Bottle Rockets

Vanderbilt Student Volunteers for Science

Fall 2008

I. Introduction: History of Rockets

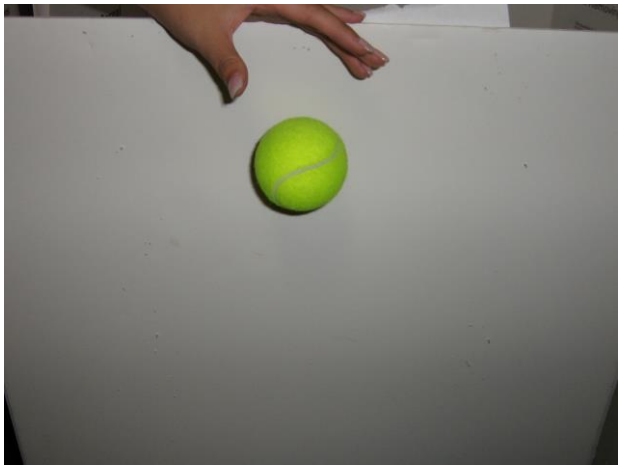
- Explain to the students that rockets are more than two thousand years old.
- Give the students a BRIEF history of rockets (found in the lesson).
- Introduce Newton's Laws (see lesson).
  - The fundamental laws of motion were developed by Sir Isaac Newton in the 1600's:

II. Demonstrating Newton's 1st Law

- An object in motion stays in motion unless acted upon by a force, and an object at rest stays at rest unless acted upon by a force.

- Show the students a tennis ball.
- Place the ball on the floor and tell the students that it will stay at rest (not move) unless a force acts upon it.
- Gently roll the ball along the floor and tell the students you have applied a force.
- Ask the students why the ball stopped if the law says it should stay in motion.
- Explain to them that gravity and frictional forces are acting on the ball and cause it to stop.

II. Demonstration of Newton's 1st Law Contd.



- Hold the ball in the palm of your hand and explain that it is at rest.
- Let the ball fall to the floor and ask them why it fell.
- Tell them that at rest, the two equal forces were acting in opposite directions on the ball: the lifting force of your hand, and the forge of gravity.

II. Demonstration of Newton's 2nd Law

The force applied by an object is equal to its mass times its acceleration.

Write the equation for force on the board:

Force = Mass x Acceleration

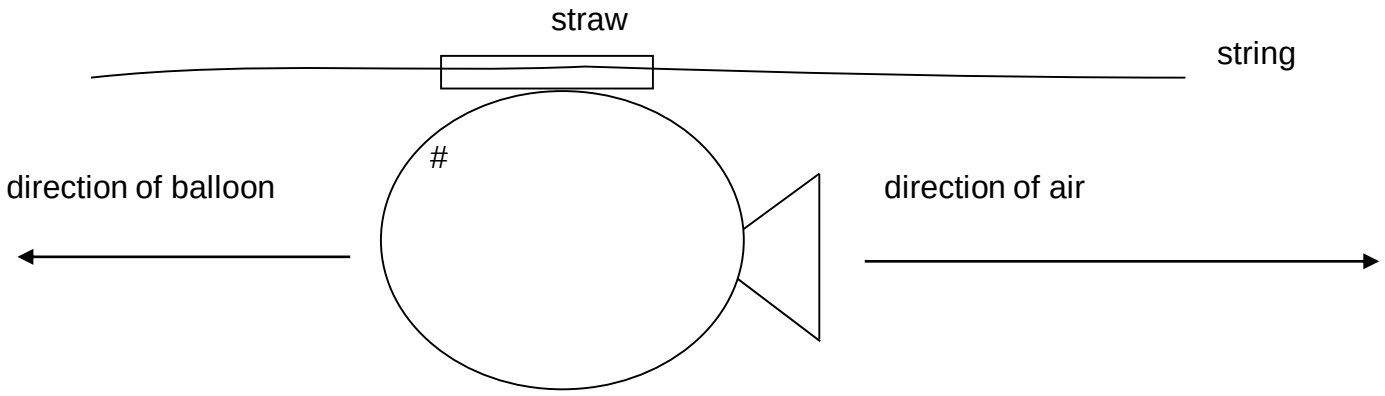
F = M x A, A = F/A

- Place the wagon on the floor and give it a push so it travels 4-6ft.
- Place a container of water on it and push it with the same amount of force. Tell the students to observe that it did not move as far. The extra mass reduced the wagon's acceleration.
- Push the wagon again with more force this time so it again moves 4-6ft.
- Using the equation, explain to the students why more force was necessary to move the wagon the same distance.

II. Demonstration of Newton's 3rd Law

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

- Feed the string though the straw and have two people hold the string taut
- Inflate the balloon and hold the end closed tightly then tape the straw to the outside.
- Ask the class what they think will happen when the balloon is let go of, and then let go.
- The air is being forced out of the balloon in one direction, forcing the balloon in the other direction.
- Ask the students what will make the balloon go further.
- Repeat the experiment with more air. The balloon should travel farther.
- The air moves in one direction and forces the balloon in the other direction. Rockets work the same way.



III. Bottle Rocket Workshop

- If students are doing this activity on a second day, give them the design handout. Students will design their own rockets and bring them back to be tested.
- Tell them to work with their parents to build a rocket following the instructions on the sheet. They must use a 2-L bottle that has contained a carbonated soda drink. Non-pressurized bottles may explode when pumped to 40psi. They are free to decorate it to their liking.
- Ask the students to decide on the amount of water and the pressure of air inside the bottle, and to make a prediction about the rocket's flight.
- On the next day, students will test the designs and compare the results to the their predictions.

IV. Alka-Seltzer Rockets

- This demonstration needs to be done in a grassy area, and the launches should occur on a flat wooden board.
- Give each pair of students an alka-rocket and demonstrate its use as follows:
- Remove the cap from the bottom and turn the rocket upside down
- Measure 15mL of water and inject into the lower section of the rocket
- Place a whole piece of alka-seltzer into the top portion of the rocket. **Do not let it fall into the water yet.**
- Cover the lid and make sure it is secure
- Be ready to time when the rocket will “take off”, and to estimate how high the rocket will fly.
- Flip the rocket over so the water mixes with the alka-seltzer and place on a flat surface.

IV. Alka-Seltzer Rockets

- Tell the students they will be launching their own rockets now, and that they will be changing variables to see what effect they have on the rockets.
- In order to see the changes, they can only change one variable at a time.
- The first variable they will change is water temperature.
  - They will place 15mL of ice water in the lower portion of the rocket as before and add a half piece of alka-seltzer. Flip the rocket over and tell the students to record how long it takes for the rocket to "lift off."
  - Now they will try the same experiment again only this time they will use hot water. The hot water can be obtained from the school. (if there is no hot water source available, fill a plastic beaker with water and add an activated hot pack to warm the water. This should only take a few minutes)
- The second variable they will change is the surface area of the tablet.
  - First add 15mL of room temperature water to the bottom of the rocket, then place a half tablet of alka-seltzer into the rocket, seal it, and flip it over onto the board. Record how long it takes for the rocket to lift off.
  - Now do the same thing, only this time, tell the students to use a full tablet, with 15mL of room temperature water. Record how long this rocket takes to lift off and compare the results.

Launching the Bottle Rocket

- Before beginning there are some mandatory safety precautions:
  -ONLY VSVS members may launch the rockets
  -Students must stand at least 30ft away from the launcher at all times.
  -Safety goggles must be worn AT ALL TIMES.
  -Do no launch rockets near cars, buildings, trees, or power lines.

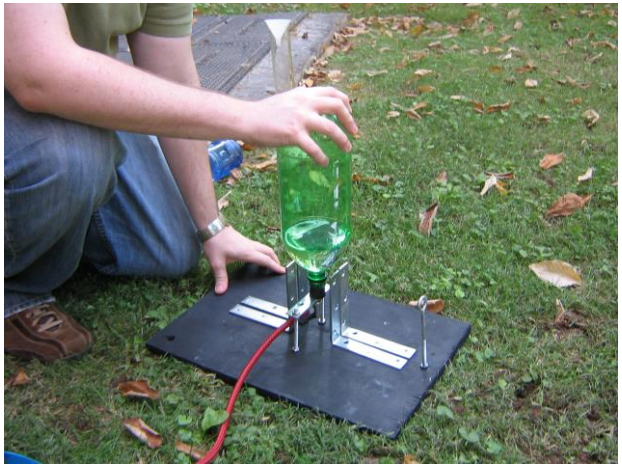
V. Bottle Rocket Testing

- This activity will be done on the second day.
- Tell the students they will be seeing how Newton's laws affect the motion of rocket.
- Also explain that they will be experimenting with different variables, such as air pressure and water level, to see what will happen to the rocket.
- Demonstrate a rocket launch for the students following the procedure below:

Launching the Bottle Rocket

- Find a level area to place the launcher.
- Measure the desired amount of water (1000mL) in the large graduated cylinder.
- Fill the bottle with this water using a funnel.

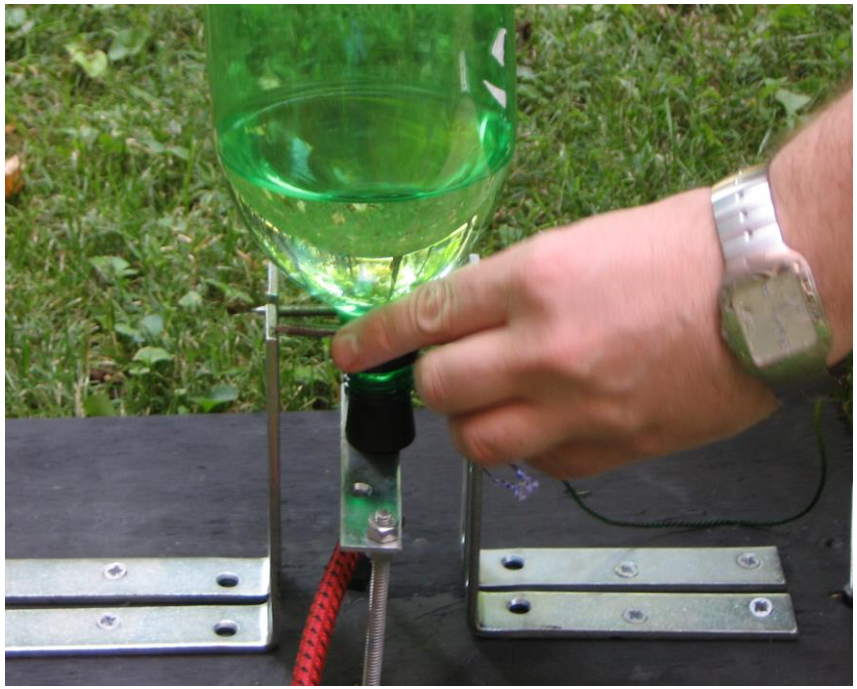
Launching the Bottle Rocket



- Tip the launcher on its side and place the bottle on the rubber stopper.
- Holding the bottle firmly, tip the launcher back upright and press the bottle tightly onto the rubber stopper.

Launching the Bottle Rocket

- Once the rocket is secure (no water is leaking out) insert the nails with the quick release cord attached through the holes in the L-brackets on both sides of the bottle.
- Secure the launcher and carefully run the quick release cord away (minimum of 10ft) from the launcher.



Launching the Bottle Rocket

- Make sure all observers and participants area safe distance from the launcher.
- Put on your safety goggles.
- Use the foot pump to bring the bottle to the desired pressure (25-45psi).

Launching the Bottle Rocket

- Count down with the class and quickly pull the release cord with the nails attached.
- Time how long the rocket spends in the air.
- NOTE: If the rocket does not launch, one VSVS member should remove the nails and carefully rock the bottle back and forth to relieve the pressure inside the bottle.

Possible Experiments

- When the students have seen the launch and Newton's laws have been reviewed, tell them that they will experiment with different pressures, water levels, and design.
- Tell them the goal is to change only one variable at a time and see what its effect on the rocket is.
- At this time, show them the pre-made rocket with fins and a nose cone.

Experiment 1: Pressure

- In this test, the air pressure inside the bottle is the variable.
- Experiment with 3 different pressures inside the bottle using 1000mL of water every time.
- The first test should be with 1000mL of water and 25psi of air. The second should be 35psi and the third at 45psi.
- Prepare the rocket as before, launch and record the time of flight for each variable. Have the students mark the information on their observation sheets.

Experiment 2: Water Level

- In this experiment the water level inside the bottle is the variable.
- The bottle should be pumped to 40psi for this and every other trial.
- Launch an empty bottle rocket and record the flight time.
- Repeat this experiment with 500mL, 1000mL, and 1500mL of water in the bottle. Remember to pump to 40psi each time.
- Have the students record all their observations in the data tables.

Experiment 3: Design

- The variable in this experiment is the use of fins and nose cone.
- Ask the students what effect on the rocket fins and a nose cone will have. Fins add stability to the rocket and should increase flight time.
- Add 1000mL of water to the regular 2-Liter bottle, prepare the launcher as before, and pump the bottle to 40psi.
  - Launch the rocket and have the students record their observations.
- Try the same experiment again with the pre-made rocket with fins and nose cone, launching with 1000mL of water at 40psi.
- Have the students record their observations again and make comparisons.

Return to the Rocket Workshop

- If the students have made their own rockets, tell them they will now test them along with the rest of the class.
- The students will decide how much water to put into the bottle and how much air to put in (more than 25psi, less than 45psi)
- Ask the students to predict what will happen to the rocket and how long it will fly.
- Test each student’s design and compare them to their predictions.

VI. Clean-up

- Empty all the water bottles before returning them to the kit.
- Be sure to collect all the materials associated with the kit and return to VSVS.
- Be absolutely sure both launchers are returned to the VSVS lab.