STEM LAB:
Balloon Race Car

TEACHER

LEVEL: All Year Levels | TOPIC: STEM | TIME REQUIREMENT: 45 mins

BACKGROUND

In 1686, Sir Isaac Newton presented 3 laws of motion. The first law, relating to inertia, states that an object will remain in motion or at rest until an external (unbalanced) force acts upon it. Inertia describes an object's resistance to change in its motion. For example, a cup sitting on a table will remain motionless until it is knocked over, lifted or otherwise acted on by a force.

Relating to an object's mass, Newton's second law describes how the acceleration of an object changes when subjected to external forces acting on it. According to this law, a greater force results in proportionally greater acceleration. It also asserts that objects with a greater mass will have less acceleration, provided that the force is kept the same. In equation form, this law can be written as $a = F/m$. If more than one force is acting on an object, the force used in the equation is the total force. Forces acting in the same direction are added together, and those in opposite directions are subtracted.

Newton's third law states that when one object exerts a force on another object, the second object exerts an equal (in magnitude) and opposite (in direction) force on the first. The law asserts forces occur in pairs, with the two forces in the pair acting on two different objects. For example, as the jet of hot gases rushing out of a rocket causes it to be propelled forward, a backward force acts on the gases, and the gases then exert a forward force on the rocket.

In this investigation, students explore the laws of motion by observing the motion of a balloon-powered racing car. In the first activity, students will construct a car according to the instructions. In the second activity they test the car to record the pattern of its motion and how far it travels. Based on their conclusions from the results, they are tasked with developing their own design challenge and designing a car to meet it.

METHOD - STUDENT PRACTICAL

Assembling the Prototype

1. Collect the Race Car Template and cut out the car body and wheel patterns.
2. Place the race car body and the 4 wheel patterns on the foam tray. Arrange them so they all fit on the flat part of the tray.
3. Using a pen, trace each pattern on the tray and carefully cut them out.
4. Smooth the rough or uneven edges of the wheels using sandpaper. The wheels should have an even surface and turn smoothly.
5. Measure and cut 3 straws to be 11 cm long.
6. Measure 2.5 cm in from the bottom and top (short end) of the foam race car body using a ruler. Tape 1 straw across the bottom 2.5 cm point and another across the top. Centre the length of the straws so that they extend equally from each side of the race car body.
7. To create an axle, attach a wheel to a wooden stirrer by carefully pressing the wooden stirrer through the centre of a foam wheel. Press the stirrer through until it protrudes 0.5 cm on the other side of the wheel.

MATERIALS

- 1 Balloon Race Car Template
- 1 Balloon (9-inch)
- Modelling clay
- 3 Straws
- 1 Square of sandpaper
- 2 Wooden stirrers
- 1 Foam tray
- 5 m String (approx)
- Scissors
- Ruler
- Sticky Tape
- Masking Tape
- Pen/ Permanent marker
- Timer (Optional)
- Scissors
- Any additional materials for students own design

SAFETY PRECAUTIONS

- Ensure that only one person inflates each balloon to prevent the spread of germs.
- Be aware of any latex allergies or latex sensitivities.

8. Thread the wooden stirrer into one of the straws that is secured to the race car body. Once the wooden stirrer has been threaded through, press a foam wheel onto the free end of the stirrer. Adjust the stirrer so the tips of the stirrer protrude from the wheels equally on each side.
9. Repeat steps 7 and 8 for the other set of wheels.
10. Use clay to stabilise the wheels. To do this, mould clay on the outside of each wheel where the wooden stirrer protrudes from the wheel. Push the wheel closer to the straw to allow the wheel to roll freely, but without any instability. Do not push the wheel too close, as it will restrict the movement of the wheel.
11. Collect the remaining 11 cm straw and insert half the length of the straw into the neck of a balloon.
12. To attach the balloon to the straw and create an airtight seal, secure it in 3 places along the neck of the balloon using sticky tape. Wrap 2 pieces of tape around the neck of the balloon approximately 1 cm apart. Use the tape to securely hold the straw in place without crushing it. The final piece of tape should be wrapped around the neck of the balloon where it meets the straw to create an airtight seal.
13. To test there is no air escaping the balloon, blow air through the straw into the balloon. If you hear or feel air escaping, then the seal is not airtight. Place additional tape around the balloon and straw until you can no longer hear air escaping.
14. Decide which end is the rear of the car and position the straw so that it extends from the rear of the race car body. Once happy with the positioning, tape the straw to the body of the car.

Testing the Prototype

1. Set up a racetrack by clearing a straight path of approximately 5 metres for the car to race. This surface should be as even as possible. Create a starting line using a length of masking tape.
2. Place the string on a flat, even surface and mark the string at 25 cm intervals using a marker and ruler. You will use this string to measure the distance travelled by the race car.
3. Blow through the straw to inflate the balloon, and then squeeze the end of the straw to prevent the air from escaping.
4. Place the car at the racing track with the front wheels just behind the starting line of the track.
5. Let go of the straw and car at the same time, and watch it travel down the track.
6. Watch how the race car moves. Observe whether it travels in a straight line or has a more curved, or even circular path. Using the length of string, measure how far the car travelled. Record this information in Table 1. If the race car gets stuck on the edge of the track, record its stopping point as the distance travelled. Only measure the distance travelled straight along the track. Do not measure the diagonal distance from start to finish if the race car curves.
7. Run 2 more tests and record the distances travelled in Table 1.
8. Calculate the average distance the race car travelled and record this information in Table 1.

Designing your own car

1. Based on your experience assembling the car prototype in the above activity, what conclusions can be made on which structures and materials are more effective? Consider how the assembly method can be changed, improved or used to test a hypothesis.
2. Develop a 1 sentence design challenge. For example, design a car that can travel 15 metres in 2 seconds. Write your design challenge here:
3. Develop a design plan for a car that fulfils the needs of your design challenge.

    - List 3 concepts or techniques you will employ to construct the car to meet your design challenge.
    - Describe and draw the car you will construct. Include annotations.
    - List of the required materials you will need.
    - Describe the building steps you will follow.
    - Describe the method you will use for testing the car.
    - List the safety measures you will use to ensure no harm comes to yourself or others. List the safety equipment you will use to do this.
    - Design a data table of what you will measure as you conduct your tests.
    - Develop a criteria for success for determining if you met or exceeded your design challenge goals.

4. Based on your design plan, construct the car.
5. Test your car and record the results in the data table you created earlier.
6. If necessary, make changes to the design. Record these modifications and determine if these changes had the desired impact.

OBSERVATION AND RESULTS

Below is an example of expected results. Individual results will vary.

	Trial 1	Trial 2	Trial 3	Trial 4
Distance (cm)	236	301	320	286

Table 1: Testing the Prototype Results

Designing your own car

Student results will vary. Some student designs will meet or exceed their design challenge goals. Other designs will fail to meet design expectations. Regardless of the outcome, students should provide a detailed description of how their design performed against the design criteria and an analysis of why they believe their design yielded such results.

INVESTIGATIONS

- Ask students to consider what modifications they made to their car and how these modifications changed their results. Students should also identify what further modifications they would make to improve the design and describe what impact these changes would have.
- Hover cars are vehicles that float above the ground without making any physical contact with it. These vehicles have long been the topic of science fiction and have even been built. Despite this hover cars have never been mass produced. Ask students to describe the advantages and disadvantages of a hover car are according to Newton's laws of motion.