Stomp Rockets

Objectives

Students will:

- Design, build, and launch their own rockets.
- Learn that force is needed to overcome gravity.

Suggested Grade Level

PreK-12th

Subject Areas

Science

Timeline

60-90 minutes

Standards

- K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
- K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
- 5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
- HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

21st Century Essential Skills

- Creativity/imagination
- Information literacy
- Carrying out investigations
- Obtaining/evaluating/communicating ideas

Background

Much of the background needed for the completion of this lesson can be found in the NASA Rockets educator guide. The guide can be downloaded from http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html. The lesson in the guide can be found on pages 63-71, called Pop Rockets.

This lesson will give students a very basic understanding of rocket construction and the parts needed for a rocket to fly. Students will be able to build their own rocket and launch them using a stomp system which is very easy and very safe for young learners.

The instructor must understand some basic principles of rocketry. Two things that you must know that may be too difficult for your students are the center of mass and the center of pressure. Understanding what and where these are on a rocket will make a successful flight of your rocket. The center of mass is the central part of the mass of the rocket. If you were to balance your rocket on a ruler, where it balances is the center of mass. There are equal parts, in mass, on either side of the ruler. The center of pressure is the central point of the surface area of the rocket. In other words, as the air rushes over a rocket in flight, the center of pressure is the point at which the surface area in contact with the air is equal in the front and back of the rocket. The Rockets educator guide will show you how to calculate that.

To make a rocket fly successfully, the center of mass must be in front of the center of pressure. In other words, the center of mass must be closer to the nose of the rocket than the center of pressure. If the center of mass moves behind the center of pressure, or closer to the fins, your rocket will become very unstable and tumble through the air. That doesn't make for a very aerodynamic rocket.

The closer you can make the center of mass and center of pressure, without having the center of mass move behind (or closer to the fins) the center of pressure, the farther your rocket will fly. However, your rocket will be very unstable. If you move the center of pressure far away from the center of mass, you will have a very stable rocket, but it won't go very far.

You can move the center of mass and the center of pressure by doing the following. If you put more weight in the nose of the rocket (adding pennies, paper clips, etc.) that will move the center of mass forward or toward the nose. Be careful, if you add too much mass to the nose your rocket will not fly far at all. You can also take mass away from the nose and that will move the center of mass closer to the fins.

You can change the center of pressure by changing the size of your rocket's fins. If you use bigger fins the center of pressure will move toward the back of the rocket, or toward the fins. By using bigger fins, this creates more surface area toward the back of the rocket. Therefore, the center of pressure moves back. If you use smaller fins, the center of pressure moves toward the front of the rocket because there is less surface area toward the back of the rocket.

The instructor also needs to know the basic parts of the rocket: nose, body, and fins. The nose or nose cone is the top of the rocket where they payload is-usually, this would be astronauts or satellites. This must be the heaviest part of the rocket. According to the way physics works, when an object flies through the atmosphere the heaviest part of that object will

be in front. If the heaviest part is in back, the back will then swing around to be first. Remember, the old game of Lawn Darts? The tips of those were very heavy. That is why they always stuck in the ground.

The body or rocket body is the long tube that makes up the majority of the rocket. This is where the fuel of the rocket is housed.

The fins are the last major part of the rocket. In the rockets that are used in classrooms or those that are used to fly through the atmosphere, the fins help steer and stabilize the rocket. In modern rockets, rocket nozzles gimbal or move from side to side to steer the rocket.

Vocabulary

Rocket, gravity, thrust, nose, nose cone, payload, body, rocket body, fins, center of mass, center of pressure, aerodynamic

Materials

- Rocket template
- Old bicycle tube (mountain bike tubes work the best)
- ½" PVC pipe
- Zip ties
- 2L soda bottles
- Tape
- Scissors
- Sand paper
- A penny for each student

Lesson

1. Construct the launcher prior to teaching this lesson. If you have older students, you could have them construct the launcher. First, cut a section of the ½" PVC pipe approximately 2 feet long.
2. Cut a section of the bicycle tube, approximately 3 feet long.
3. Zip tie the tube to one end of the PVC pipe.
4. Zip tie the other end of the tube over the lip on the mouth of the 2L bottle.
5. Introduce the lesson by asking students, "How do we get to space?" Answers will vary, however guide discussion to rockets, a cylindrical object that can be sent to great heights or distances by the use of force (combustion of fuel or air).
6. Ask, "What force on Earth keeps us on the ground?" Answer: Gravity. Explain how we need a force that will push us off the ground to lift us up. To get a heavy rocket full of fuel to leave Earth, it will need a lot of thrust, a force that pushes suddenly and violently.
7. Explain parts of a rocket.
    a. Nose or nose cone: The top of a rocket. It's where the payload (cargo, astronauts or satellites) is usually located. The heaviest part of the rocket must be at the top, or else the rocket becomes unstable.
    b. Body: The long cylindrical part of the rocket. It's where the fuel is housed.

   c. Fins: The bottom pieces on a rocket that steer and stabilize the rocket.
8. Ask students, "What would happen if the top was too heavy?" Answer: It will fall back down. Ask, "Or the bottom too heavy?" Answer: It'll fall back down. Ask, "Why is it important for a rocket to remain stable?" Answer: We don't want the rocket not to explode or crash. Explain to students that all rockets must have these two principles:
   a. Center of Mass: The central part of the mass of the rocket. If you were to balance your rocket on a ruler, where it balances is the center of mass. There are equal parts, in mass, on either side of the ruler.
   b. Center of Pressure: The central point of the surface area of the rocket. As the air rushes over a rocket in flight, the center of pressure is the point at which the surface area in contact with the air is equal in the front and back of the rocket. This is right behind the center of mass. (for older students, you can have them calculate this information).
9. Design your rockets. You can use the template or if you have older students, they can develop their own model. Ask students, "What does aerodynamic mean?" Answer: Moving through the air efficiently. Express the importance of making a stable rocket. Explain to students, the center of mass must be closer to the nose of the rocket than the center of pressure. If the center of mass moves behind the center of pressure, or closer to the fins, your rocket will become very unstable and tumble through the air. That doesn't make for a very aerodynamic rocket. Allow construction time.
   a. Cut out template and tape together.
   b. Chose fin shapes and tape to rocket body.
   c. Add penny to nose cone and tape closed.
   d. Find the center of mass and pressure of the rocket. Make adjustments as needed to make the rocket balanced.
10. Launch rockets once students are done constructing their rockets. Go to an open area for launch. The students will launch their rockets by placing their rocket over the end of the PVC pipe and stomping on the 2L soda bottle. Be careful where you aim; aim rocket away from all students. It is best to have the teacher or parent volunteer aim the launcher. Have each student stomp on the 2L soda bottle to launch their rocket. Re-inflate the bottle after each launch. Do this by blowing in the end of the PVC pipe.
11. Ask students, "What's going to power our rockets?" Answer: Air. Ask, "What does the air represent in our rocket going to space?" Answer: The fuel. Ask, "What will be our force that will thrust our rockets?" Answer: Us stomping on the bottle, pushing the air through the tube into our rocket, releasing into the atmosphere.
12. Remind them that if rockets are unstable, go back at modify it. Have students test for distance, aim and/or height. If you have older students, you could have students record data and graph the information.
13. Come back together as a class to analyze the information gathered from this experiment. Ask students, "How did you make sure your rocket was aerodynamic? How did the shape of the fins affect the flight? What modifications did you make to improve flight? Name some factors that affected the performance of your rocket?" Answers will vary.

Extensions

- Design a more stable platform. How does this affect your rocket?

- Research different types of rockets and compare the performance of them.
- Discuss Newton's Laws of Physics. How does these laws affect flight?

Resources
NASA Rockets Educator Guide
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html