Rotation Sensors

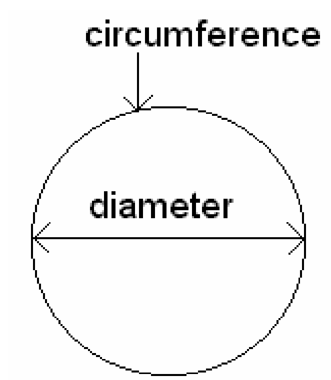
The rotation sensor measures how much an axle rotates. As the axle turns, the rotation sensor counts how much the axle rotates. When the axle starts rotating, the rotation sensor starts counting. There are 16 counts in 1 complete revolution of the axle. The number of counts is what the RCX reads as input. When the axle stops rotating, the rotation sensor stops counting. If the axle starts to rotate again, the rotation sensor begins counting where it left off. Since the number of counts is relative, it needs to be reset to zero at the start of your program.

Attach a rotation sensor with an axle through the hole to your RCX on port 3. Press the view button on the RCX until the triangle is above port number 3, the port the rotation sensor is attached to. Turn the wheel forward. The rotation sensor should be counting. What happens when you turn the wheel backwards?

Controlling Distance

Up to now, you have been using time to control how long the motors of your robot are activated. As the batteries in the RCX wear down, or if the surface that your robot is moving on changes, then that could affect the amount of time that you need to turn on the motors to get the robot to move the same amount of distance.

Rotation sensors are very useful to measure and control how far your robot move no matter what the conditions are. By measuring how many times your robot's wheels turn, and knowing the circumference of the wheels, you can control how far your robot moves.

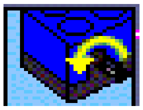


Remember that the circumference of a circle is the distance around the outside of the circle. The circumference is equal to the diameter of the circle times pi. When your robot's wheel makes one full rotation, the robot travels one circumference of the wheel. The circumference is the wheel's diameter multiplied by Pi. Pi =3.14.

For example the diameter of this wheel is 4 cm. The circumference is 4 x 3.14 which equals 12.56 cm. The distance the robot will travel in one complete revolution of the axle with this wheel attached is 12.56 cm.

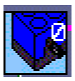
You can have your robot travel a precise distance by using the rotation sensor. IF you know the diameter of the wheel, then you can compute how many revolutions it must make from its circumference. If you know how many revolutions the wheel must make, then you know how many rotation sensor counts are needed to travel that distance. Remember 16 counts = 1

Programming Rotation Sensors



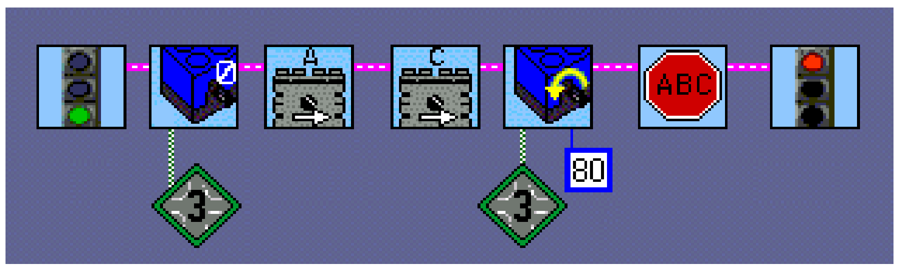
The rotation sensor can be programmed to wait for a certain number of sensor counts. Recall that there are 16 counts per one revolution of the rotation sensor.

You can therefore use a rotation sensor to control a motor and the distance your robot travels. To do this use a numeric constant to specify the number of counts to wait for.

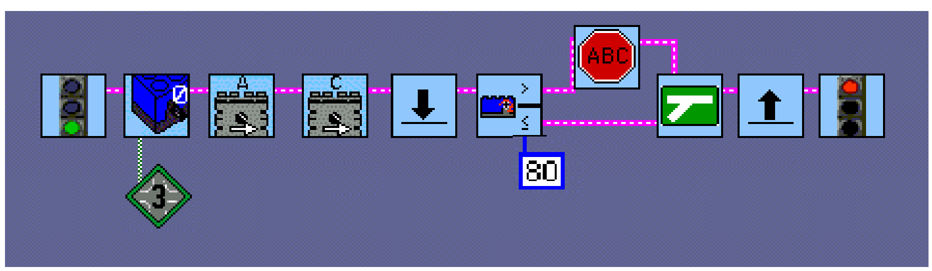


Remember rotation sensors continue counting where they left off so don't forget to reset the rotation sensor to 0 in your program.

This program turns on motor A and C, waits until the rotation sensor reads 80 counts, then turns off motor A and C. This would be 5 complete revolutions of the motor axle. Don't forget to reset the rotation sensor to 0 at the beginning of your program!

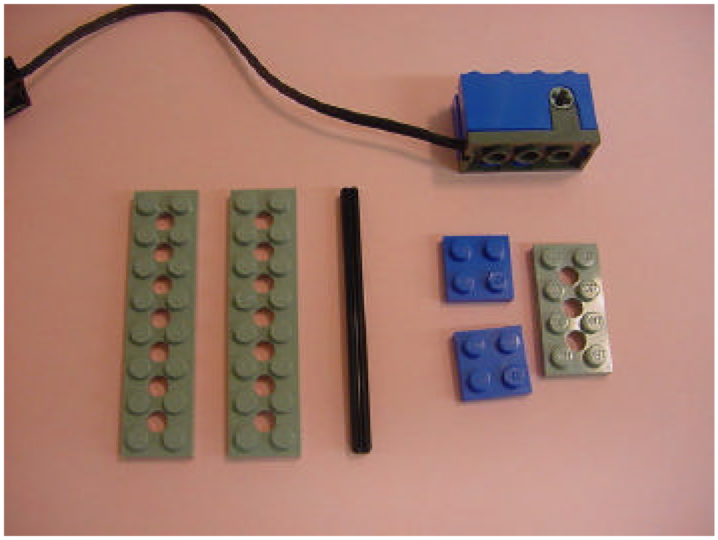


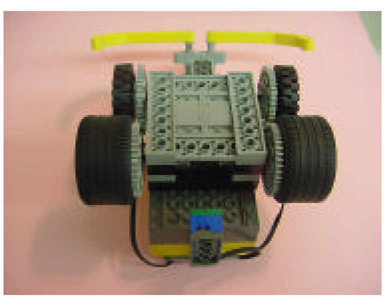
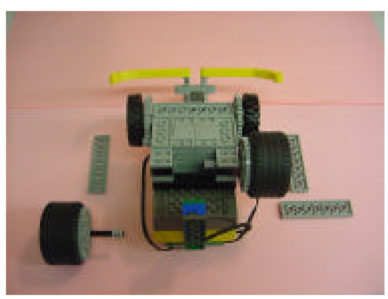
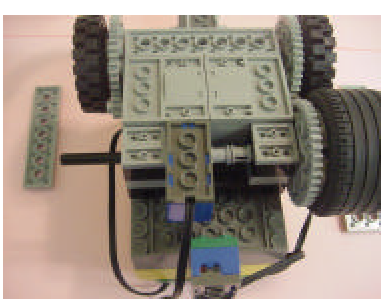
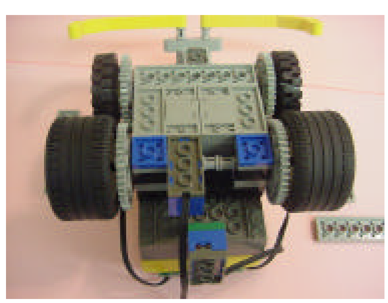
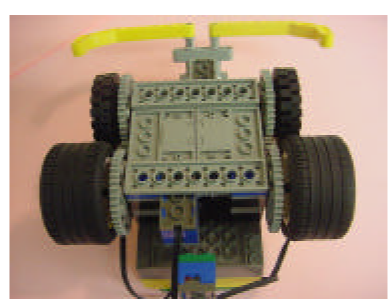
There is also a rotation sensor fork. In this program, if the number of rotation sensor counts is 80 or less, it lets motor A and C run. Once the number of counts is above 80, it stops motor A. Remember to reset your rotation sensor and all forks need a fork merge icon at the end of the decision.



Rotation Sensor Attachment

Building Instructions



Turn robot upside down	Remove pieces shown	Step Three
		
Step Four	Step Five	Step Six
		

Name ____________________________________ Hour ___________

Rotation Sensor Worksheet

1. Write a program that beeps once every time the rotation sensor is turned 1/4 rotation. Do this 10 times.

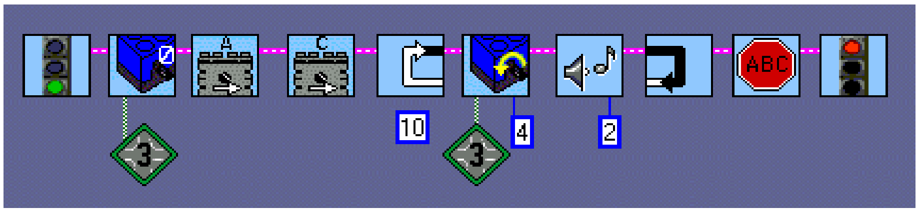
2. When the touch sensor is pressed, turn on Motor A and C in the forward direction. Then turn the rotation sensor 1 1/2 rotations to turn the motors off.

3. Start by turning on motor A and C in the forward direction. If the rotation sensor has made 3 rotations, turn off motor A and C and exit the program. Otherwise, play a beep, wait for 1 second, and continue to check the rotation sensor.

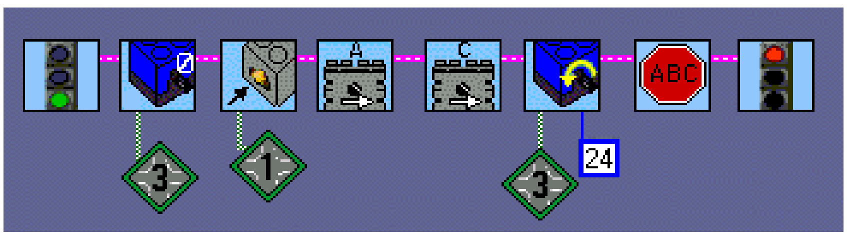
Name ________________________________ Hour __________

Rotation Sensor Worksheet Solutions

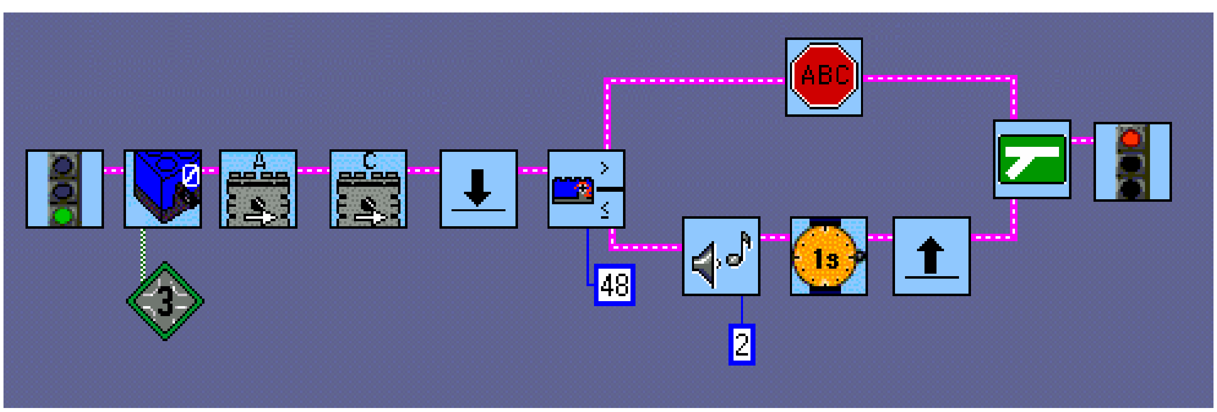
1. Write a program that beeps once every time the rotation sensor is turned 1/4 rotation. Do this 10 times.



2. When the touch sensor is pressed, turn on Motor A and C in the forward direction. Then turn the rotation sensor 1 1/2 rotations to turn the motors off.



3. Start by turning on motor A and C in the forward direction. If the rotation sensor has made 3 rotations, turn off motor A and C and exit the program. Otherwise, play a beep, wait for 1 second, and continue to check the rotation sensor.



Name ______________________________________ Hour ___________

Rotation Sensor Distance Calculation Worksheet

Question:
How can we translate a rotation sensors measurement into how far a robot moves?

Procedure:
1. Create a program that moves the robot forward exactly 1 axle or wheel rotation. How many rotation sensor counts is this? Download your program to your robot.
2. Measure the diameter (in centimeters) of the rear wheels on your robot. Fill in the data table for trial 1 and 2.
3. Calculate the circumference of the wheel and enter it into the data table for trial 1 and 2.
4. Start your robot on the black line of the poster board. Run the program. The robot should move forward.
5. When the robot stops, mark the poster board in front of the robot with a pencil. Measure the distance between the black line and the pencil mark and enter the value into the data table for trial 1. Erase your marks on the poster board when finished.
6. Modify your program to have the robot move forward for exactly 2 axle/ wheel rotations. Run the program, measure the distance and enter the data into the table for **Trial 2**.

Trials	**Number of Rotational Sensor counts**	**Number of Wheel Rotations**	**Wheel Diameter (in cm)**	**Wheel Circumference (in cm) D * PI = Cir**	**Distance Robot Traveled (in cm)**
Trial 1 Small wheels					
Trial 2 Small wheels					
Trial 3 Large wheels					
Trial 4 Large wheels					

Name ____________________________________ Hour ___________

Rotation Sensor Distance Calculation Worksheet Solutions

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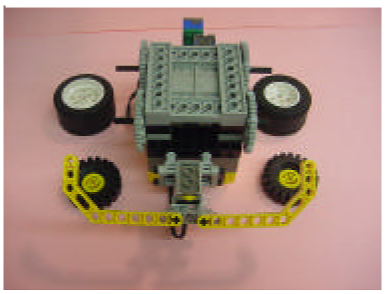
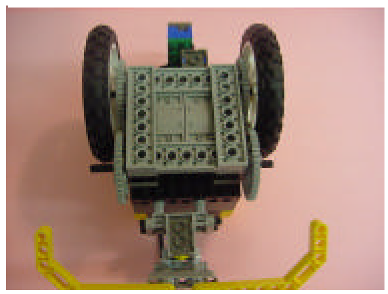
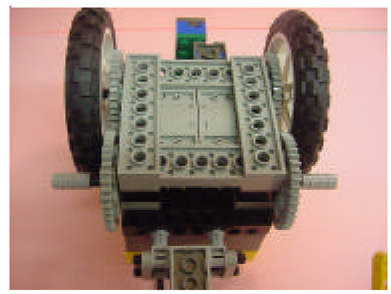
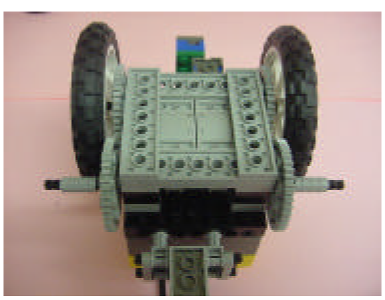
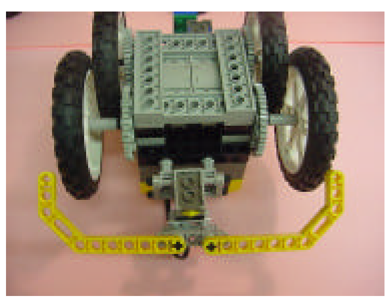
6. Modify your program to have the robot move forward for exactly 2 axle/wheel rotations. Run the program, measure the distance and enter the data into the table for **Trial 2**.

Trials	**Number of Rotational Sensor counts**	**Number of Wheel Rotations**	**Wheel Diameter (in cm)**	**Wheel Circumference (in cm) D * PI = Cir**	**Distance Robot Traveled (in cm)**
Trial 1 Small wheels	*16*	*1*	*5*	*15.7*	*15.7*
Trial 2 Small wheels	*32*	*2*	*5*	*15.7*	*31.4*
Trial 3 Large wheels	*16*	*1*	*8*	*25.1*	*25.1*
Trial 4 Large wheels	*32*	*2*	*8*	*25.1*	*50.2*

Rotation Sensor Distance Calculation Robot Modifications

Modify your robot by adding the following materials

4 large wheels
2 axle couplers
2 #2 axles
(2 Lego bumps long)

Turn robot upside down and remove small wheels	Add Large Rear Wheels	Add axle couplers to front axles, both sides
		
Insert #2 axle into axle coupler	Add Large Front wheels	Reverse front bumper pieces
		

6. Measure the large wheels diameter and calculate their circumference and enter it into the data table for **Trial 3 and 4**.
7. Run the program that has the robot move forward exactly 1 axle/wheel rotation. Measure the distance the robot travels and enter the data into the table for **Trial 3**.
8. Modify your program to have the robot move forward for exactly 2 axle/ wheel rotations. Run the program, measure the distance and enter the data into the table for **Trial 4**.

Name ____ Hour __________

Rotation Sensor Distance Calculation Worksheet

1. What type of information does a rotation sensor provide?

2. What is the advantage of a rotation sensor over a timer?

3. In trials 1 and 3 did the distance that the robot traveled change? Explain Why.

4. What is the relationship between the circumference and the distance traveled in Trials 1 and 3? Explain why.

5. What is the relationship between the circumference and the distance traveled in Trials 3 and 4? Explain why.

Use the following formulas to help you answer questions 6 and 7
Distance /Circumference = # of wheel rotations
# of wheel rotations X 16 counts per rotation = rotation sensor count

6. For the robot with the smaller wheels, if you wanted your robot to travel exactly 1 meter (100 cm) , how many rotation sensor counts would you need to wait for? (Show your work)

7. For the robot with the larger wheels, if you wanted your robot to travel exactly 1 meter, how many rotation sensor counts would you need to wait for? (Show your work)

Name ____ Hour __________

Rotation Sensor Distance Calculation Worksheet Solutions

1. What type of information does a rotation sensor provide?
   A rotation sensor is a sensor that measures how much an axle rotates. It provides the information in counts. There are 16 counts in one complete rotation.

2. What is the advantage of a rotation sensor over a timer?
   The rotation sensor can precisely measure and control how far the robot moves. It is not affected by battery strength

3. In trials 1 and 3 did the distance that the robot traveled change? Explain Why.
   Yes, the distance changed. The reason is the different sized wheels had different diameters, therefore different circumferences. The robot was programmed to travel for one wheel rotation. Since the circumferences are different, the robot traveled different distances.

4. What is the relationship between the circumference and the distance traveled in Trials 1 and 3? Explain why.
   They should be the same or pretty close. The reason is the robot was programmed to travel for exactly 1 wheel rotation, which is 1 circumference of the wheel

5. What is the relationship between the circumference and the distance traveled in Trials 3 and 4? Explain why.
   The distance traveled should be twice the circumference or pretty close. The reason is the robot was programmed to travel exactly 2 wheel rotations, which is 2 circumferences.

Use the following formulas to help you answer questions 6 and 7
Distance /Circumference = # of wheel rotations
# of wheel rotations X 16 counts per rotation = rotation sensor count

6. For the robot with the smaller wheels, if you wanted your robot to travel exactly 1 meter (100 cm) , how many rotation sensor counts would you need to wait for? (Show your work)

   1 meter = 100 centimeters Small wheel circumference =15.7 centimeters.
   100/15.7 = 6.4 circumferences = 6.4 wheel rotations.
   6.4 rotations x 16 counts per rotation = 102 counts

7. For the robot with the larger wheels, if you wanted your robot to travel exactly 1 meter, how many rotation sensor counts would you need to wait for? (Show your work)

   1 meter = 100 centimeters Large wheel circumference =25.1 centimeters.
   100/25.1 = 4.0 circumferences = 4.0 wheel rotations.
   4.0 rotations x 16 counts per rotation = 64 counts

Name ____ Hour ____________

Rotation Sensor Challenge

The robot must move exactly 1.2 meters.

The robot should do this for 2 different size wheels. You will have to write 2 different programs to accomplish this.

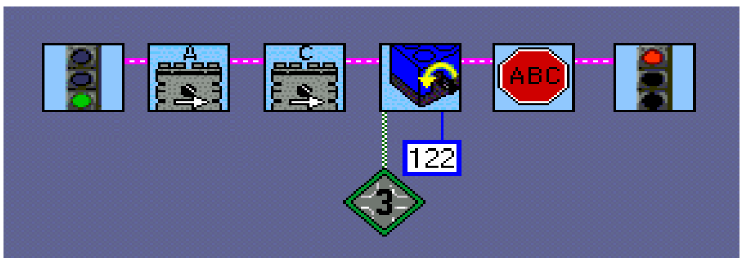
Name ____ Hour ____________

Rotation Sensor Challenge Solution

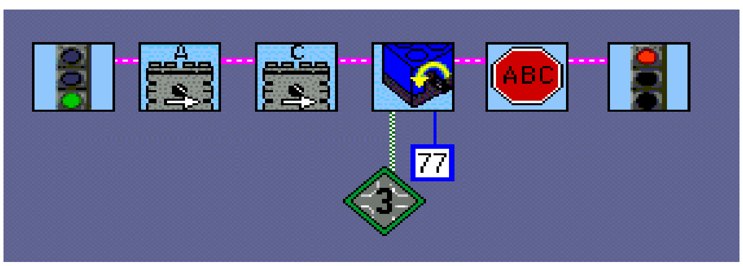
The robot must move exactly 1.2 meters.

The robot should do this for 2 different size wheels. You will have to write 2 different programs to accomplish this.

1.2 meter = 120 centimeters Small wheel circumference =15.7 centimeters.
120/15.7 = 7.6 circumferences = 7.6 wheel rotations.
7.6 rotations x 16 counts per rotation = 122 counts



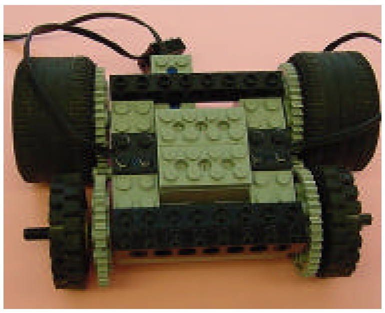
1.2 meter = 120 centimeters Large wheel circumference =25.1 centimeters.
120/25.1 = 4.8 circumferences = 4.8 wheel rotations.
4.8 rotations x 16 counts per rotation = 77 counts



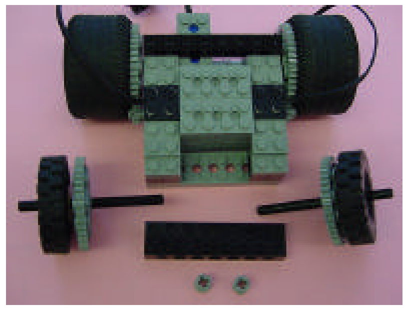
Rotation Sensor Maze

Modify your robot as shown below to include a front swivel wheel.

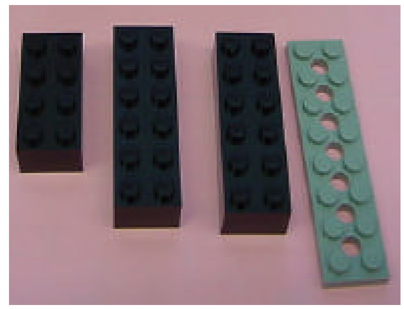
Step One
Remove brick



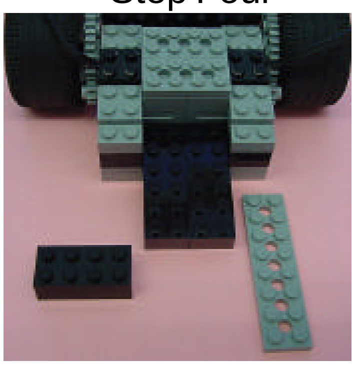
Step Two
Remove front wheels



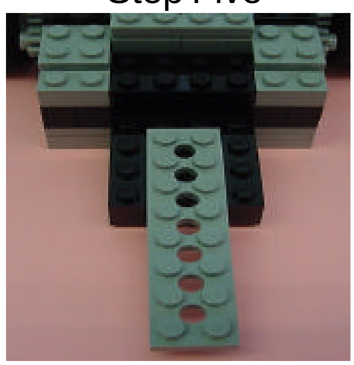
Step Three



Step Four

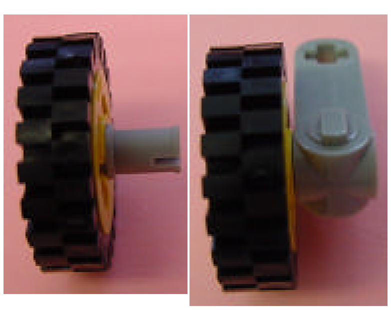


Step Five

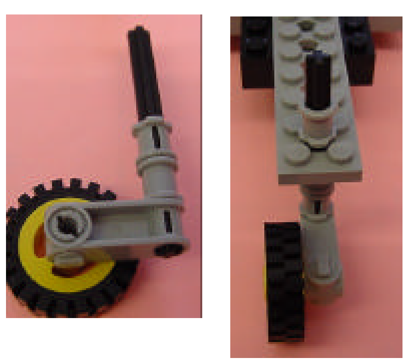


Step Six

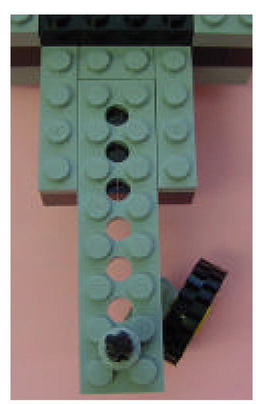
Step Seven



Step Eight

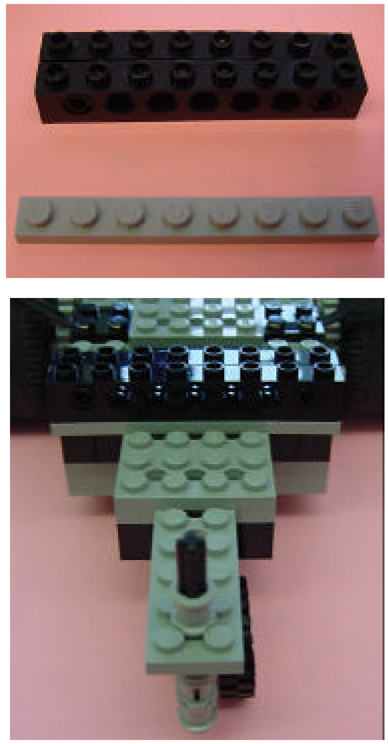


Step Nine



Step Ten

Step Eleven



Step Twelve

Now program your robot using the rotation sensor to go completely through the maze without going outside of the black lines.