Worksheet: Wheels and Distance

Introduction to Mobile Robotics > Wheels and Distance Investigation

This worksheet is provided for reference only. Be sure that you follow the steps in the online directions, and answer the questions at the appropriate times. Fill out all your answers on a separate sheet of paper.

Condition 1: Standard Wheels - Calculate Distances

Hypothesis – Condition 1 – 2 – 3 – 4 – Condition 2 – Analysis

Record your measurements in the table on the last page of this worksheet.

1. Diameter of the wheel
2. Circumference of the wheel
3. Number of motor rotations
4. Distance traveled (hypothetical)

Condition 1: Standard Wheels - Run and Measure

Hypothesis – Condition 1 – 2 – 3 – 4 – Condition 2 – Analysis

Record your calculations:

5. Actual distance traveled in each trial

Condition 1: Standard Wheels – Evaluate the Hypothesis (1)

Hypothesis – Condition 1 – 2 – 3 – 4 – Condition 2 – Analysis

6. Look at the data in your table.

i. Did the robot go the exact same distance in all three trials? Why or why not?

ii. Calculate the average distance that the robot went with these wheels and this program.

$$\text{Average Distance (for 3 trials)} = \frac{\text{distance 1} + \text{distance 2} + \text{distance 3}}{3}$$

iii. What is the purpose of averaging the three distances?

7. How far off was the experimentally measured average from the predicted value? Find the Percent Error (% error) of the measured value compared to the predicted value using the following formula:

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

8. Look back at your table.
   i. Was the average of the distances you measured close to what Dr. Turner's hypothesis predicted it would be?
   ii. Does this support the hypothesis? Why or why not?
   iii. Is this set of trials alone enough to prove or disprove how valid the hypothesis is, in general?

9. The instructions tell you to measure from the front of the robot to the back of the line. Why shouldn't you measure the space "between" the robot and the line (from the back of the robot to the front of the line)?

Condition 2 – Small Wheels: Calculate Distances and Run

Hypothesis | Condition 1 | Condition 2 | 2 | 3 | Analysis

Record your measurements in the table on the last page of this worksheet.

10. Diameter of small wheel
11. Circumference of small wheel
12. Number of motor rotations
13. Distance traveled (hypothetically)
14. Distance traveled in each trial (actual)

Condition 2 – Small Wheels: Evaluate the Hypothesis (2)

Hypothesis | Condition 1 | Condition 2 | 2 | 3 | Analysis

15. What is the average distance the robot ran with these wheels? Is this average a good representation of the data you gathered in this Condition, or does the data look nothing like the average?

$$\text{Average Distance (for 3 trials)} = \frac{\text{distance 1 + distance 2 + distance 3}}{3}$$

16. Find the Percent Error (% error) of the measured average compared to the predicted value using the following formula:

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

17. Look at the data in your table.
   i. Were the average measured distances about what Dr. Turner's hypothesis predicted they would be?

ii. Do you think you have enough evidence to reasonably accept or reject how valid the hypothesis is now?
iii. If so, do you accept or reject it? If you are not sure, what additional testing could you do to help you decide?

Analysis and Conclusions: Conclusion

Hypothesis — Condition 1 — Condition 2 — Analysis — 2 — 3

18. In her fax, Dr. Turner proposes a relationship for calculating distances traveled by a robot, based on the robot's wheel size. You have been testing this hypothesis to see how well it predicts the distance your robot travels.
  i. Does the data you have collected support the hypothesis, or are the two very dissimilar?
  ii. What is your conclusion regarding the hypothesis? If you had to decide, would you say it is correct or not?
  iii. Summarize the steps you took and data you gathered to investigate, and explain how they led to your conclusion.

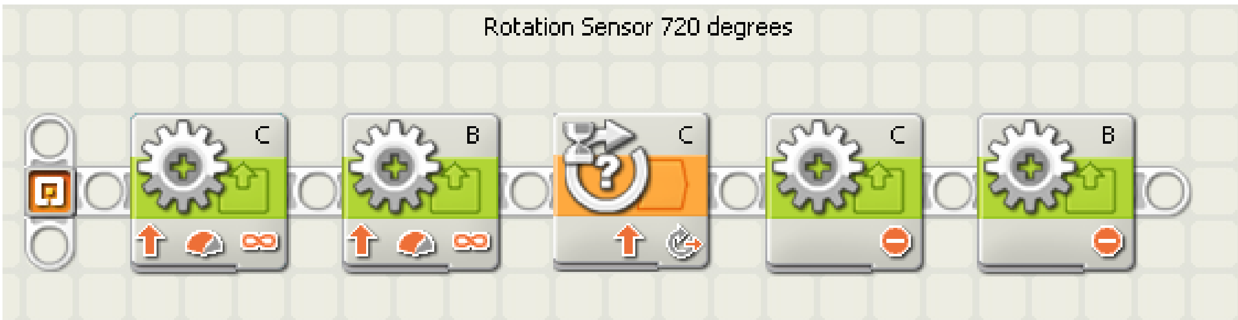
19. Configure your robot using what you feel are the best all-purpose wheels for your classroom. Measure the wheels on your robot.
  i. How many cm does your wheel travel per 360 degree rotation?
  ii. In order to travel 10 cm, how many degrees does the wheel need to turn? Show your work.
  iii. In order to travel 20 cm, how many degrees does the wheel need to turn? Show your work.
  iv. How many degrees to travel 30 cm?
  v. Look back at the procedure you used to find the number of degrees in the last 3 questions. If you want the robot to travel X cm, describe what mathematical operations (e.g. add 2 then divide by 5, etc.) you must perform on X in order to find the number of degrees.
  vi. Does the formula you found in part (v) work for any robot? If not, what robots will it work for?

20. What is the advantage of being able to control your robot's movement distance in centimeters as opposed to rotations?

21. Technically, the Wait For block in your program waits for motor rotations, and not wheel rotations. In this Investigation, we have been considering them to be interchangeable. What physical characteristics of the robot allow us to make this simplification?

Analysis and Conclusions: Exercises

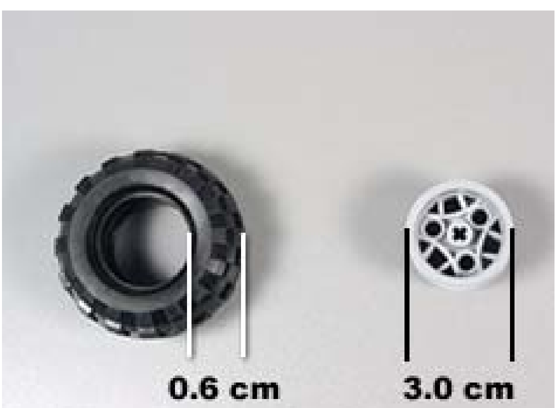
22. Tracy measures the wheels on her robot and finds that they are 2.3 cm in diameter. Her program is shown in the picture below.



i. How far should her robot go?
ii. Is her robot likely to go exactly that distance when she runs it? Why or why not?

23. Rodney likes monster trucks. He replaces the wheels on his robot with wheels that are four times as large (in diameter) as the wheels on his old one, but leaves the program the same. How many times farther (or shorter) will his robot run than the old one?

24. Many wheels are constructed from a tire (black) and a hub (grey). Mark's robot runs 720 degrees using the assembled (hub+tire) wheel.

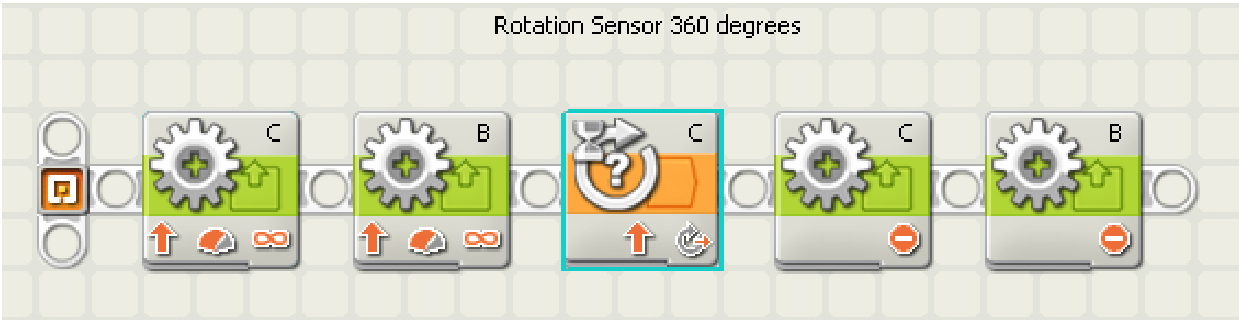


However, he wants to run the robot using just the grey hub as a wheel, without the black tire.

i. How many *degrees* must the new hub-only wheel turn in order to go the same distance?
ii. What other issues might he encounter in using the hub as a wheel by itself?
iii. How would these other issues affect the actual distance the robot travels?

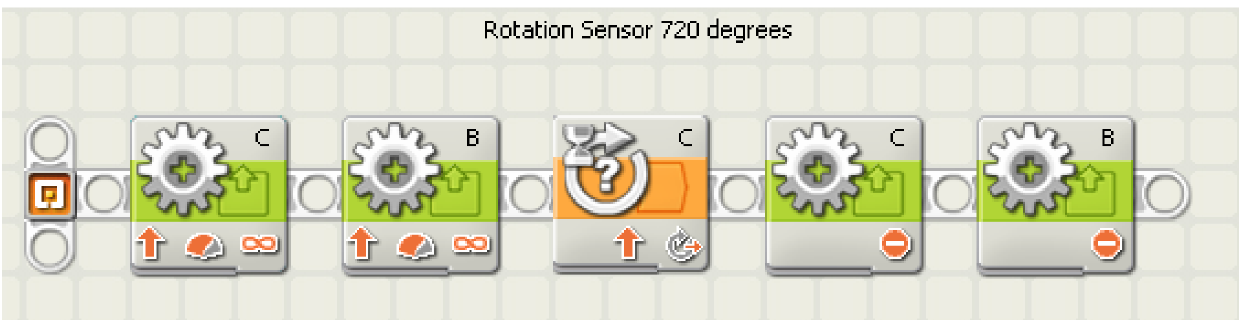
25. You are working as the mechanical engineer on your team, building a brand new wheeled robot to explore the Atacama Desert in Chile. You have just found a new wheel that seems to perform better on the rugged terrain of the *salars* there. You decide that this wheel will be used on the next prototype of the robot that will be deployed for testing. What information, if any, must you communicate to the other members on your team when you make this change to the design? What might happen to the robot's behavior if you do not make these points clear?

26. Diana's robot travels 7.85 cm using the program shown below. Assume that the comment is correct.

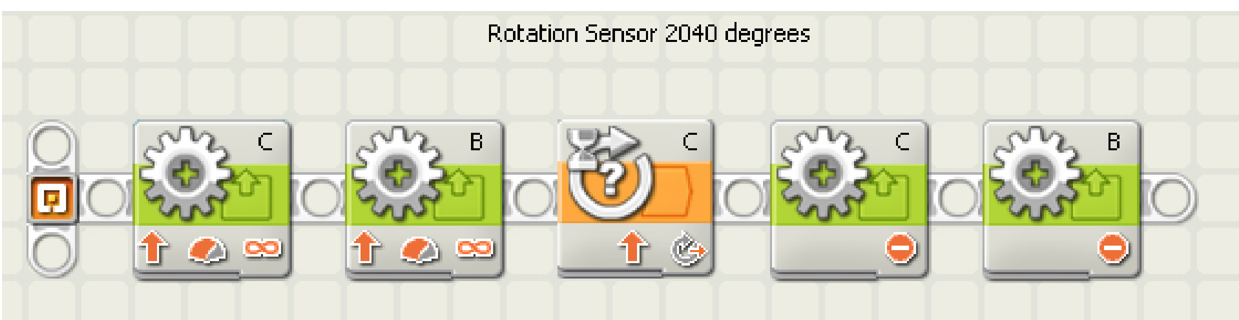


i. What size are the wheels on her robot?

ii. How far will her robot go with the following program, assuming the comment is correct? Show your work.

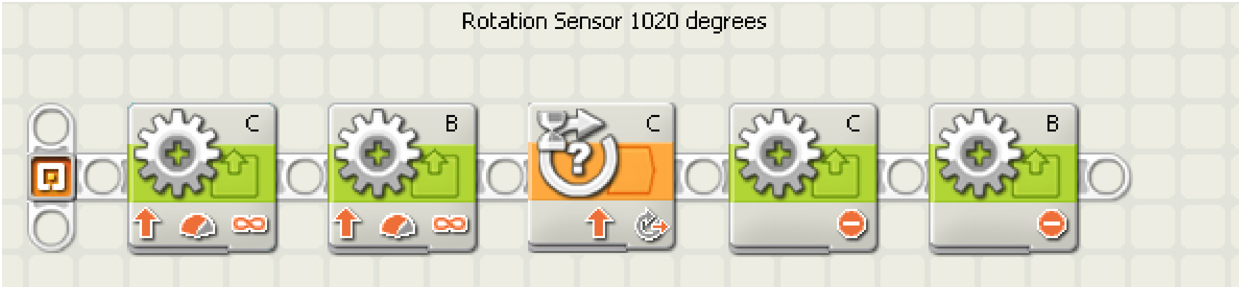


27. Jeanne's robot travels 65 cm using the program shown below. Assume that the comment is correct.



i. What size are the wheels on her robot?

ii. Jack's robot goes the same distance with the program below. Assume that the comment is correct. What size are his wheels?



28. You are your team's lead programmer hard at work refining your robot's movement code the day before it needs to compete in a hallway navigation challenge. Your friend, the team's mechanic, stops by and informs you that he seems to have misplaced the wheels for your robot during cleanup last night. He also says the local Wheels R Us will not have any replacements in stock for at least two weeks. There are several sets of 3-inch diameter wheels lying around the workshop, but they are not the same as the 2.7cm diameter ones that you had been planning to use. Your old code is shown below. What must you do in order to get your robot in working order to perform the challenge tomorrow?

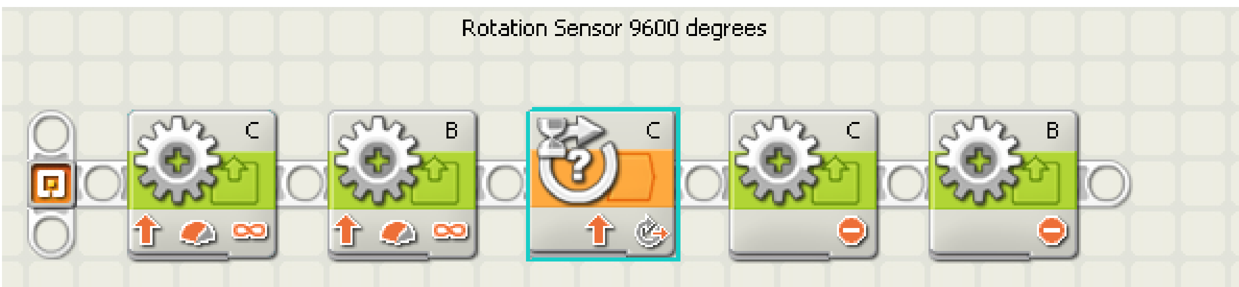


Table: Wheels and Distance

Introduction to Mobile Robotics > Full Speed Ahead > Continue Activity

Fill in this table with the numbers you get by answering the questions in the worksheet.

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)
Standard Wheel					1.	
					2.	
					3.	
Small Wheel					1.	
					2.	
					3.	

Useful Equations

pi = approx. 3.14

Circumference = Diameter * pi

Diameter = Radius * 2

1in = approx. 2.54cm

1 rotation = 360 degrees