ROCKETRY III: COMPRESSED AIR ROCKETS

Credit to the EAA Museum Education Program and NASA

Concepts Illustrated:

(1) Parts of a rocket
(2) Newton's Laws of Motion
(3) Three forces of rocket flight

Time Requirements: 60 Minutes

Grade Level of Audience: This activity is primarily suited for kids in grades 5-9.

Challenge: Using safe household materials, the students will work together in small teams to design and build air-powered rockets that are able to; carry and protect a valuable cargo inside, and fly to an altitude of 100 feet. Students will be instructed on the basics of rocket design, including the physics of rocket flight and the physical events of motion. The activity will culminate with a competitive launch of the rockets followed by a discussion.

I. Materials and Equipment Utilized

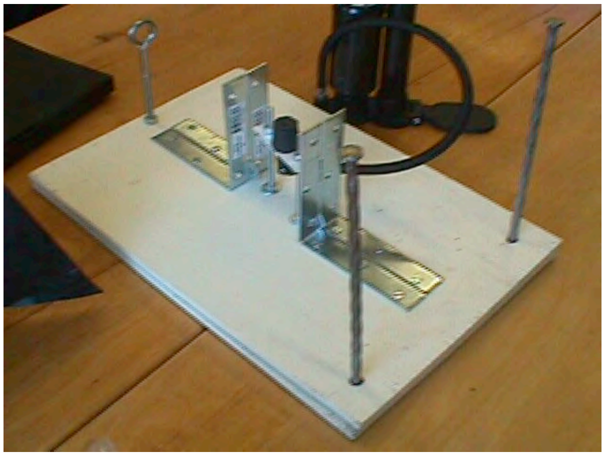
1. two liter soda bottle
2. duct tape
3. cardboard for fins, packing material, and nose cone
4. scissors for cutting out fins and nose cone
5. two liter bottle launcher (construction details below)
6. bicycle pump

II. Construction Details For Launcher

The launcher is simple and inexpensive to construct. 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. An electric drill is a common household tool. If you do not have access to a drill 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 or the parent of a student to help.

Materials Needed

· 4 5-inch corner irons with 12 3/4-inch wood screws to fit
· 1 5-inch mounting plate
· 2 6-inch spikes
· 2 10-inch spikes or metal tent stakes
· 2 5-inch by 1/4-inch carriage bolts with 6 1/4-inch nuts
· 1 3-inch eyebolt with 2 nuts and washers
· 4 3/4-inch diameter washers to fit bolts
· 1 #3 rubber stopper with a single hole
· 1 Snap-in Tubeless Tire valve (small 0.453 inch hole, 2 inches long)
· Wood board 12 x 18 x 3/4 inches
· 1 2-liter plastic bottle
· Electric drill and bits including a 3/8-inch bit
· Screw driver
· Pliers or open-end wrench to fit nuts
· Vice
· 12 feet of 1/4-inch cord
· Pencil



Construction of the Launcher

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.
3. Prepare the mounting plate by drilling a 3/8 inch hole through the center of the plate. **(*As safety precautions, hold the plate with a vice during drilling and wear eye protection.*)** Using a drill bit slightly larger than the holes, enlarge the holes at the opposite ends of the plates. The holes must be large enough to pass the carriage bolts through them.
4. 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.
5. Pass the carriage bolts through.
6. 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.
7. 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.
8. Screw a second nut over each bolt and spin it about halfway down the bolt. Place a washer over each nut and slip the mounting plate over the two bolts.
9. 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.
10. Set up two corner irons so that 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.
11. 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.*)
12. 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.
13. Attach the launch "pull cord" to the head end of each spike. Run the cord through the eyebolt.

14. 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.
15. Drill two holes through the wood base along one side. The holes should be large enough to accommodate large spikes (metal tent stakes). When the launch pad is set up on a grassy field, the stakes will hold the launcher in place as you yank the pull cord to launch the rocket.
16. The launcher is now complete.

III. Details of Student Implementation

1. Introduction

A rocket in its simplest form is a chamber enclosing a gas under pressure. A small opening at one end of the chamber allows the gas to escape, and in doing so provides a thrust that forces the rocket in the opposite direction. A good example of this is a balloon. The balloon's rubber walls compress air inside the balloon. The air pushes back so that the inward and outward pressing forces balance. When the nozzle is released, air escapes through it and the balloon is propelled in the opposite direction.

When we think of rockets we rarely think of balloons. *What do you think of when they hear the word rocket* (giant vehicles that carry satellites into orbit and spacecraft to the Moon and planets). Although a rocket and a balloon don't seem to be similar there is a strong similarity between the two. The only difference is the way the pressurized gas is produced. With space rockets, the gas is produced by burning propellants that can be solid or liquid. *How is the pressurized gas produced with balloons* (the pressurized gas is produced when we blow air into the balloon).

2. Forces Affecting Flight

- **Gravity**

  Gravity is the downward force applied to all objects on earth. More force is required to lift a heavy rocket than a light rocket. The heavier the rocket, the more thrust required to lift the rocket into space.
- **Drag**

  Drag is the amount of air resistance or friction on the rocket as it flies.
- **Thrust**

  Thrust is the force generated by a rocket engine that propels the rocket forward. Thrust must be greater than the pull of gravity for the rocket to fly upwards.

3. Newton's 3rd Law and Thrust

- Thrust is created by the power of the rocket. This is caused by Newton's Third Law: to every action is an equal and opposite reaction.
- *Demonstrate Newton's Third Law*. Blow up a balloon and let it go. Draw a balloon on the board and ask what direction the air is traveling in inside the balloon, (Every direction). Ask how we got the balloon to move through the air, (Let it go). The action is the air coming out the bottom of the balloon and the reaction is the balloon traveling in the opposite direction. When you let go of the balloon you are opening up the bottom. This causes the air traveling in that direction to leave the balloon. The air in the opposite direction is still pushing on the top of the balloon.
- *Demonstrate Newton's Third Law* using the play foam rockets. Show or ask where the action and reactions are.

4. Parts of a Rocket

A system is made up of parts, if one of the parts doesn't work the system will not work. A rocket is an example of a system. *Can you name any parts of a rocket?*

Body: The body of the rocket holds the fuel, payload, and the recovery method (parachute). Drag is minimized by reducing the frontal surface area of the rocket and by having a smooth exterior finish.

Fins: The fins stabilize flight, guide our rocket and help keep it flying straight.

- Rockets are more stable if the fins are near the thrust.
- Angling all your fins the same way may slow down your rocket a little, but will often make it go higher and straighter. This is because they make it spin like a football or rifle bullet.

Nose Cone: Is Pointed for aerodynamics (it helps cut through the air), it can hold people, instruments, re-entry parachutes, landing devices, and may have its own fuel supply**.** Most of the rocket's weight is in the nose cone.

- Lighter noses are easier to get started, but don't coast very long.
- Heavier noses are harder to start moving, but coast longer.
- Lopsided noses steer the rocket off a straight course.

Why do you think systems fail? If one of the parts doesn't work the system will not work. *Why do systems depend on a variety of resources to produce a desirable outcome?* The parts of a system need to do a job and if they are all working together they will produce a desired outcome.

5. Compressed Air Rockets

The energy to make a water bottle rocket fly comes from compressed air. A plastic bottle is filled with compressed air and water. There is a lot of pressure inside the bottle. When released, the action of the air and water rushing out through the neck of the bottle causes a reaction and the bottle flies upward.