Quiz: Wheels and Distance

Introduction to Mobile Robotics > Wheels and Distance Investigation

Condition	Wheel Diameter (cm)	Wheel Circumference (cm)	Number of wheel rotations in program	Theoretical (predicted) distance traveled in program (cm)	Actual distance traveled (cm) in each trial	Average actual distance traveled (cm)
New Wheel 1	6.27	19.69	3.00	59.07	1) 63.2 2) 54.9 3) 56.6	58.2
New Wheel 2	4.5	14.1	3.00	42.3	1) 37.0 2) 38.1 3) 43.7	39.6

1. Complete the data table above by filling in the blanks.

2. Find the % error of the measured data in the table above for both wheels. Discuss briefly whether the data from each of the new wheels supports Dr. Turner's hypothesis and why.

Remember that Dr. Turner's hypothesis said that:
Distance Traveled = Wheel Rotations x Wheel Circumference

And that you can calculate %error using the equation:

$$\frac{|\text{theoretical measurement} - \text{actual measurement}|}{\text{theoretical measurement}} \times 100\%$$

For New Wheel 1:
Error = (|59.07 – 58.2|) / 59.07 = 0.015 = 1.5%

For New Wheel 2:
Error = (|42.3 – 39.6|) / 42.3 = 0.064 = 6.4%

Students should find a fairly low % error value, because the hypothesis is theoretically correct in this case. Since students are working with LEGO and not multi-million dollar lab equipment, reasonable % error values can range up to about 20%.
Students should draw on their % error calculations and general sense of data trends to draw conclusions based on their calculations, but generally, the average measured distance and the hypothetical distance will be very similar.
This result supports Dr. Turner's hypothesis, if the % error calculations are low, meaning that the measured distances are similar to those predicted by the hypothesis.

3. How many degrees must a robot with "New Wheel 1" be programmed to travel in order to go:

a. 15cm?

The robot should be programmed to rotate its wheels 274 degrees.

Start with the hypothesis equation:
Distance Traveled = Wheel Circumference x Wheel Rotations = 15cm = 19.7cm x Wheel Rotations
Wheel Rotations = (15cm/19.7cm) = 0.76 Wheel Rotations
Number of Degrees = Wheel Rotations x 360 degrees-per-rotation = 0.76 x 360° = 274 degrees

b. 30cm?

The robot should be programmed to rotate its wheels 548 degrees.

Students can determine this number through two methods. They can either recognize that the new distance is twice the old distance, and since all other factors are equal and the distance and rotations are directly proportional, they should just double the number of degrees from the last problem.
Or they can determine the answer using the same equations as before.

Distance Traveled = Wheel Circumference x Wheel Rotations = 30cm = 19.7cm x Wheel Rotations
Wheel Rotations = (30cm/19.7cm) = 1.52 Wheel Rotations
Number of Degrees = Wheel Rotations x 360 degrees-per-rotation = 1.52 x 360° = 548 degrees

4. Benny replaces the wheels on his robot with wheels that are half as large (in diameter) as the wheels on his old one, but leaves the program the same. What percent of the old distance will his new robot run?

Half as far, or 50% of the old distance.

Because the Distance Traveled and Wheel Circumference in the equation

Distance Traveled = Wheel Circumference x Number of Rotations

are directly proportional, halving something on one side of the equation will halve the other side of the equation. In this case the number of rotations is held constant for both wheel sizes, so reducing the wheel circumference will proportionally reduce the distance traveled.

This is similar to Question #19 on the Wheels and Distance Worksheet, where Rodney is replacing his wheels by wheels with four times the diameter. A more detailed explanation of the methods used to answer this question can be found on the Teacher's Guide for that question.