[i]**Investigation Question:** Will a rounded or square toy car roll faster?

As the cars roll down the ramp both will be exposed to friction from the air. During this investigation, I want to determine if the shape of the car affects the amount of friction from the air flowing over the car by comparing the speed of the cars over a distance of 55cm.

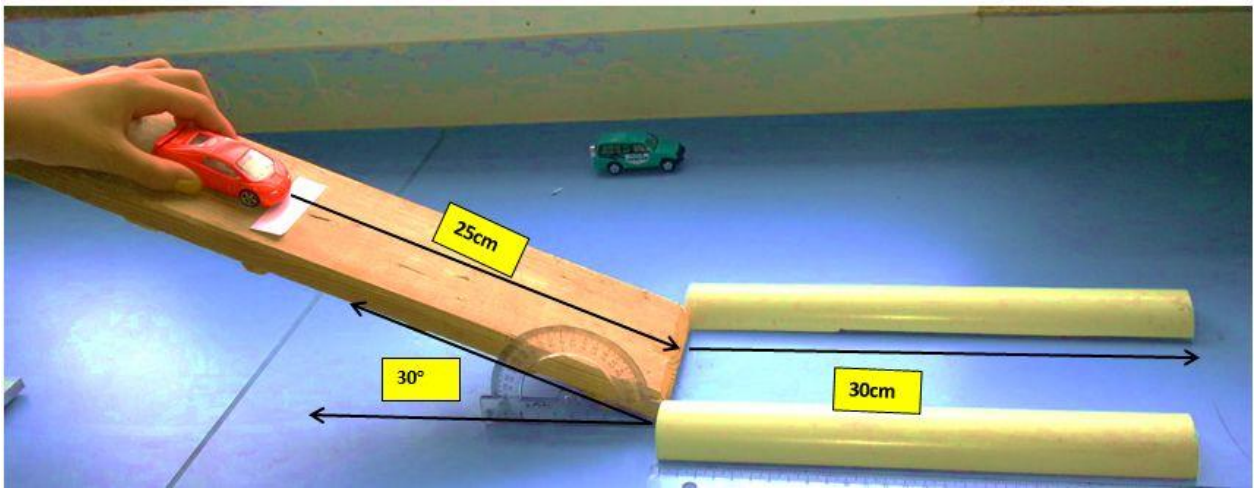
**Hypothesis**
**If** I roll different shaped toy cars down a ramp, a rounded toy car and a square toy car, and measure the speed they travel over a distance of 55 cm **then** I predict the rounded car will roll faster than the square toy car **because** the air will flow smoother over the rounded car than the square car so there will be less air friction slowing down the rounded car.

| Independent Variable | Dependent Variable | Controlled Variables |
|---|---|---|
| I will manipulate the shape of the vehicle I roll down a ramp:<br>• Round toy car<br>• Square toy car | I will measure the time it takes for the cars to travel 55cm using a stop watch that is precise to the nearest millisecond. | For both cars I will use the same:<br>• wooden ramp<br>• ramp angle set at 30$^{o}$<br>• starting place on the ramp marked with tape with the front bumper of each car placed at the front of the line<br>• distances – each car will roll 25cm along a ramp then 30cm along the lab table<br>➢ The cars will have a mass difference of no more than 5g<br>➢ The time will be stopped for every trial when the front of the car bumpers pass the end line<br>➢ Both vehicles will roll onto the same surface, which will be the lab table |

**Materials:**
1 meter stick or ruler
1 rounded toy car and 1 square toy car
1 wooden ramp
1 pan balance
1 clamp stand
1 stop watch
Tape
Protractor

**Method**

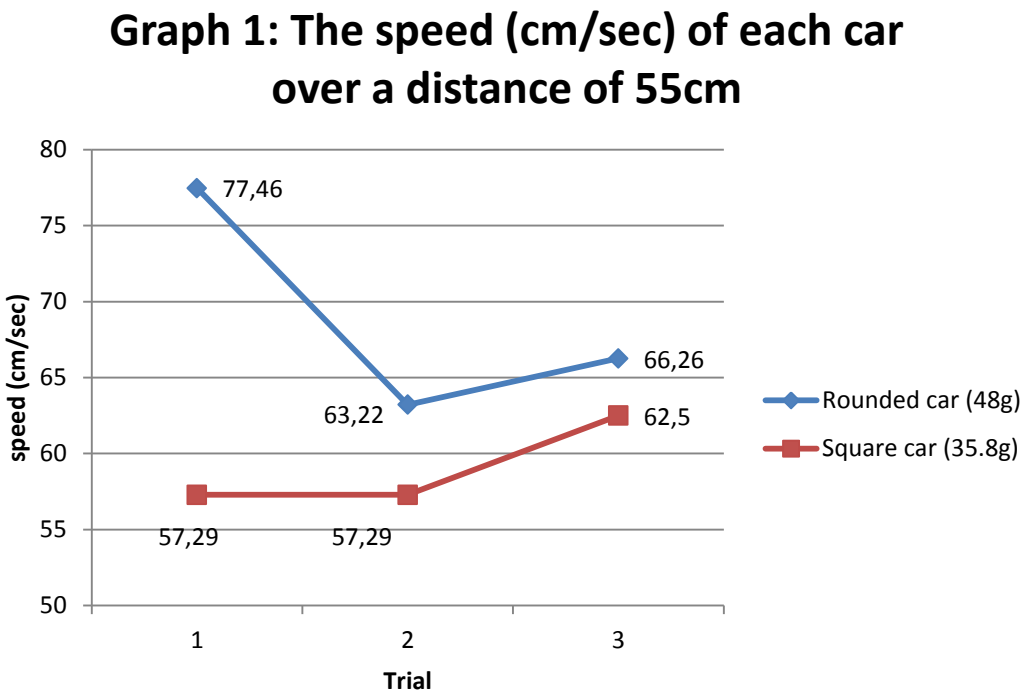
1. Using a pan balance, measure and record the mass of both cars.
2. Set the ramp onto the clamp stand and adjust the placement of the ramp and clamp stand until the ramp is at an angle of 30$^{o}$ with the floor.
3. Place one PVC half tube along each side of the distance on lab table the cars wil roll so the cars do not travel sideways (see illustration)
4. Measure the length of the PVC tubes to be certain they are 30cm in length
5. Measures 25cm from the end of the ramp towards the top of the ramp then place a piece of tape at the 25cm mark on the ramp to indicate the starting place of the cars– the front bumper of each car should line up with the tape.
6. Set the round car in place with the front bumper at the start of the tape.
7. As soon as the car is released, start the stopwatch.
8. Stop the stopwatch when the front bumper of the car has passed the end of the PVC tubes
9. Record the time.
10. Repeat the procedure for the square car.
11. Calculate the speed of the cars for each trial using the following formula:
    **Speed = distance ÷ time**, where the distance is always 55cm
12. Calculate the average speed for each car.

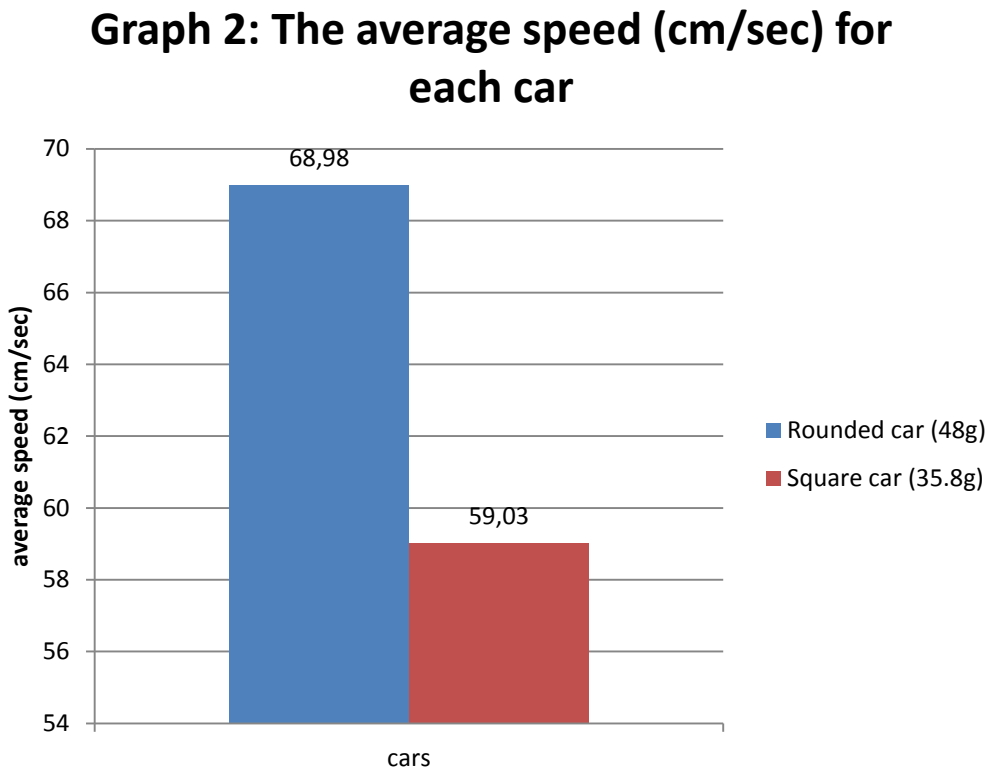


**DATA**

**Table 1**: The time (sec), speed (cm/sec), and average speed (cm/sec)for a rounded toy car and square toy car to travel a distance of 55cm

| | **Rounded car (48g)** | | **Square car (35.8g)** | |
|---|---|---|---|---|
| | time (sec) | speed (cm/sec) | time (sec) | speed (cm/sec) |
| trial 1 | 0.71 | 77.46 | 0.96 | 57.29 |
| trial 2 | 0.87 | 63.22 | 0.96 | 57.29 |
| trial 3 | 0.83 | 66.26 | 0.88 | 62.5 |
| average speed | | 68.98 | | 59.03 |






**Description of Data**
The square car (35.8g) rolled with an average speed of 59.03cm/sec. The round car (48g) rolled with an average speed of 68.98cm/sec. The fastest speed, 77.46cm/sec, occurred in trial 1 for the rounded car. The slowest speed, 57.29cm/sec, occurred in trial 1 & 2 for the square car.

**Data Interpretation**
Overall, my data were reliable because the times recorded for each car over each trial were consistent. The times recorded for the rounded car to travel 55cm ranged from 0.71 to 0.83 seconds; a difference of 0.12 seconds. The times recorded for the square car to travel 55cm ranged from 0.88 to 0.96 seconds; a difference of 0.08 seconds.

The results from my investigation were that the rounded car rolled the 55cm in less time and therefore with a faster speed than the square car. There are 2 possible reasons the rounded car rolled faster than the squared car. First, this may have occurred because the rounded car had more mass, approximately 12g more mass, than the square car. The larger mass of the rounded car means the rounded car had more momentum than the square car. Momentum is a measure of how hard it is to stop an object; the more mass an object has the harder the object is to stop. Since the rounded car had more mass it would have been harder for the air friction to stop the car and therefore the rounded car took less time to travel the 55cm. Second, the rounded car may have traveled faster because of it's aerodynamic shape. As cars travel, they disturb the air. Aerodynamic cars, cars that have a rounded shape, will disturb the air less than squared cars resulting in less friction between the car and the air. With less friction the rounded cars will be able to roll faster than squared cars because there is less air trying to stop the car from rolling. (Edgar 2012)

## EVALUATION

### Validity of Hypothesis

My hypothesis was valid because my results supported my prediction. I predicted the rounded car would roll farther than the square car. My hypothesis was supported by my data because the rounded car rolled an average of approximately 9cm/sec faster than the square car.

### Validity of Method

I choose a stopwatch to measure the time for each car to roll 55cm. The stopwatch was **appropriate** because the stopwatch was **precise** to the nearest millisecond so I was able to record minor time differences.

I was unable to keep each controlled variable constant throughout the investigation. For both cars I used the same: wooden ramp, ramp angle set at 30$^{o}$, starting place on the ramp marked with tape, starting place at the front bumper of each car, both traveled the same distance on the ramp (25cm) and lab table (30cm), the cars started each trial with the front bumper on the line, and each traveled a total distance of 55cm. However, the mass difference between the cars was more than 5g; the actual difference in mass was 12g. This means that I cannot be certain whether the mass difference or car shape or both together affected the speed of the car more. Finally, a **flaw** in my method was the ramp I used. The end of the ramp was square resulting in the cars sometimes flipping over when they traveled from the ramp to the lab table. I repeated the trials where the car flipped over but the jump itself may have affected the times for each car.

In general, my method was not valid since the masses were different and the ramp was flawed.

### Improvements or Extensions

If I were to repeat this investigation, I would use toy vehicles that had the same mass to make certain the shape of the car affects the speed. I would also use a ramp with an end that angled into the table so the car would travel smoothly from the ramp to the table.

### Resources

Edgar, Julian. "Low Drag Car Aerodynamics." *AutoSpeed Articles RSS*. Web Publications Pty., 3 Apr. 2012. Web. 20 June 2014. <http://www.autospeed.com/cms/article.html?&A=112609>.

"Physics4Kids.com: Motion: Momentum." *Rader's PHYSICS 4 KIDS.COM*. Andrew Rader Studios, 1997. Web. 08 July 2011. <http://www.physics4kids.com/files/motion_moment.html>.

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[i] Revised 21 June 2014