

## Bottle Rocket

Lesson 2 of 2

**Grade Level:** 5-8

**Subject:** Science

**Prep Time:** Overnight/Extended

**Activity Duration:** Two class periods

**Materials Category:** Special Requirements

National Education Standards				
Science	Mathematics	Technology		Geography
		ISTE	ITEA	
3a, 3b, 6a, 6b	11, 21			

**Objective:** To construct and launch a simple bottle rocket.

### Materials:

For each launch pad:

- Four 5-inch corner irons with 12  $\frac{3}{4}$  inch wood screws to fit
- One 5-inch mounting plate
- Two 6-inch spikes
- Two 10-inch spikes or metal tent stakes
- Two 5-inch by  $\frac{1}{4}$ -inch carriage bolts with six  $\frac{1}{4}$ -inch nuts
- One 3-inch eyebolt with two nuts and washers
- Four  $\frac{3}{4}$  inch diameter washers to fit bolts
- One number 3 rubber stopper with a single hole
- One snap-in tubeless tire valve (small 0.453-inch hole, 2-inches long)

- Wood board 12 by 18 by  $\frac{3}{4}$  inches
- Electric drill and bits including a  $\frac{3}{8}$ -inch bit
- Screwdriver
- Pliers or open-end wrench to fit nuts
- Vice
- 12 feet of  $\frac{1}{4}$ -inch cord
- Pencil
- Bicycle pump with pressure gauge

For each student group:

- 2-liter plastic soft drink bottles
- Low-temperature glue guns
- Poster board
- Tape
- Modeling clay
- Scissors
- Safety Glasses
- Decals
- Stickers
- Marker pens

### Related Links:

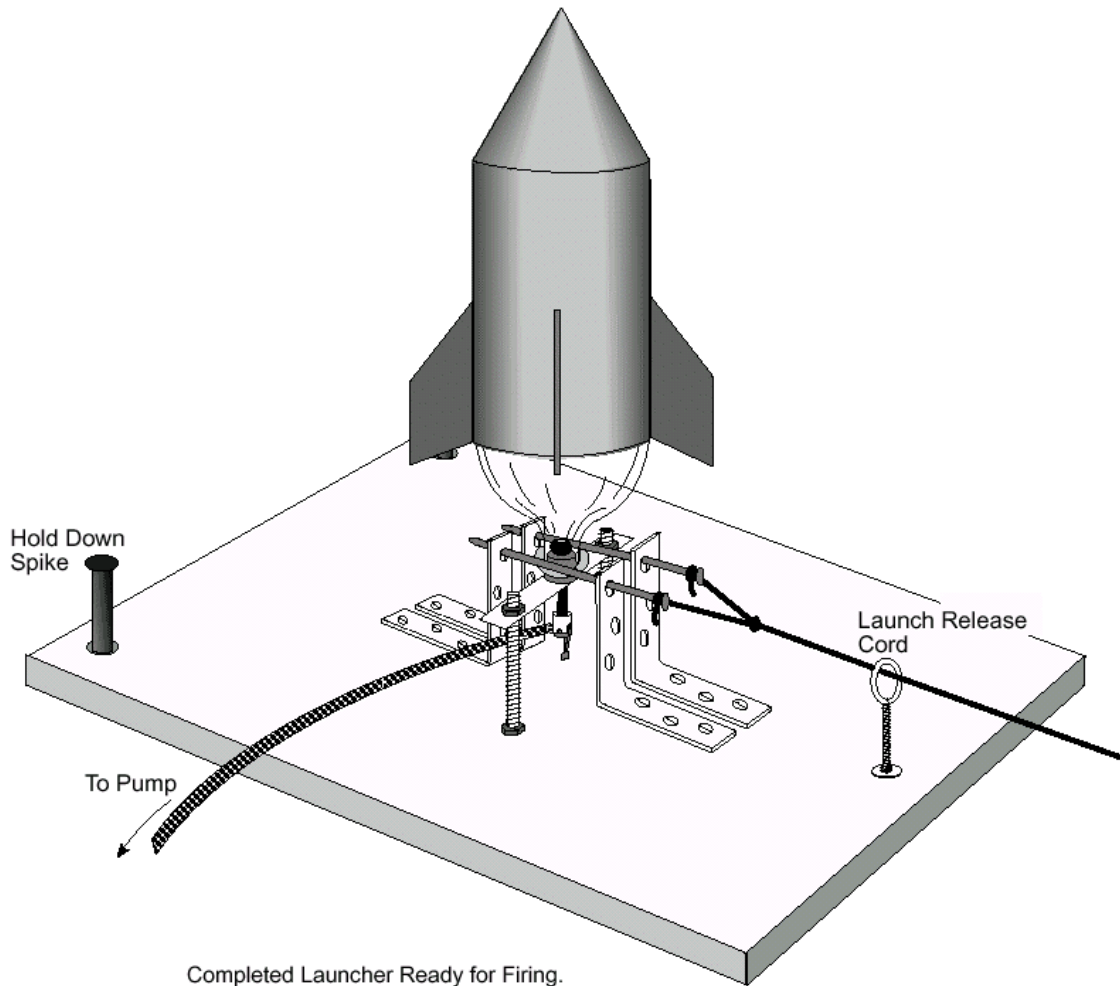
NASA Site used for derivation of Lesson Plan  
Rockets

<http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Rockets/>

## Bottle Rocket

Teacher Sheets

### Pre-lesson Instructions



Consult the materials and tools list to determine what you will need to construct a single bottle rocket launcher. The launcher is simple and inexpensive to construct. Air pressure is provided by means of a hand-operated bicycle pump. The pump should have a pressure gauge for accurate comparisons between launches. Most needed parts are available from hardware stores. In addition, you will need a tire valve from an auto parts store and a rubber bottle stopper from a school science experiment. The most difficult task is to drill a 3/8-inch hole in the mending plate called for in the materials list. Electric drills are a common household tool. If you do not have access to one, or do not wish to drill the holes in the metal mending plate, find someone who can do the job for you. Ask a teacher or student in your school's industrial arts shop, a fellow teacher, or the parent of one of your students to help.



If you have each student construct a bottle rocket, having more than one launcher may be advisable. Because the rockets are projectiles, safely using more than one launcher will require careful planning and possibly additional supervision. Please refer to the launch safety instructions.

## Background

Bottle rockets are excellent devices for investigating Newton's Three Laws of Motion. The rocket will remain on the launch pad until an unbalanced force is exerted propelling the rocket upward (First Law). The amount of force depends upon how much air you pumped inside the rocket (Second Law). You can increase the force further by adding a small amount of water to the rocket. This increases the mass the rocket expels by the air pressure. Finally, the action force of the air (and water) as it rushes out the nozzle creates an equal and opposite reaction force propelling the rocket upward (Third Law). The fourth instruction on the Student Sheet asks the students to press modeling clay into the nose cone of the rocket. Placing 50 to 100 grams of clay into the cone helps to stabilize the rocket by moving the center of mass farther from the center of pressure.

Having the learners work in teams will reduce the amount of materials required. Begin saving 2-liter bottles several weeks in advance to have a sufficient supply for your class. You will need to have at least one bottle rocket launcher. Construct the launcher described in the previous activity or obtain one from a science or technology education supply catalog.

The simplest way to construct the rockets is to use low-temperature electric glue guns that are available from craft stores. High-temperature glue guns will melt the plastic bottles. Provide glue guns for each table or set up glue stations in various parts of the room.

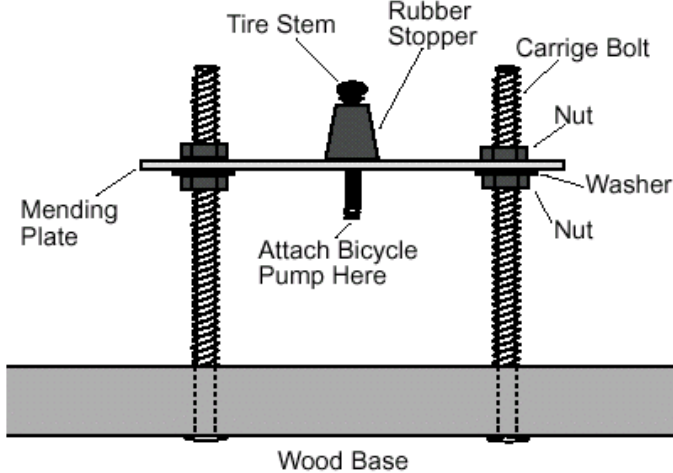
Collect a variety of decorative materials before beginning this activity so students can customize their rockets. When the rockets are completed, test fly them. When launching rockets, it is important for the other students to stand back. Countdowns help everybody know when the rocket will liftoff. In group discussion, have your students create launch safety rules that everybody must follow. Include how far back observers should stand, how many people should prepare the rocket for launch, who should retrieve the rocket, etc.

## Guidelines

### Instructions for constructing Launch Pad

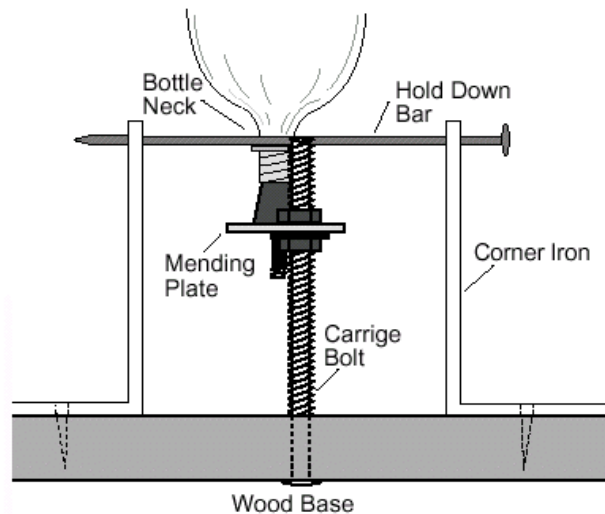
1. Prepare the rubber stopper by enlarging the hole with a drill. Grip the stopper lightly with a vice, and gently enlarge the hole with a 3/8-inch bit and electric drill. The rubber will stretch during cutting, making the finished hole somewhat less than 3/8 inches.
2. Remove the stopper from the vice, and push the needle valve end of the tire stem through the stopper from the narrow end to the wide end.

- Prepare the mounting plate by drilling a 3/8-inch hole through the center of the plate. Hold the plate with a vice during drilling, and wear eye protection. Enlarge the holes at the opposite ends of the plates using a drill bit slightly larger than the holes to do this. The holes must be large enough to pass the carriage bolts through them. (See Attachment of Mending Plate and Stopper diagram below.)



Attachment of Mending Plate and Stopper

- Lay the mending plate in the center of the wood base and mark the centers of the two outside holes that you enlarged. Drill holes through the wood big enough to pass the carriage bolts through.
- Push and twist the tire stem into the hole you drilled in the center of the mounting plate. The fat end of the stopper should rest on the plate.
- Insert the carriage bolts through the wood base from the bottom up. Place a hex nut over each bolt and tighten the nut so that the bolt head pulls into the wood.
- Screw a second nut over each bolt and spin it about half-way down the bolt. Place a washer over each nut and then slip the mounting plate over the two bolts.
- Press the neck of a 2-liter plastic bottle over the stopper. You will be using the bottle's wide-neck lip for measuring in the next step.



Positioning Corner Irons

- Set up two corner irons so they look like bookends. Insert a spike through the top hole of each iron. Slide the irons near the bottleneck so that the spike rests immediately above the wide-neck lip. The spike will hold the bottle in place while you pump up the rocket. If the bottle is too low, adjust the nuts beneath the mounting plate on both sides to raise it.



10. Set up the other two corner irons as you did in the previous step. Place them on the opposite side of the bottle. When you have the irons aligned so that the spikes rest above and hold the bottle lip, mark the centers of the holes on the wood base. For more precise screwing, drill small pilot holes for each screw, and then screw the corner irons tightly to the base.
11. Install an eyebolt to the edge of the opposite holes for the hold-down spikes. Drill a hole and hold the bolt in place with washers and nuts on top and bottom.
12. Attach the launch "pull cord" to the head end of each spike. Run the cord through the eyebolt.
13. Make final adjustments to the launcher by attaching the pump to the tire stem and pumping up the bottle. Refer to the launching instructions for safety notes. If the air seeps out around the stopper, the stopper is too loose. Use a pair of pliers or a wrench to raise each side of the mounting plate in turn to press the stopper with slightly more force to the bottleneck. When satisfied with the position, thread the remaining hex nuts over the mounting plate, and tighten them to hold the plate in position.
14. Drill two holes through the wood base along one side. The holes should be large enough to pass large spikes of metal tent stakes. When the launch pad is set up on a grassy field, the stakes will hold the launcher in place when you yank the pull cord. The launcher is now complete.

### **Instructions for leading student activity**

1. Read the 5-8 NASAexplores article, "Bolting It Down."
2. Go over the procedure listed on the Student Sheet.
3. Show students the launch pad, and ask them what part of the launch pad is similar to the hold-down bolts talked about in the article. (The spikes holding the bottle on the pad.)
4. Have students construct their rockets. Encourage imagination, creativity, and scientific thought (symmetry, etc.).
5. Have the students present their designs to the class.
6. Launch the rockets (see Launch Safety Instructions below).

### **Discussion / Wrap-up**

Evaluate each bottle rocket on its quality of construction. Observe how well fins align and attach to the bottle. Also observe how straight the nose cone is at the top of the rocket. If you choose to measure how high the rockets fly, compare the altitude the rockets reach with their design and quality of the construction.

### **Launch Safety Instructions:**

1. Select a grassy field that measures approximately 30 meters across. Place the launcher in the center of the field, and anchor it in place with the spikes or tent stakes. (If it is a windy day, place the launcher closer to the side of the field from which the wind is coming so that the rocket will drift on to the field as it comes down.)



2. Have each student or student group set up their rocket on the launch pad. Other students should stand back several meters. It will be easier to keep observers away by roping off the launch site.
3. After the rocket is attached to the launcher, the student pumping the rocket should wear eye protection. The rocket should be pumped no higher than about 50 pounds of pressure per square inch.
4. When pressurization is complete, all students should stand behind the rope for the countdown.
5. Before conducting the countdown, be sure the place where the rocket is expected to come down is clear of people. Launch the rocket when the recovery range is clear.
6. Only permit the students launching the rocket to retrieve it.

### **Extensions**

- Challenge rocket teams to invent a way to attach a parachute to the rocket that will deploy on the rocket's way back down.
- Parachutes for bottle rockets can be made from a plastic bag and string. The nose cone is merely placed over the rocket and parachute for launch. The cone needs to fit properly for launch or it will slip off. The modeling clay in the cone will cause the cone to fall off, deploying the parachute or paper helicopters, after the rocket tilts over at the top of its flight.
- Extend the poster board tube above the rounded end of the bottle. This will make a payload compartment for lofting various items with the rocket. Payloads might include streamers or paper helicopters that will spill out when the rocket reaches the top of its flight. Ask the students to identify other possible payloads for the rocket. If students suggest launching small animals with their rockets, discuss the purpose of flying animals and the possible dangers if they are actually flown.
- Conduct flight experiments by varying the amount of air pressure and water to the rocket before launch. Have the students develop experimental test procedures and control for variables.
- Conduct spectacular nighttime launches of bottle rockets. Make the rockets visible in flight by taping a small-size chemical light stick near the nose cone of each rocket. Light sticks are available at toy and camping stores and can be used for many flights. This is an especially good activity for summer "space camp" programs.

## **Bottle Rocket**

*Student Sheets*

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### **Materials**

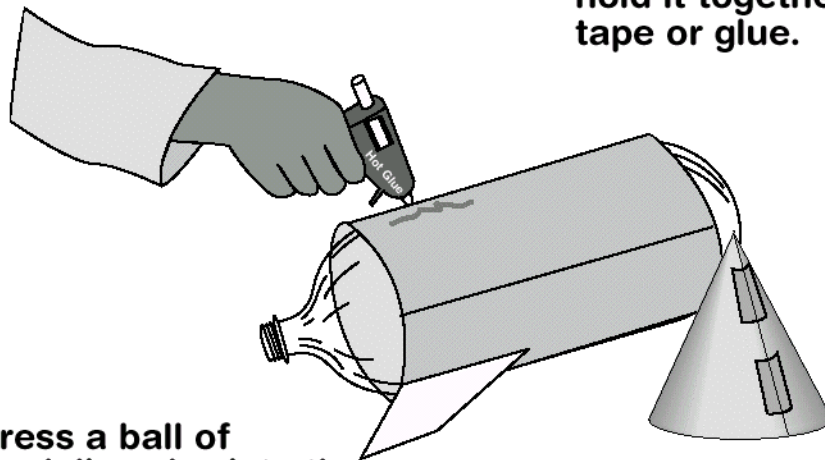
- 2-liter plastic soft drink bottles
- Low-temperature glue guns
- Poster board
- Tape
- Modeling clay
- Scissors
- Safety Glasses
- Decals
- Stickers
- Marker pens
- Launch pad

### **Procedure**

**1. Wrap and glue or tape a tube of posterboard around the bottle.**

**2. Cut out several fins of any shape and glue them to the tube.**

**3. Form a nosecone and hold it together with tape or glue.**



**4. Press a ball of modeling clay into the top of the nosecone.**

**5. Glue or tape nosecone to upper end of bottle.**

**6. Decorate your rocket.**

