Worksheet: Measured Turns

Introduction to Mobile Robotics > Measured Turns 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.

Phase 1: Swing Turn Path – Evaluate the Hypothesis (1)

1. When you ran your robot, which wheel spun?

2. Observe the shape traced by the tracer on the paper. Remember that the tracer approximates the position of the robot's left wheel, but is not exactly on top of it.
   i. What shape did the wheel trace on the paper?
   ii. What part of the robot is at the center of the circle?
   iii. What part of the robot ran along the circumference of the circle?
   iv. Are these observations consistent with the first part of the hypothesis?

Hypothesis (part 1)
As the robot swing-turns, the moving wheel traces out a portion of a circle.

3. Measure the path traced by the robot's wheel.
   i. What is the diameter of the traced circle?
   ii. What is the circumference of the traced circle?
   iii. Rewrite Dr. Turner's hypothesis equation, filling in the values you have now calculated. The hypothesis equation is as follows:

Hypothesis (equation form)

$$\frac{\text{Angle turned}}{\text{Full circle}} = \frac{\text{Distance traveled by wheel}}{\text{Circumference of traced circle}}$$

Phase 2: Hypothesis – Part 2

Hypothesis | Trace Path | 90 degrees | 2 | 3 | 4 | Conclusions

Answer the following:

4. There is an important distinction between the circumference of a wheel on your robot and the circumference of the circle your robot traces.
   i. Explain the difference.
   ii. Which one is used, along with motor axle rotations, to calculate distance traveled?
   iii. Which one can be measured by placing a marker near the outside wheel of your robot and programming it to turn?

Phase 2: Calculate for a 90-degree Turn

Hypothesis | Trace Path | 90 degrees | 2 | 3 | 4 | Conclusions

Calculate the following:

5. Following along with the calculations in the video (using your own numbers), determine how many motor degrees you need to set in your program to make the robot turn 90 degrees.

Analysis and Conclusions: Conclusions

Hypothesis | Trace Path | 90 degrees | Conclusions | 2 | 3

6. Now that you've run your program, answer the following questions:
   i. Did your robot turn about 90 degrees? If not, what factors may have caused the difference?
   ii. Does this behavior support the hypothesis? Why or why not?
   iii. Do you now have enough information to say whether or not the hypothesis is valid, or do you need more information?

7. Recall the number of motor degrees you used to make the robot turn 90 degrees using a swing turn. Estimate how many degrees the motor would need to spin to turn the robot:
   i. 180 degrees
   ii. 270 degrees
   iii. 360 degrees
   iv. 2 full turns

8. Modify your program and run the robot for the amounts you predicted for each of the angles in the Question 7.

i. 180 degrees
ii. 270 degrees
iii. 360 degrees
iv. 2 full turns
v. Do these new results support or refute the hypothesis?

9. The tracer was close to, but not exactly under the wheel when you ran the robot. As such, the circle it traced was not exactly the path the wheel traveled. Your robot attempted to turn for 90 degrees based on calculations made using the tracer's path instead of the actual wheel.

i. What was the actual distance between the tracer tip and the point where the wheel touched the ground?
ii. How successful was your robot in turning 90 degrees using the estimate rather than the exact value?
iii. Would you say this was a good estimate, based on the results you got from using it?
iv. Since the right wheel stays planted and the left wheel moves, what is the actual physical distance of the radius or diameter of the turn?

10. Vehicle designers in the real world deal with turning issues all the time. It is important for both safety and performance that they know exactly what their vehicles can and cannot handle. Think about real world vehicles while you answer the following questions.

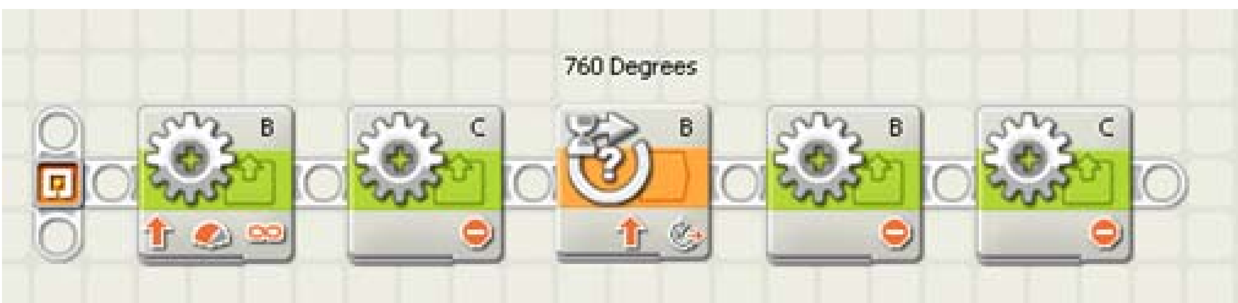
i. What are the limitations of swing turns?
ii. Name another mobile vehicle that is capable of a swing turn, and estimate its turning radius (or diameter).
iii. Do normal cars use this type of turn?

Analysis and Conclusions: Exercises

11. Shante's robot has wheels that are 4.5 cm in diameter and traces a turning circle with a 12.4 cm radius. Her wheels are driven directly by the motors on each side. She needs her robot to make a swing turn of 210 degrees. How many degrees do her motors need to run in order to make the robot make this turn? Show your work.

12. Larry has forgotten to save his program, and now he can't remember what he had his Wait For block set to. He knows that he wanted his robot to do a swing turn, and he measured his wheels to find out that they are 2.5 cm in diameter and they are 9.0 cm apart. He also knows that the robot turned exactly 180 degrees. How many degrees should Larry set his Wait For block to when he rebuilds his program?

13. Below is Peter's program. Assume that the comment he wrote accurately describes the amount the Wait For block will wait. He wants his robot to make a full 180 degree swing turn, and his robot traces a circle with a radius of 10.8 cm. He has a choice between two wheel sizes: 4.6 cm in diameter and 7.2 cm in diameter.



i. Which wheels should he choose to come closest to making the 180 degree turn with his current program?

ii. What else can he change on the robot to make the turn?