WestVirginiaUniversity
EXTENSION SERVICE

extension.wvu.edu

BALLOON CARS: THE SCIENCE OF MOTION

A WVU Extension Service STEMCARE Lesson

Audience:

Grades 4-12

Time:

60 to 75 minutes

10 minutes reviewing the engineering design process and Newton's laws of motion; 14 minutes watching WVU STEMCARE Balloon Cars demonstration video; 5 minutes of students designing a balloon-powered race care; 25 minutes of students testing prototype that demonstrates Newton's three laws of motion; 10 minutes to reflect and redesign; 10 minutes of retesting.

Materials:

For each student or team: Plastic foam tray or cardboard; 3 regular-size drinking straws; 2 bamboo skewers or balsa wood sticks; 1 piece cardstock or cardboard; 1 wheel template (disposable cup bottom); 1 balloon (preferably non-latex); 1 piece of string or yarn; 6 pennies or washers

Class materials: Pencils, masking tape, scissors, tape measure, markers or stickers to decorate (optional)

Vocabulary:

Friction, inertia, thrust, elastic potential energy, kinetic energy

Goal:

Develop an understanding of Newton's laws of motion in relation to racecars.

Introductory Activities

THE ENGINEERING DESIGN PROCESS

Source: http://www.thunderboltkids.co.za/Grade5/03-energy-and-change/chapter3.html

1. Show the WVU STEMCARE Balloon Car video *(https://youtu.be/O1RGrWsT83Q)*. Tell youths that they have been tasked with designing, building and testing a balloon-powered racecar to demonstrate Newton's three laws of motion.

2. Review Newton's laws of motion in relation to racecars.

- Newton's First Law: The Law of Inertia
  – Motion, or a lack of motion, will not change unless acted upon by an unbalanced force.
  – Example: A toy car will not move unless given a push. Friction will eventually cause the toy car to slow down and come to a stop. Both the push and friction are examples of an unbalanced force.
- Newton's Second Law: The Law of Force
  – Force = mass × acceleration ($F = m \times a$)
  – Example: Given the same push, a smaller, lighter toy car will move faster and farther than a bigger, heavier toy car.
- Newton's Third Law: The Law of Action and Reaction
  – For every action, there is an equal and opposite reaction.
  – Example: A jet engine forces hot air in one direction causing the plane to move forward in the opposite direction. This phenomenon is known as thrust.

Newton's laws govern how modern racecars are designed, how they perform and what safety features are implemented.

Inertia is the resistance to change in motion. Once a racecar is moving, it and everything inside wants to keep moving in the same direction. If the racecar is stopped abruptly by an outside force, safety belts help slow the driver and prevent him or her from flying out of the vehicle.

— continued —

STEMCARE
TURNING POSSIBILITIES INTO OPPORTUNITIES

Racecars are designed for speed. Using the law of force, mechanical engineers design vehicles with powerful engines and lightweight bodies made from materials such as aluminum and carbon fiber composite.

A racecar accelerates forward when the engine transfers force to the tires. The tires then push backward against the pavement in a direction equal and opposite to the movement of the racecar.

Core Learning Activity: Build and Test A Balloon Racecar

In this activity, youths will design and build a balloon-powered racecar. The use of the balloon "motor" provides a visual demonstration of both the law of inertia and the law of action and reaction (first and third laws). In step 2, teams investigate the relationship between force, mass and acceleration (second law). In four trials, teams will sequentially add pennies to the body of their racecars to increase the mass. By constraining the amount of air in the balloon and the force given in each trial, teams should see their racecars travel a shorter distance with each penny addition. The final activity will have the teams improve their designs to compete in a group race-off.

The following instructions may be distributed to students or they may follow you step by step as you build.

STEP 1: Build the Racecar

Using the materials provided, each team will build a racecar body, wheels and axels.

1. Use the wheel template to trace and cut out four wheels from the cardstock.
2. Using the tip of a pencil or bamboo skewer, make a small hole in the center of each wheel and secure with a small piece of tape.
3. Using scissors, cut two straws such that they are slightly longer than the width of the plastic foam tray or cardboard body.
4. Turn the plastic foam tray or cardboard body upside down and tape the straws on each end of the body. These will serve as shafts for the wheel axels.
5. Cut the skewers such that there is ½ inch (~1 centimeter) extending beyond each straw end when inserted.
6. Slide one skewer through each straw. These will serve as the wheel axels.
7. Put one wheel onto each end of the skewers. Make sure your racecar rolls freely when pushed.

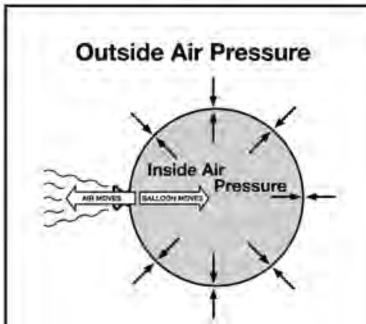
STEP 2: Test Your Car

Test your racecar to demonstrate Newton's first and third laws of motion.

1. Carefully cut the elastic rim off the end of your balloon.
2. Insert the jumbo straw about 1 inch inside the balloon and tape to the straw to secure it in place. Make sure there are no gaps that will allow air to leak. (Note: Regular straws also will work but require more caution in taping closed the gaps.)
3. Tape the straw to the top-middle of the racecar body. The straw opening should stick out a bit from the end of the tray.
4. Blow into the straw to inflate the balloon and pinch the straw to keep it from deflating.
5. Place the racecar on a smooth surface and let go of the straw. What happened?

THINK ABOUT IT

- Did your racecar move? If so, what direction did it travel in relation to the air in the balloon?
- If your racecar did not move, inspect your wheels and axels. What might you do to remedy this problem?
- The balloon is the source of force to move the racecar. When the balloon is inflated and the straw is pinched, the force of the outside air pushing in on the balloon is equal to the force of the inside air pushing out on the balloon. Explain how your racecar demonstrated Newton's first and third laws.



Source: http://quest.nasa.gov/space/teachers/liftoff/newton.html

— continued —

STEP 3: Investigate Newton's Second Law of Motion

1. Mark a starting line for the placement of your racecar (to be setup by the facilitator).
2. Blow into the straw to inflate the balloon and pinch to keep it from deflating. (Note: Because the balloon provides the force, it is important that it is inflated to the same size for each trial. Using a piece of string, measure the circumference of the balloon at its widest part. Mark the string with a pen or pencil and use to set the balloon size for all trials.)
3. Place the racecar at the starting line and let go of the straw.
4. Measure the distance the car traveled and record in the data chart.
5. Place two pennies on the racecar body on top of the plastic foam tray and repeat steps 2 through 4.
6. Repeat step 5 with two additional pennies until you have added a total of six pennies to the tray and recorded data for a total of four trials.

THINK ABOUT IT

- How did the distance traveled by the racecar change as you added pennies to the body?
- The addition of the pennies results in a higher mass. How does this demonstrate Newton's second law of motion ($F = m \times a$)?

Reimagine and Redesign

Building from the concepts of force and mass learned in steps 1 through 3, redesign and improve racecars in preparation for a race-off.

Evaluation

Students will reflect and answer "Think About It" questions.

Take It Further

Visit the National Science Foundation's "Science of Speed" special report to watch videos and learn more about the science behind the sport of racecars *(http://www.nsf.gov/news/special_reports/sos/).*

Resources

Balloon Rockets. COSI. n.d. https://smile.cosi.org/balloon-rockets.pdf.

"Beginner's Guide to Propulsion: Balloon Rocket Car (Easy) - Activity." NASA. Accessed October 16, 2020. https://www.grc.nasa.gov/www/k-12/BGP/Ashlie/BalloonRocketCar_easy.html.

Buddies, Science, and Ben Finio. "Build a Balloon-Powered Car." Scientific American, May 18, 2017. https://www.scientificamerican.com/article/build-a-balloon-powered-car/.

West Virginia Next Generation, General Science Standards

- S.3-5.ETS.1 Engineering Design – Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time or cost.
- S.4.GS.4 Energy – Apply scientific ideas to design, test and refine a device that converts energy from one form to another.
- S.7.PS.5 Energy – Construct, use and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
- S.HS.PS.17 – Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.

WVU STEMCARE Balloon Cars Demonstration Video
https://youtu.be/O1RGrWsT83Q

4H20-147