Worksheet: Gears and Speed

Introduction to Mobile Robotics > Gears and Speed 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: Take Measurements

Record your calculations:

1. Number of teeth on each gear, reduced gear ratio (see data table on last page of worksheet).

2. Distance traveled in each trial.

Condition 1: Calculate Speed

3. 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 gears 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?
4. Calculate the robot's average speed for this gear ratio.

$$\frac{\text{average distance traveled}}{\text{time taken}} = \text{average speed}$$

5. Do you have enough information to draw any conclusions about the two hypotheses yet? Explain why or why not?

6. 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) instead?

Condition 1: Predict with Hypothesis A

7. Based on the average speed you measured in Condition 1 (Speed 1), what does Hypothesis A predict that the average speed will be for Condition 2? In Condition 2, you will have a 20-tooth gear driving a 12-tooth gear. Fill this in your data table.

Hypothesis A
(Speed 1 / Gear Ratio 1) = (Speed 2 / Gear Ratio 2)

Known:

Speed 1 = _____cm/sec

Gear Ratio 1 = _____

Gear Ratio 2 = _____

Find:

Predicted Speed 2: _____cm/sec

8. Based on the average speed you measured in Condition 1 (Speed 1), what does Hypothesis A predict that the average speed will be for Condition 3? In Condition 3, you will have a 12-tooth gear driving a 20-tooth gear. Fill this in your data table.

Hypothesis A
(Speed 1 / Gear Ratio 1) = (Speed 3 / Gear Ratio 3)

Known:

Speed 1 = _____cm/sec

Gear Ratio 1 = _____

Gear Ratio 3 = _____

Find:

Predicted Speed 3: _____cm/sec

Condition 1: Predict with Hypothesis B

9. Based on the average speed you measured in Condition 1 (Speed 1), what does Hypothesis B predict that the average speed will be for Condition 2? In Condition 2, you will have a 20-tooth gear driving a 12-tooth gear. Fill this in your data table.

Hypothesis B
(Speed 1 x Gear Ratio 1) = (Speed 2 x Gear Ratio 2)

Known:

Speed 1 = _____cm/sec

Gear Ratio 1 = _____

Gear Ratio 2 = _____

Find:

Predicted Speed 2: _____cm/sec

10. Based on the average speed you measured in Condition 1 (Speed 1), what does Hypothesis B predict that the average speed will be for Condition 3? In Condition 3, you will have a 12-tooth gear driving a 20-tooth gear. Fill this in your data table.

Hypothesis B
(Speed 1 x Gear Ratio 1) = (Speed 3 x Gear Ratio 3)

Known:

Speed 1 = _____cm/sec

Gear Ratio 1 = _____

Gear Ratio 3 = _____

Find:

Predicted Speed 3: _____cm/sec

Condition 2: Take Measurements

Record your calculations:

11. Number of teeth on each gear, reduced gear ratio (see data table on last page of worksheet).
12. Distance traveled in each trial.

Condition 2: Calculate Speed

13. Calculate the average distance that the robot went with these gears and this program.

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

14. Calculate the robot's average speed for this gear ratio.

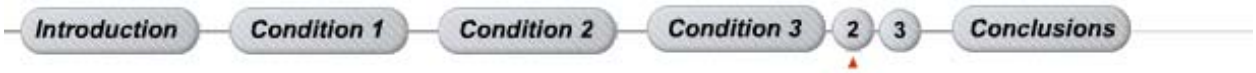
$$\frac{\text{average distance traveled}}{\text{time taken}} = \text{average speed}$$

15. Examine Hypothesis A.
- i. From Question 7, what did Hypothesis A predict for the speed of Condition 2?
- ii. What was the actual average speed you found using this gear ratio (from Question 14)?
- iii. Do these values seem to match closely?

16. Examine Hypothesis B.
- i. From Question 9, what did Hypothesis B predict for the speed of Condition 2?
- ii. What was the actual average speed you found using this gear ratio (from Question 14)?
- iii. Do these values seem to match closely?

17. Compare the two hypotheses.
- i. Did Hypothesis A or Hypothesis B do a better job of predicting the effect that changing the gear ratio will have on speed?
- ii. Explain your answer to part (i) using numeric evidence.
- iii. Is this enough evidence to prove that one hypothesis is incorrect? Explain briefly.
- iv. Is this enough evidence to prove that one hypothesis is correct? Explain briefly.
- v. Which hypothesis (if any) do you believe has stronger support at this point in time, and why?

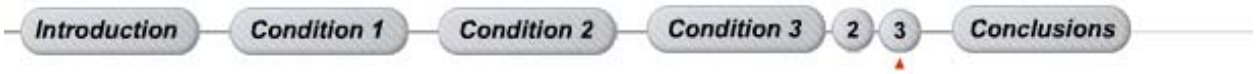
Condition 3: Take Measurements



Record your calculations:

18. Number of teeth on each gear, reduced gear ratio for this condition (see data table on last page of worksheet).
19. Distance traveled in each trial.

Condition 3: Calculate Speed



20. Calculate the average distance that the robot went with these gears and this program.

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

21. Calculate the robot's average speed for this gear ratio.

$$\frac{\text{average distance traveled}}{\text{time taken}} = \text{average speed}$$

22. Examine Hypothesis A.
- i. From Question 8, what did Hypothesis A predict for the speed of Condition 3?
- ii. What was the actual average speed you found using this gear ratio (from Question 21)?
- iii. Do these values seem to match closely?

23. Examine Hypothesis B.
- i. From Question 10, what did Hypothesis B predict for the speed of Condition 3?
- ii. What was the actual average speed you found using this gear ratio (from Question 21)?
- iii. Do these values seem to match closely?

24. Compare the two hypotheses.
- i. Did Hypothesis A or Hypothesis B do a better job of predicting the effect that changing the gear ratio will have on speed?
- ii. Explain your answer to part (i) using numeric evidence.
- iii. Combined with your results from Condition 2 (Question 17), is this now enough evidence to prove that one hypothesis is incorrect? Explain briefly.
- iv. Is this now enough evidence to prove that one hypothesis is correct? Explain briefly.
- v. If you had to decide right now to support one hypothesis over the other, which would you choose as the correct hypothesis, and why?

Conclusions

25. Summarize the conclusion you reached regarding which of Hypotheses A or B was correct, and explain the steps you followed in order to reach this conclusion.

26. Commonly, two values will be either *directly proportional* or *inversely proportional*.

i. Directly proportional values are values that increase and decrease together, always by the same factor. Doubling one value means the other must double as well. Which hypothesis predicted that gear ratios and robot speeds would be *directly proportional*?

ii. Inversely proportional values are values that increase and decrease oppositely from each other, but always by the same factor. Doubling one value means the other will cut in half. Which hypothesis predicted that gear ratios and robot speeds would be *inversely proportional*?

iii. Based on your results, did gear ratio and robot speed turn out to be directly proportional, inversely proportional, or neither?

iv. If you did the Wheels and Distance investigation, would you call the relationship between wheel size and distance directly proportional, inversely proportional, or neither?

Exercises

27. Chloe's robot went an average of 36cm in 3 seconds when her gears were all 16-tooth gears. Now she wants to slow her robot down, so she puts 18-tooth gears on the motors and 6-tooth gears on the wheels. How many centimeters will her robot now travel in 3 seconds?

28. Luke has designed a robotic vehicle to be part of a movie his father is making. It needs to carry humans, and he did not build in seat belts, so he wants to make sure that it stays below a certain speed. He thinks that the vehicle should not go above 4 m/s. He had a gear ratio of 1 between the motors and the wheels, and the robot went 1.5 m/s. Unfortunately, one of his gears broke, and he can't find another, so he's going to swap out all of the gears on the vehicle, and replace them with 24-tooth gears on the motors, and 8-tooth gears on the wheels. Will the robot still be below the safe speed?

29. As manager of your robotics team, you are in charge of keeping track of the materials that have been used, so that the project doesn't go over budget. Last week, your team's robot only went 9cm/sec, but now it goes 15 cm/sec, and the team's mechanical engineer was working to speed it up. You know that she switched out all four of the original 40-tooth gears (one for each motor and one for each wheel), but she is out sick, so you can't ask her what gears she put in their places. You can count that the gears on the wheels have 36 teeth, but you can't tell what size the motor gears are, and you need to know to get the project budget correct. Use the correct hypothesis and the formula for calculating gear ratio to determine how many teeth the motor gears have.

Worksheet: Get in Gear

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

Condition	**Teeth on driving gear** (motor)	**Teeth on driven gear** (wheel)	**Gear Ratio** driven / driving	**Time robot traveled** (sec)	**Distance robot traveled** (cm)	**Average distance robot traveled** (cm)	**Average Speed** (cm/sec)	**Hypothesis A predicted speed** (cm/sec)	**Hypothesis B predicted speed** (cm/sec)
Condition 1 *16-tooth: 16-tooth*					**1)** **2)** **3)**				
Condition 2 *20-tooth: 12-tooth*					**1)** **2)** **3)**			(Question 7)	(Question 9)
Condition 3 *12-tooth: 20-tooth*					**1)** **2)** **3)**			(Question 8)	(Question 10)