



# Classroom Connections

Newton's  
Third Law:  
Rocket Races

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Classroom Connections, visit  
[www.nasa.gov/stemonstation](http://www.nasa.gov/stemonstation).

# Rocket Races

## Teacher Background



Grade Level: **6<sup>th</sup>-8<sup>th</sup>**



Suggested Time: **60-90 minutes**



Next Generation Science Standards (NGSS):

**MS-PS2-1.** Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. **Science and Engineering Practices:** Constructing Explanations and Designing Solutions. **Disciplinary Core Ideas:** PS2.A: Forces and Motion. **Crosscutting Concepts:** Stability and Change.

### Background

Newton's Third Law of Motion states that for every action, there is an equal and opposite reaction. This means that when one object exerts a force on another object, the second object also exerts an equal and opposite force on the first object. These two forces are referred to as a force pair. A force pair identifies two interacting objects and describes the direction of the force acting on each object. It is important to note that both forces in the force pair are the same type (e.g. gravitational), are equal in magnitude, and are opposite in direction.

NASA uses rockets to launch astronauts and supplies to the International Space Station. Launching a rocket relies on Newton's Third Law of Motion. A rocket engine produces thrust through



action and reaction. The engine produces hot exhaust gases which flow out of the back of the engine. In reaction, a thrusting force is produced in the opposite reaction.

You can use a balloon to provide a simple analogy of how a rocket engine works. The air trapped inside the balloon is pushed out the open end of the balloon. According to Newton's Third Law

of motion, the expelled air exerts an equal force in the opposite direction of the motion of the air, causing the balloon to move forward. The force of the balloon on the air is one part of the force pair, and the force of the air on the balloon is the other part.

If you want to read more about Newton's Third Law of Motion and launching rockets, check out a NASA blog post at <https://blogs.nasa.gov/Rocketology/tag/newtons-third-law/>.

### Objective

Following this activity, students will be able to:

- Predict and make observations about the nature of forces and motion
- Explain Newton's Third Law of Motion, and apply examples to everyday life
- Investigate Newton's Third Law of Motion by designing and constructing rocket-powered racing cars

### Materials

- Styrofoam food trays (like the trays grocery stores use for poultry)
- Small plastic stirrers (round cross section) – 2 per student
- Flexi-straws – 3 per student
- 4- or 5-inch round balloons
- Balloon pump (recommend having at least 4-5 so students can do testing)
- Masking Tape
- Pencils
- Scissors
- Rulers
- Meter stick or measuring tape
- Sandpaper (optional)
- Additional supplies for modifications to cars (rubber bands, cardboard, CDs, etc.)

## Procedure

- **Watch and Discuss**

Watch STEMonstrations: Newton's Third Law available at [www.nasa.gov/stemonstrations](http://www.nasa.gov/stemonstrations). After watching the video, help reinforce the concept of force pairs. Can students think of some additional examples of force pairs?

- **Exploration Activity**

Working individually or in pairs, students will complete the "Rocket Races" activity found on the next several pages. Students will construct "rocket racers", powered with inflated balloons. Instructions for building a basic racer are provided on pages 5-6. Students can modify this basic design or come up with their own unique designs using other materials (optional).

After building their rocket racer, students will conduct trials to see how far they can go. To prepare for these trials, lay out a course in a large open space, preferably on a smooth floor. Stretch out a straight, 10 meter-long line of masking tape, and make a mark at 10 cm intervals (this will help students calculate their distance quickly). Students will line up their racers at the start (two students per trial) and fill up their balloons using a balloon pump (have students use the same number of pumps – you may want to test the balloons ahead of time to determine how many pumps it takes to adequately fill the balloons). Students will record the distance their racer travels. Students will complete three trials and have the option to modify their racer to improve performance between each trial.

- **Final Discussion**

Have a few students share their rocket racer and their results. Would it be a good idea for automobiles to be powered by rocket engines? How are the wheels on a rocket racer similar to and different from wheels on a regular automobile? What types of modifications would students like to make that weren't available to them?

## Extension Activities

- 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.
- Have students try multiple balloons for additional thrust. How will students design cars that are balanced with the extra load?
- What other devices can be created that demonstrate the action-reaction principle of Newton's Third Law of Motion?

*This Classroom Connection was adapted from NASA's "Rocket Races" activity. You can view the original activity at [https://www.nasa.gov/pdf/153417main-Rockets\\_Rocket\\_Races.pdf](https://www.nasa.gov/pdf/153417main-Rockets_Rocket_Races.pdf).*



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# Rocket Races

## Student Activity

Names: \_\_\_\_\_

### Procedure

1. Look at the instructions and template for building a rocket racer on pages 5-6 and the materials you have to build your racer. You want to build the rocket racer that goes the farthest. Make a sketch of your racer below, and label the body, wheels, and propulsion system.

2. Build your rocket racer using the template or create your own design. Test your design to make sure it travels straight. Remember, you want to build a racer that can go the farthest distance!
3. When your rocket racer is ready, take it over to the track to perform your trials. You will run three trials with your racer. You can make modifications or improvements to your design between each trial to try to increase the distance it will travel.
4. Fill out the table below for each of the trials.

<b>Trial</b>	<b>How Far Did Your Racer Go? (cm)</b>	<b>How Well Did Your Racer Run?</b>	<b>What Improvements Do You Plan to Make?</b>
<i>Example</i>	<i>412 cm</i>	<i>It went a little crooked.</i>	<i>I want to use smaller wheels.</i>
1			
2			
3			

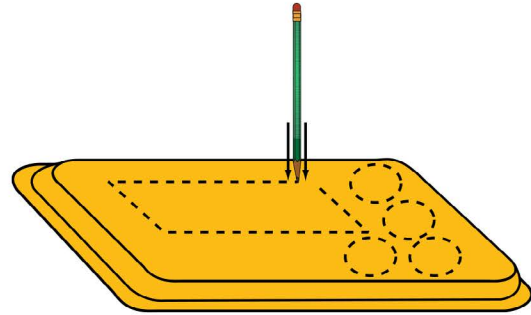
5. Did your improvements make your racer better? Explain why or why not.
6. How did your rocket racer show Newton's Third Law?



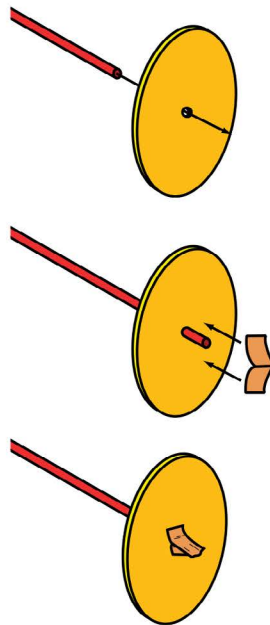
# How to Build a Rocket Racer

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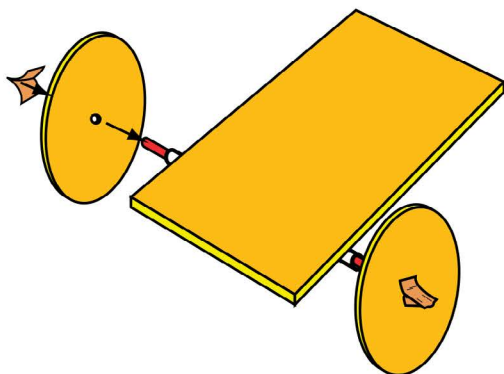
1. Lay out your pattern on the Styrofoam tray. You will need a racer body and wheels. Use a pencil point to score the Styrofoam. Snap out your pieces and smooth them. Make sure your wheels are round! Use sandpaper to round the wheels OR press them on a hard surface and roll them.



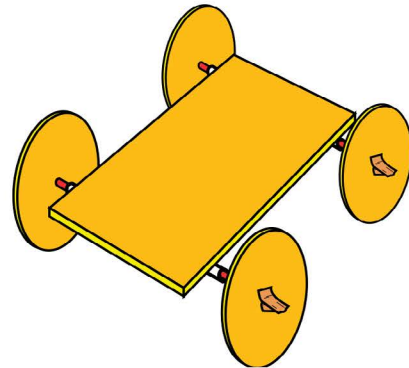
2. Punch a small hole in the center of each wheel with the pencil. Push the axle (stirrer) straw through the hole of one wheel so that it extends 1 cm on the other side. Pinch a piece of masking tape around the end of the straw and smooth it on to the wheel. Do the same for the second axle. Do not add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



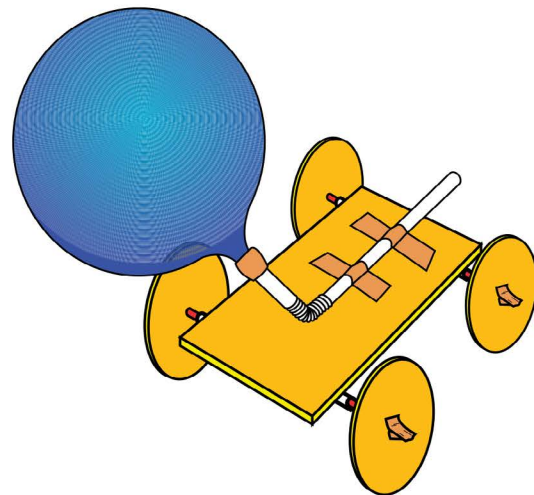
3. Cut two large straws to the size you want. Tape them parallel to each other on the bottom of the racer body at opposite ends. Slide a wheel and axle through one of the straws and mount a second wheel on the other end of the axle.



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.

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

