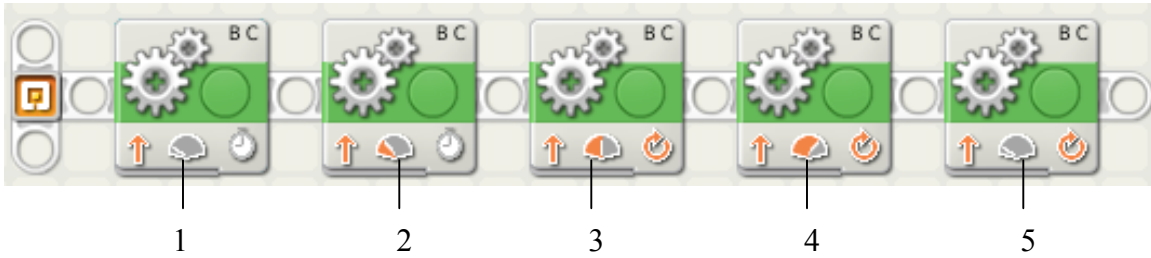
Step 2: Connect one motor to Output Port B and another motor to Output Port C.

Programming Procedure:

Step 1: Open MINDSTORMS and start a new program

Step 2: Select blocks from the Common Block Palette to create a 5 block NXT-G program that will make your NXT vehicle drive at driving at speed 20 for 1 second, 40 for 1 second, 60 for 1 second, 80 for 1 second, and then 1 for 1 second.

A sample program is included below:



Block # Block Configuration

1		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td colspan="2">20</td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td>1</td> <td>Seconds</td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td colspan="2"></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	20		Direction:		Duration:	1	Seconds	Steering:		Next Action:		
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	20														
Direction:		Duration:	1	Seconds													
Steering:		Next Action:															
2		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td colspan="2">40</td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td>1</td> <td>Seconds</td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td colspan="2"></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	40		Direction:		Duration:	1	Seconds	Steering:		Next Action:		
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	40														
Direction:		Duration:	1	Seconds													
Steering:		Next Action:															
3		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td colspan="2">60</td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td>1</td> <td>Seconds</td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td colspan="2"></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	60		Direction:		Duration:	1	Seconds	Steering:		Next Action:		
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	60														
Direction:		Duration:	1	Seconds													
Steering:		Next Action:															
4		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td colspan="2">80</td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td>1</td> <td>Seconds</td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td colspan="2"></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	80		Direction:		Duration:	1	Seconds	Steering:		Next Action:		
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	80														
Direction:		Duration:	1	Seconds													
Steering:		Next Action:															
5		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td colspan="2">1</td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td>1</td> <td>Seconds</td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td colspan="2"></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	1		Direction:		Duration:	1	Seconds	Steering:		Next Action:		
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	1														
Direction:		Duration:	1	Seconds													
Steering:		Next Action:															

Additional Activity:

Customize the pace of your vehicle and race with a partner. Your vehicle will travel for a total of 5 seconds and the vehicle that goes the furthest wins. However, your robot can only travel at speeds 20, 40, 60, and 80 and the “total velocity” must be less than 250.

To determine the “total velocity” of your robot, multiple the speed of your robot (i.e. 20, 40, 60, 80) by the amount of time your robot travels at that speed. Add up all these values to determine the “total velocity” for your vehicle. A chart below can help with this calculation.

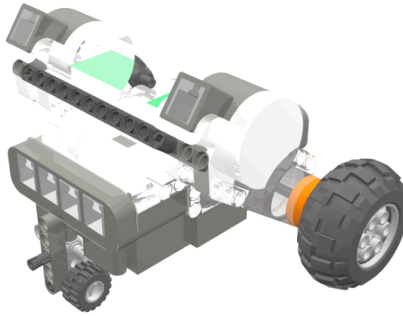
Speed	X	Time	=	Velocity
20	X		=	
40	X		=	
60	X		=	
80	X		=	
TOTAL VELOCITY				

Open-Ended Activity

Volleymobile

Learning Objective:

Build a robotic LEGO car and program the car to repeatedly drive back and forth.



NXT Car

Student Challenge:

Build and program a two-motor car to drive forward for 4 seconds and then reverse direction and drive for 4 seconds. Your car should repeat this movement forever.

Building Procedure:

Step 1: Build the NXT 2-motor car.
(See Building Instructions for NXT - Section A)

Step 2: Connect one motor to Output Port A and the other to Output Port C.

NXT Wiring Diagram

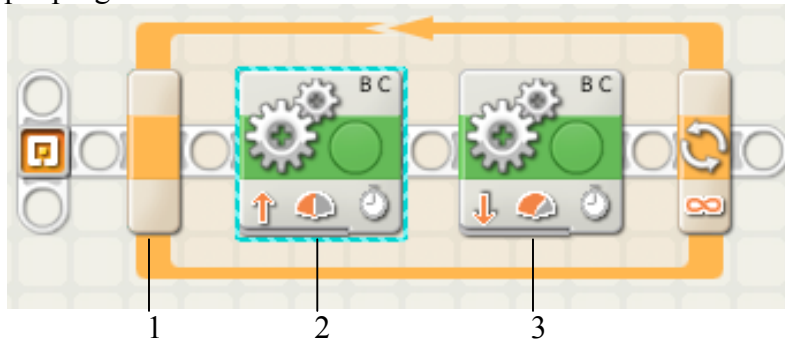
Output Port	Hardware	Input Port	Sensors
A	Motor	1	NONE
B	NONE	2	NONE
C	Motor	3	NONE
		4	NONE

Programming Procedure:

Step 1: Open LEGO MINDSTORMS and start a new program

Step 2: Select blocks from the Common Block Palette to create a 3 block NXT-G program that will make your NXT vehicle drive back and forth forever.

A sample program is included below:



1 Loop		<table border="1"> <tr> <td>Control:</td> <td>Forever</td> </tr> <tr> <td>Show:</td> <td></td> </tr> </table>	Control:	Forever	Show:									
Control:	Forever													
Show:														
2 Move		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td>50</td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td>4 Seconds</td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	50	Direction:		Duration:	4 Seconds	Steering:		Next Action:	
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	50											
Direction:		Duration:	4 Seconds											
Steering:		Next Action:												
3 Move		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td>50</td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td>4 Seconds</td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	50	Direction:		Duration:	4 Seconds	Steering:		Next Action:	
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	50											
Direction:		Duration:	4 Seconds											
Steering:		Next Action:												

Open-Ended Activity

Light In the Tunnel

Learning Objective:

You will program your LEGO car to use the light sensor to stop.



NXT Vehicle with Light Sensor

Challenge:

Using a two-motor car, program your LEGO vehicle to drive until it reaches the light at the end of the tunnel. When it sees a brighter light reading, make the vehicle back up and return to where it started.

Building Procedure:

Step 1: Build a NXT 2-motor vehicle with a Light Sensor.
(See Building Instructions for NXT – Section C.)

Step 2: Connect one motor to Output Port B and another motor to Output Port C.

Step 3: Connect a Light sensor to Input Port 1.

Programming Procedure:

Step 1: Open LEGO MINDSTORMS and start a new program.

Step 2: Select blocks from the Common Block Palette to create an NXT-G program that will make your NXT vehicle drive forward until it sees a light. When it sees a light, the NXT vehicle will reverse and return to its starting point. A sample program is provided on the following page.



Block # Block Configuration

1		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td>75</td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td>Unlimited</td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	75	Direction:		Duration:	Unlimited	Steering:		Next Action:	
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	75											
Direction:		Duration:	Unlimited											
Steering:		Next Action:												
2		<table border="1"> <tr> <td>Control:</td> <td>Sensor</td> <td>Port:</td> <td><input checked="" type="radio"/> 2</td> </tr> <tr> <td>Sensor:</td> <td></td> <td>Until:</td> <td>< 35</td> </tr> <tr> <td></td> <td></td> <td>Function:</td> <td><input checked="" type="checkbox"/> Generate light</td> </tr> </table>	Control:	Sensor	Port:	<input checked="" type="radio"/> 2	Sensor:		Until:	< 35			Function:	<input checked="" type="checkbox"/> Generate light
Control:	Sensor	Port:	<input checked="" type="radio"/> 2											
Sensor:		Until:	< 35											
		Function:	<input checked="" type="checkbox"/> Generate light											
3		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td></td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td></td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td><input checked="" type="radio"/> Brake</td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:		Direction:		Duration:		Steering:		Next Action:	<input checked="" type="radio"/> Brake
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:												
Direction:		Duration:												
Steering:		Next Action:	<input checked="" type="radio"/> Brake											
4		<table border="1"> <tr> <td>Control:</td> <td colspan="2">Time</td> </tr> <tr> <td>Until:</td> <td>Seconds</td> <td>1</td> </tr> </table>	Control:	Time		Until:	Seconds	1						
Control:	Time													
Until:	Seconds	1												
5		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td>75</td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td>Unlimited</td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td></td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	75	Direction:		Duration:	Unlimited	Steering:		Next Action:	
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:	75											
Direction:		Duration:	Unlimited											
Steering:		Next Action:												
6		<table border="1"> <tr> <td>Control:</td> <td>Sensor</td> <td>Port:</td> <td><input checked="" type="radio"/> 2</td> </tr> <tr> <td>Sensor:</td> <td></td> <td>Until:</td> <td>< 35</td> </tr> <tr> <td></td> <td></td> <td>Function:</td> <td><input checked="" type="checkbox"/> Generate light</td> </tr> </table>	Control:	Sensor	Port:	<input checked="" type="radio"/> 2	Sensor:		Until:	< 35			Function:	<input checked="" type="checkbox"/> Generate light
Control:	Sensor	Port:	<input checked="" type="radio"/> 2											
Sensor:		Until:	< 35											
		Function:	<input checked="" type="checkbox"/> Generate light											
7		<table border="1"> <tr> <td>Port:</td> <td><input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C</td> <td>Power:</td> <td></td> </tr> <tr> <td>Direction:</td> <td></td> <td>Duration:</td> <td></td> </tr> <tr> <td>Steering:</td> <td></td> <td>Next Action:</td> <td><input checked="" type="radio"/> Brake</td> </tr> </table>	Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:		Direction:		Duration:		Steering:		Next Action:	<input checked="" type="radio"/> Brake
Port:	<input checked="" type="checkbox"/> B <input checked="" type="checkbox"/> C	Power:												
Direction:		Duration:												
Steering:		Next Action:	<input checked="" type="radio"/> Brake											

NOTE: The light level in the *Until* section of **Wait for Light** (block 2) configuration panel may need to be modified from 35 to another value - based on how light or dark the room you work in is. (See page II-30 to view procedures for viewing sensor reading on the NXT brick.)