Rotations and Distance

Objective: Students will understand that there is a direct relationship between wheel size, number of rotations and distance traveled.

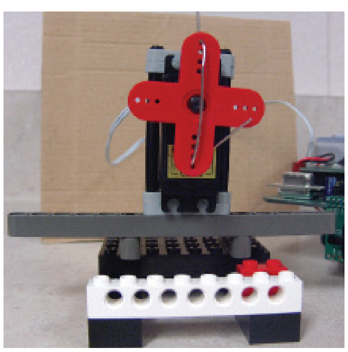
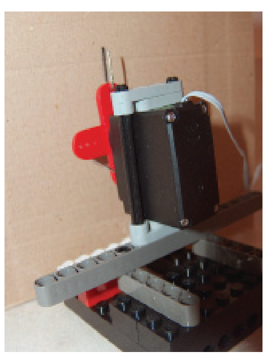
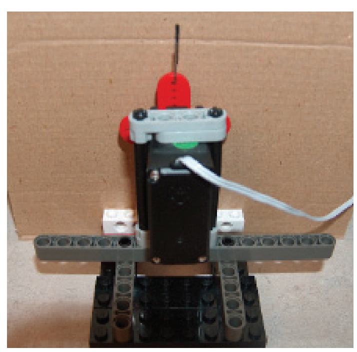
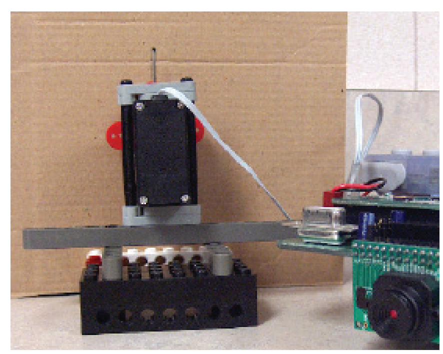
Procedure: Students will test the black gear motors and determine how many programming ticks it takes for one rotation. Students will find the circumference of the wheels in the Botball kit and use this information to determine how far the robot travels in one rotation. Students will program the robot to travel different distances. Students will determine how to program 90˚ turns. Students will plot a scale model path and program a robot to follow it and draw the path on butcher paper as the robot travels.

Student activity:

Black Gear Motor Test:

It takes approximately 1100 ticks to turn the black gear motors one full rotation at half speed.
Build a device to hold the black gear motor in place and a pointer out of a paper clip attached to the red horn to measure rotations.
Place the motor with the pointer next to a piece of paper and mark the starting position.
Write a program to turn the motor at half speed for 1100 ticks and measure the accuracy of the rotation.
Adjust the number of ticks until the motor turns exactly one rotation.
Test each number 10 times in a row to see if the pointer is still accurate. If the rotation is just slightly off, it will not show up until after numerous rotations. If there are differences in the number of ticks for different motors, pair the motors with the closest numbers.
Record this information on the Wheel Worksheet. (1 rotation = __________ ticks)

Sample motor holder:

Example program:

```
void main()
{
   set_motor_position_counter(1,0L); //sets motor 1 counter to 0
   move_relative_position(1,500,1100L); //moves motor 1 1100 ticks at half speed
   block_motor_done(1); //waits until position moves are completed
}
```

Challenges

Challenge 1:

If the speed of the motor is changed, do you think the number of ticks required to make one rotation will change? Why or why not?

Change the motor speed to 1/4, 3/4, and full speed and test.
Which speed was the most accurate?

Challenge 2:

Compete to see who can make the robot travel as close to an object without touching it. Place an object on the Botball board and estimate the distance and the number of ticks needed to have the robot travel to the object. Write a program and run the experiment. Try to get as close as possible without touching it.

Run the experiment again, but this time measure the distance and calculate the ticks before writing the program.

Which way worked best, estimating or measuring?

Exercises:

Small groups of students (2 -4) build a robot that can move forward, backwards, left and right, and have interchangeable wheels. Make sure the motors are placed so that all of the different size wheels can be attached and still touch the floor. Attach the wheels directly to the motors or gear them so that they turn with the same rotation. Do not gear up or down.

#1 Wheel Size and Distance:

Student Activity:

Find the circumference for 4 wheels in the Botball kit. Try to make the measurements as precise as possible. If using centimeters, use a ruler with both centimeters and millimeters.
Fill out the Wheel Worksheet. Remember to use the same motor speed.
Using the move_relative_position commands to control the robot and the data from the worksheet, write the following programs:

Wheel 1 - Make the robot go forward 24 in and then stop.
Wheel 2 - Make the robot go forward 90 cm and then stop.
Wheel 3 - Make the robot go forward 12 in and then stop.
Wheel 4 - Make the robot go forward 40 cm.

Attach the correct wheels and run the programs. Measure to see if the robot traveled the correct distance.

Answer the following questions:
- How does changing the number of ticks effect the distance traveled? Why?
- How does the size of the wheel effect the distance traveled? Why?
- Did you encounter problems and how did you solve them?

#2 Making 90˚ turns:

Student Activity:

Choose the wheel size that will be used on the robot.
Estimate the number of wheel rotations (or fraction of a rotation) needed to make the robot complete a 90˚ turn.
Figure out how many ticks are needed to complete the turn. Write a program to make the robot complete a 90˚ turn. Run the program and adjust the number of ticks to make as accurate a turn as possible.
Repeat for all of the different wheel sizes. Fill out the Turn Worksheet.

> **Challenge:** Estimate how many ticks would be needed to complete different turns: 45˚, 180˚, etc. Write the program and test.

#3 Scale Model Navigation Map:

Students will create a scale model of the Botball board on graph paper and then plot a path from one end to the other. Using the Wheel Worksheet and the Turn Worksheet, students will figure out how many wheel rotations and program ticks it will take to make the robot follow a similar path on the Botball board and then write the program. Students will then add a pen to their robot that will draw on butcher paper as the robot travels. After running the program, students will compare the model path with the robot drawing.

Student Activity:

Create a model navigation map and plot a path for the robot to follow.

Using graph paper create a scale model of the 4 by 8 ft. (approximately 122 by 244 cm) Botball playing board or a similar size tabletop. Use cm or in, but be able to explain the choice. Include a key to explain the scale. (How many cm or in to each grid square.)

Plot a path from one end of the board to the other end of the board (8 ft length). The path must have at least three 90˚ turns. Draw and label the path on the model navigation map. Labels should include the length in cm or inches and mark the turns left or right.

Figure out how many wheel rotations would be needed for the robot to complete each leg of the path. Use the information in the Wheel Worksheet.

Write a program that will make the robot follow the path. Use the information in the Turn Worksheet to program the 90˚ turns.

Adjust the robot design to include a device to hold a marker that will write on paper on the board as the robot travels. The marker should draw the path. Consider where the pen should be placed.

Cover the Botball table with white butcher paper. Use a different colored marker for each group to distinguish the paths.

Run the program and compare the path from the table with the path on the model map.

Answer the following questions:

Did the robot do what was expected? Explain.
After comparing the paths, does the program need to be changed to make it more accurate? How?
How does the positioning of the pen make a difference in the path drawn?
Did the model use in or cm? Explain the reason for the choice.
After having completed the project once, what would you do differently? Why?

Challenge: Modify the robot to change the gear ratio. Gear the wheels up or down and figure out how the wheel rotation is effected. Fill in the Wheel Worksheet and the Turn Worksheet using the new gear ratio. Repeat the exercises.

Wheel Worksheet

How many ticks does it take to complete one rotation of the wheel?

1 rotation = ___________ ticks

Key

radius r
diameter d=2r
Circumference c = πd
π = 3.14
1 rotation = c
Centimeters to inches:
cm x 0.39
Inches to Centimeters:
in x 2.54

r = ______cm ______in
d = ______cm ______in
c = ______cm ______in
10 rotations = ________cm ________in
50 rotations = ________cm ________in
24 in = ______________ ticks

r = ______cm ______in
d = ______cm ______in
c = ______cm ______in
10 rotations = ________cm ________in
50 rotations = ________cm ________in
90 cm = ______________ ticks

r = ______cm ______in
d = ______cm ______in
c = ______cm ______in
10 rotations = ________cm ________in
50 rotations = ________cm ________in
12 in =______________ ticks

r = ______cm ______in
d = ______cm ______in
c = ______cm ______in
10 rotations = ________cm ________in
50 rotations = ________cm ________in
40 cm = ______________ ticks

Wheel Worksheet

How many ticks does it take to complete one rotation of the wheel?

1 rotation = ___________ ticks

r = ______cm ______in
d = ______cm ______in
c = ______cm ______in
10 rotations = ________cm ________in
50 rotations = ________cm ________in
24 in = ______________ ticks

r = ______cm ______in
d = ______cm ______in
c = ______cm ______in
10 rotations = ________cm ________in
50 rotations = ________cm ________in
90 cm = ______________ ticks

r = ______cm ______in
d = ______cm ______in
c = ______cm ______in
10 rotations = ________cm ________in
50 rotations = ________cm ________in
12 in =______________ ticks

r = ______cm ______in
d = ______cm ______in
c = ______cm ______in
10 rotations = ________cm ________in
50 rotations = ________cm ________in
40 cm = ______________ ticks

Key

radius r
diameter d=2r
Circumference c = πd
π = 3.14
1 rotation = c
Centimeters to inches:
cm x 0.39
Inches to Centimeters:
in x 2.54

90° Turn Worksheet

Wheel #1

d = ______cm ______in

1 rotation = _______cm _______in

90° turn = ______________ ticks

Wheel #2

d = ______cm ______in

1 rotation = _______cm _______in

90° turn = ______________ ticks

Wheel #3

d = ______cm ______in

1 rotation = _______cm _______in

90° turn = ______________ ticks

Wheel #4

d = ______cm ______in

1 rotation = _______cm _______in

90° turn = ______________ ticks

Key

radius r
diameter $d=2r$
Circumference $c = \pi d$
$\pi = 3.14$
1 rotation = c
Centimeters to inches:
cm x 0.39
Inches to Centimeters:
in x 2.54