MUSEUM OF THE ROCKIES

Rockets: Taking Off!

***For every action there is an equal and opposite reaction*.**

Rockets and Balloons

What happens when you blow up a balloon then let it go? Does the balloon move through the air? Did you know that balloon and rockets have something in common? Rockets and balloons are both chambers enclosing a gas under pressure. The pressurized fuel inside a rocket is gas produced by burning solid and/or liquid fuels.

Action and Reaction

Let's think about the balloon again. What happens when you blow the balloon up and let it go? The air moves out of the opening in one direction, (action) while the balloon moves in the opposite direction (reaction). The same is true of rockets. Rocket fuel ignites at the base of the rocket and the gases propel the rocket into space, in the opposite direction.

Racing Balloon

Mission:

Discover the action and reaction of a balloon car.

Experiment:

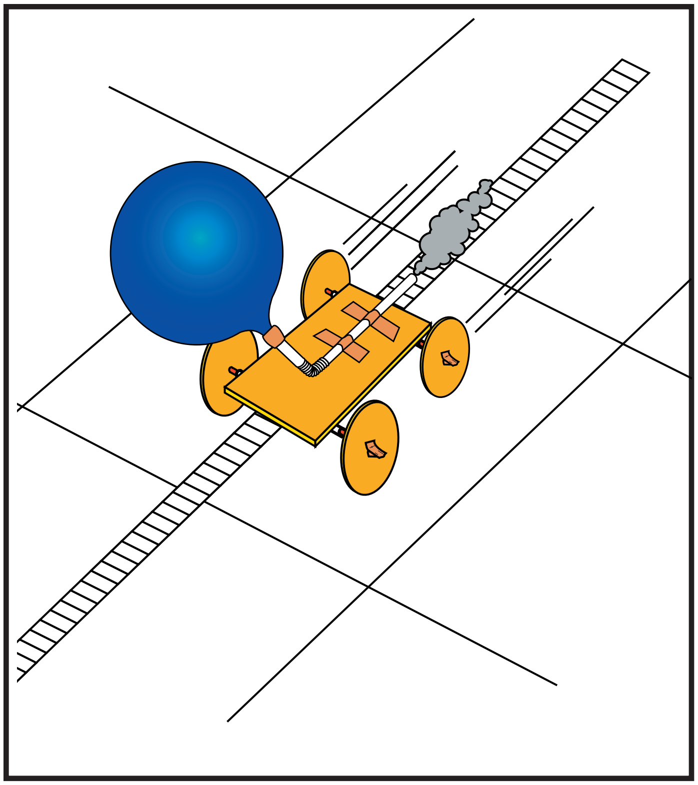
Step 1: Using the pump, inflate the balloon through the straw.
Step 2: Remove the pump and release the balloon car on the floor.
Step 3: Watch what happens!

Questions:

What is the action? The air (fuel) leaving the balloon in one direction.
What is the reaction? The car moving in the opposite direction.

Theorize:

A. What causes the balloon car to move?
B. What is the car's fuel?
C. In what direction is the fuel released?
D. In what direction does the balloon car move?
E. How could you make the balloon car move faster? Slower?



Rocket Activity

Rocket Races

Objective

Students investigate Newton's third law of motion by designing and constructing rocket-powered racing cars.

Description

Individual students construct racing cars from Styrofoam food trays and power them with the thrust of an inflated balloon. In three racing trials, the racers shoot along a straight course, and the distance the racers travel is measured. Between trials, students redesign their racers to improve their performance and solve any "mechanical" problems that crop up. At the conclusion of the activity, students submit a detailed report on their racer design and how it performed in the trials.

National Science Content Standards

Unifying Concepts and Processes
- Change, constancy, and measurement

Science as Inquiry
- Abilities necessary to do scientific inquiry

Physical Science
- Position and motion of objects
- Motions and forces

Science and Technology
- Abilities of technological design

National Mathematics Content Standards
- Number and Operations
- Geometry
- Measurement
- Data Analysis and Probability

National Mathematics Process Standards
- Problem Solving
- Reasoning and Proof
- Communication
- Connections
- Representations

Materials

Styrofoam food trays (ask for donations from local supermarkets)
Small plastic stirrer straws (round cross section) - 2 per racer
Flexi-straws - 3 per racer
4- or 5-inch round balloon
Masking tape
Sharp pencil
Scissors (optional)
Ruler
Meter stick or metric measuring tape for laying out race course
Sandpaper (optional)

Management

Each student will need a Styrofoam food tray. Request donations from your local supermarket. Ask for thicker trays (about 3/16" thick). Yellow trays used for poultry work well. Waffle-bottom trays are acceptable. Although the trays can be cut using scissors, save the scissors for trimming. It is much easier to score the Styrofoam with a sharp pencil and then break away the pieces. Score lines can be continuous or the tip of the pencil can be punched into the Styrofoam to make a dotted line. Demonstrate the scoring process to your students. After the pieces are broken out, the edges are smoothed. Wheels can be smoothed by rolling them on a hard surface while applying pressure. Sandpaper can also be used for smoothing.

Lay out a race course in a large open space or hallway. The space can be carpeted, but textured carpets interfere with the movements of the racers. Stretch out a 10 meter-long line of masking tape and mark 10-centimeter intervals. If you have a 10 meter tape measure, just tape it to the floor.

Double check the taping of the balloon to the straw. The balloon should be completely sealed, or it will be difficult to inflate, and some of its thrust will be lost through the leaks. Pre-inflating the balloon will loosen it and make it easier to inflate through the straw.

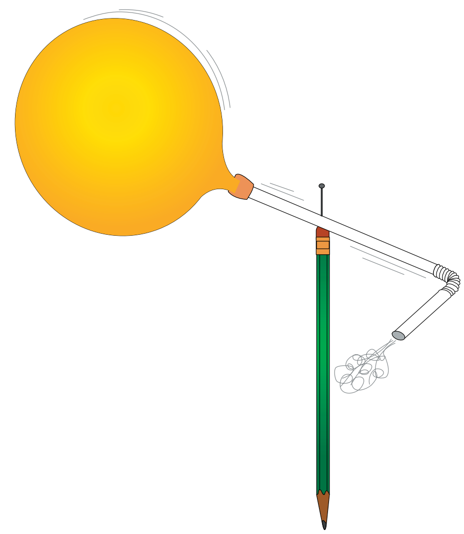
Guide students through the redesign process to improve their racers. If their racers are not running well, ask them what they think the problem is. Then, ask them what they can do about it. Typical problems include having wheels too tight to the sides of the cars (friction), wheels or axles mounted crooked (racer curves off course), and axles not mounted in center of wheel or wheels not round (like "clown car" wheels).

Background

The rocket racer is an excellent demonstration of Newton's third law of motion. Air is compressed inside a balloon that is expanded. When the nossle is released, the balloon returns to its original uninflated size by propelling the air out its nozzle. The straw mounted to the balloon extends the nozzle beyond the rear end of the car. The action force of the expelling air produces a reaction force that pushes the racer in the opposite direction. The racer's wheels reduce friction with the floor, and the racer takes off down the race course.

Although the rocket racer seems simple, there are many challenging complexities in its operation. In principle (Newton's second law of motion), the less mass the car has, the greater its acceleration will be. Generally, heavy rocket racers do less well than lighter racers. However, very small racers are limited by other factors. Vehicles with short wheel bases tend to circle or partially lift off the floor. Balance becomes a problem. The mass of the balloon may cause the car to tilt nose down to the floor, causing a poor start.

The engineering design of the racer is very important. Many designs are possible, including wide, narrow, and I-beam shaped bodies and three, four, or even six wheels.



Demonstrate the action-reaction principle by inserting a pin through the straw and into a pencil eraser. Inflate the balloon, and it will pinwheel around the pencil as air rushes out. Compare this to the straight thrust produced by the balloon in the rocket cars.

Students will have to review the trade-offs of their design. For example, an extra-long body may provide a straighter path, but the car might travel a shorter distance as a result.

Procedure

1. Explain the activity to the students. Provide them with the How To Build A Rocket Racer Sheet. Go over the construction steps and demonstrate how to snap out parts, mount the wheels, and attach the straw to the balloon.

2. Stress that the racer shown in the instructions is a basic racer. Many designs are possible. Have them think up their own designs.
3. Review the Rocket Racer Data Sheet and make sure students know how to fill out the graphs and what data they should collect.
4. Distribute materials and lay out the racer course.
5. When student racers are ready, have one or two students at a time inflate their balloons and pinch off the end of the straw to keep the air inside. Have them place their racers just behind the starting line and release the straws. Regardless of how much curving a racer does, the measured distance is how far along the straight line of the race course the car reached.
6. Post distance records to motivate students to modify their racers to set new records.
7. After each racer runs three times, have students complete their data sheets and sketch their final design on the design sheets.

Discussion

- *Would it be a good idea for automobiles to be powered by rocket engines?*
  If there was only one rocket powered automobile on the road, it would work fine. However, imagine rush hour traffic loaded with rocket cars. Each would blow exhaust gas at the vehicles to the rear.
- *How are the wheels on a rocket racer similar to and different from wheels on a regular automobile?*
  Rocket racer wheels reduce friction with the ground. They turn when the air coming from the balloon exerts a thrust. Wheels for an automobile also permit the car to roll across the ground, but the thrust of an automobile depends upon friction. The engine turns the wheels, and friction with the rubber and the pavement transmits the action force so that the car rolls forward.

Assessment

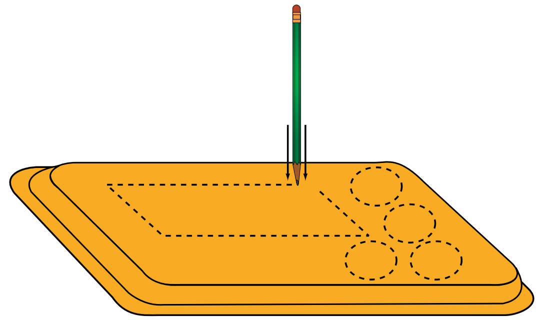
- Review student Rocket Racer Data Sheets and Design Sheets.
- Have students write an explanation of Newton’s third law of motion using their rocket racers as examples.

Extensions

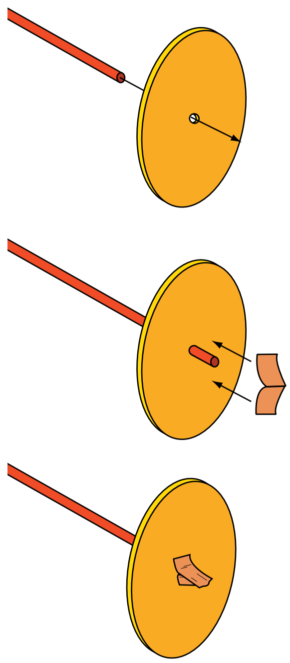
- Hold Rocket Racer drag races. Lay out a 3-meter-long course. The fastest car is the one that crosses the finish line first. Calculate racer average speed by timing start to finish with a stopwatch (e.g., four seconds to go three meters = 0.75 m/second or 2.7 km/h).
- Have students try multiple balloons for additional thrust. How will students design cars that are balanced with the extra load?
- Have students control the thrust of their balloons by inflating them to the same diameter each time. How can students ensure that the balloon is always the same?
- Using the same materials, what other devices can be created that demonstrate the action-reaction principle of Newton’s third law of motion?

How to Build a Rocket Racer

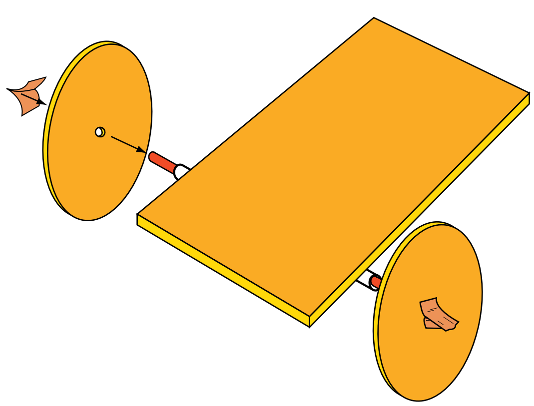
1. Lay out your pattern on the Styrofoam tray. You will need a racer body and wheels. Use a pencil point to score the Styrofoam. Snap out your pieces and smooth them. Make sure your wheels are round! Use sandpaper to round the wheels OR press them on a hard surface and roll them.



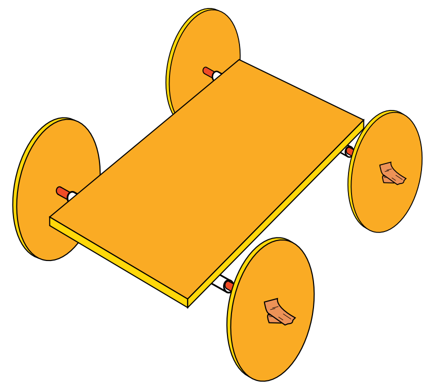
2. Punch a small hole in the center of each wheel with the pencil. Push the axle (stirrer) straw through the hole of one wheel so that it extends 1 cm on the other side. Pinch a piece of masking tape around the end of the straw and smooth it on to the wheel. Do the same for the second axle. Do not add wheels to the other ends yet!



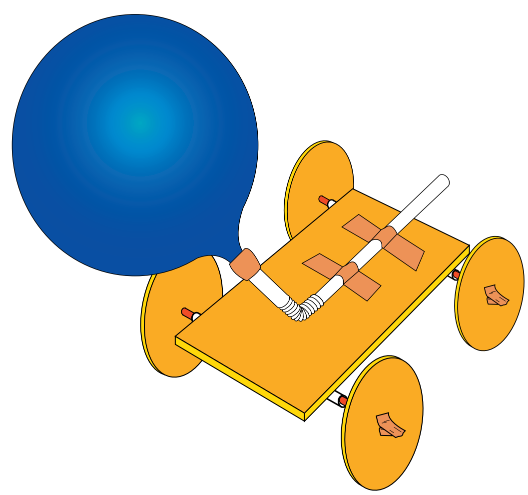
3. Cut two large straws to the size you want. Tape them parallel to each other on the bottom of the racer body at opposite ends. Slide a wheel and axel through one of the straws and mount a second wheel on the other end of the axle.



4. Slide the second wheel and axle through the remaining straw and mount the remaining wheel at its opposite end.



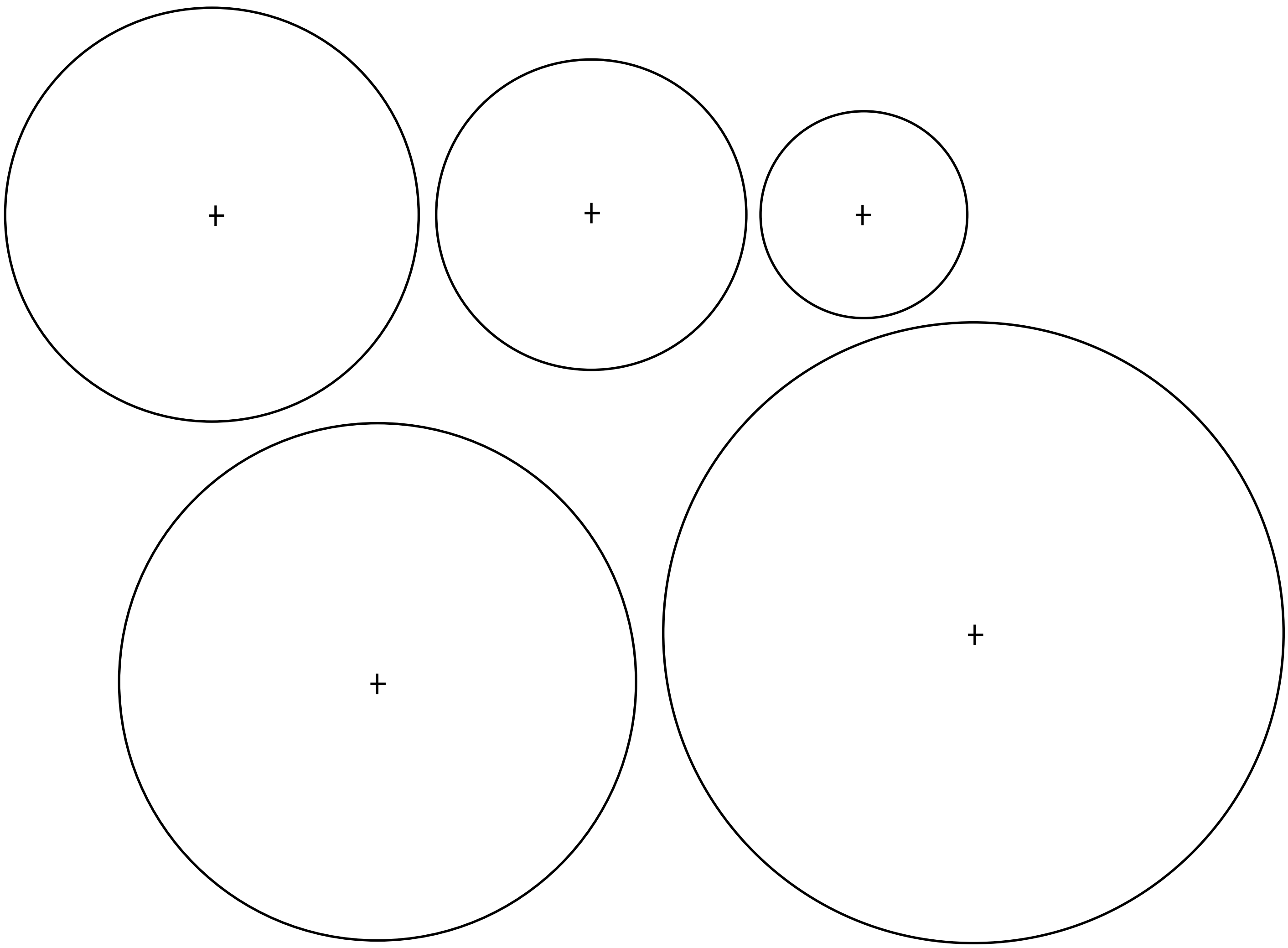
5. Blow up the balloon and then let the air out. Next, slip the straw into the balloon as shown. Use masking tape to seal the balloon nozzle to the straw. Squeeze the tape tightly to seal all holes. Test the seal by blowing up the balloon again through the straw.



6. Mount the balloon and straw to the racer with masking tape as shown. Be sure the end of the straw (rocket nozzle) extends off the end of the racer body.

Wheel Patterns

Cut out the desired wheel size. Trace the wheel outline on the Styrofoam. Punch the pencil point through the cross to mark the center.



Name: ________________

Rocket Racer Design Sheet

Draw a diagram showing your best design for a rocket racer.

Show your racer as seen from the front, top, and side.

Each square on the graphs = 1cm.

TOP VIEW

FRONT VIEW

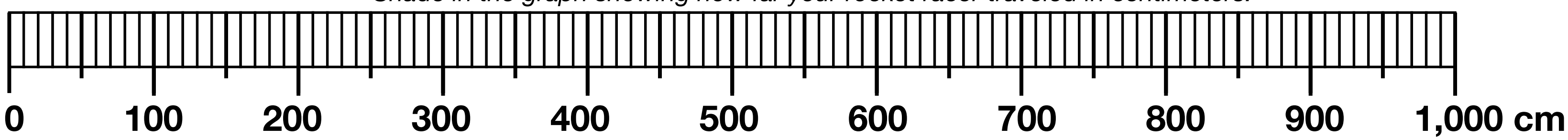
SIDE VIEW

Rocket Racer Data Sheet

Name: ____________________________

Shade in the graph showing how far your rocket racer traveled in centimeters.

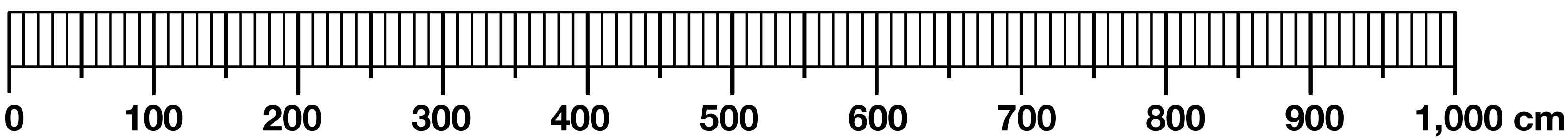
Rocket Racer Trial #1



Describe how your rocket racer ran (straight, curved, circles, stuck, etc.).

Did your racer perform as well as you hoped? Explain why or why not.

Rocket Racer Trial #2



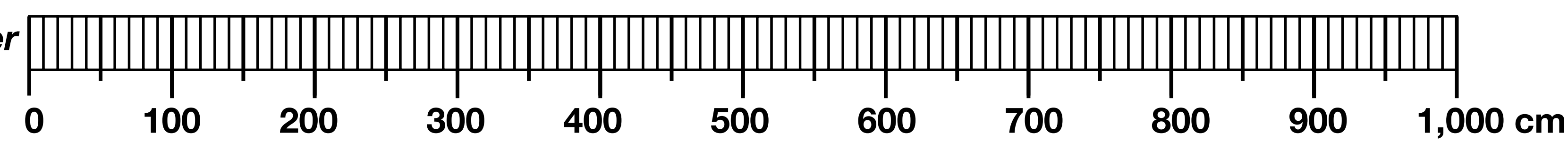
How did you improve your rocket racer?

Predict how far your racer will run. ___________ cm

Describe how your rocket racer ran.

Did your improvements work? Explain why or why not.

Rocket Racer Trial #3



How did you improve your rocket racer?

Predict how far your racer will run. ___________ cm

Describe how your rocket racer ran.

Did your improvements work? Explain why or why not.