



Lesson Plan
Revised 6/04

Lesson #1
Rockets
Grade Level: 5-6

Teachers, this is a basic lesson plan that you may modify at your discretion.

Modifications to video: There may have been changes to the lesson plan since the video was made. This lesson plan reflects the latest updates made as a result of suggestions from teachers who have presented the lesson during the daytime program. Please continue to send us your ideas!

Overall educational objective: Students will understand the basics of rocketry and be able to explain the relationships between mass, acceleration, and thrust.

Associated Standard and CORE objectives:

- 3050-03 Students will understand the characteristics and management of water.
3050-0301 Students will understand the properties of water.

Materials list:

- | | |
|--|--------------------------|
| 1 - Nerf® spiraled football | 3 - rocket launchers |
| 1 - football dart with fins | 1 - valve/gauge manifold |
| nose cone templates | 1 - air compressor |
| fin templates | 1 - extension cord |
| masking tape | |
| heavy construction paper for nose cones & fins | |

Teacher provides:

- 1 - 2-liter pop bottle (with ring under threads) for every two students
- pens and markers to decorate rockets
- scissors

Lesson activities:

1. Select two to four students to toss the football back and forth. Try to select one person who doesn't know how to throw a "spiral." Ask the students to describe the flight path of the football. Have the students form a hypothesis about the way to throw the football the greatest distance with the straightest path (put a spin on the football - "spiral"). Select two to four different students to toss the football dart. Have the students compare the flight paths of the football and football dart. Which one flew the straightest? With the least amount of effort? What is the purpose of the fins? (to stabilize the flight and direct the dart in a straight path).

2. Separate students into teams of two. Have each team assemble one rocket as shown in the video. Use the templates to make one nose cone and 1-5 rocket fins. The students may alter the fins into any shape they desire. Don't rush the students as they are decorating and assembling the rockets. Predict the straightness of the path of a rocket without fins. Predict the straightness of the path of a rocket with fins. (This exercise should not exceed 20 minutes.) Compare the rocket's flight path to the football's, as performed previously.
3. Explain that the rockets will be propelled by pressurized air. This means that we pump lots of air into the rocket. What happens to the molecules of air as we do this? (The molecules get closer and closer together.) What happens when we let the air escape? (The air molecules want to get back to their original spacing (pressure) as quickly as possible.) The air escapes from the rocket very quickly. The greater the pressure inside the bottle, the higher the speed at which the air escapes from the rocket. The greater the speed of escape, the greater the distance the rocket will fly. Therefore, the higher the pressure, the higher and farther the rocket will go.
4. When water is added to the rocket, the effect of mass is demonstrated. Before the air can leave the rocket, the water must be forced out first. Since water has much greater mass than air, it contributes to a much greater thrust than air alone can provide. Thus, the rockets travel much farther when they have water in them than they do if there is no water. By varying the amount of water and air in the rockets and measuring how far they travel, the students can determine the optimal amount of water for the greatest thrust. Have the students hypothesize the effect of adding water weight to the bottle. (Students will see that the thrust the rocket experiences depends on the amount of mass (water) being expelled and the speed of that expulsion. Thrust is greatest when mass and acceleration are greatest.) Have each team decide how much water they will add to their rocket.
5. Discuss the safety rules of the launch which are included on the instruction sheet. Fill the bottles with water. Take the students to the launch area and prepare for launch.
6. Call attention to the career fields that are related to this module. Discuss how students might prepare for occupations that interest them.
7. Allow time to clean up. At the end of the day, put templates in box with paper that is left. Junior Engineering staff will help load launch equipment if needed.

NOTE: This is a **daytime** module. The launch is a great finale at the end of the day with the principal launching the rockets out in the parking lot area.

REDUCE! REUSE! RECYCLE!: Remove the nose cone and fins from the rocket bottles and reuse during each session.

ROCKETS INSTRUCTION SHEET

Safety rules for the launch:

1. The teacher will inspect all rockets prior to launching.
2. Students not involved in the launch are to stand at least 25 feet from the launch area.
3. NO ONE will approach a rocket while it is pressurized.
4. Only one rocket is launched at a time.
5. DO NOT attempt to catch a rocket as it falls.
6. DO NOT step on any cords or hoses, as this may damage them.
7. The students do not need to pull hard on the cord for the rockets to launch. They are not starting a lawn mower. A small tug is all that is needed.

Launching instructions:

1. Prepare the launch area. Connect launch pads, gauges, compressor, electrical cords, release cords, plastic tubing, and stoppers.
2. Go over safety rules with the students. ALWAYS follow the safety rules.
3. Prepare rockets for launch.
 - a. Fill each rocket with the desired amount of water. You might want to have extra bottles or pitchers of water on hand.
 - b. Place the stopper plug in the bottle opening.
 - c. Turn the rocket upside down and insert neck of the bottle into the launch door.
 - d. Place flaps of the launch assembly on top of the ring on neck of the bottle.
 - e. Put the lever in the vertical (up-and-down) position.
 - f. Keep the launch cord slack.
 - g. Clear the launch site. Have rocket owners move to the end of the launch cord.
4. Prepare for lift-off.
 - a. Turn on air compressor and move valve lever at gauge to ON position.
 - b. Pressurize first rocket to 100 pounds. The safety control valve will not allow more than 100 pounds pressure in each rocket.
 - c. Determine if rocket and observers are ready.

NOTE: IF THE ROCKET NEEDS ADJUSTING, DEPRESSURIZE IT BEFORE APPROACHING THE LAUNCH PAD!!!!!! Have a Junior Engineering staff member help.

 - d. Begin countdown.
 - e. Pull launch cord on BLAST-OFF!

5. Depressurization instructions.
 - a. Release the air pressure by turning the lever by the gauge to the OFF position.
 - b. Remove the plastic tubing by the rocket and “bleed off” the pressure.
 - c. Adjust the rocket as necessary and begin the launch steps over.

Teacher tips: With younger students, demonstrating the idea of thrust can be done with a balloon. Blow up a balloon and then let it go. The force of the high-pressure air coming out of the neck makes the balloon rush aimlessly in all directions. To give the balloon a little more direction, blow up the balloon and slip a button into the balloon’s neck so that the neck closes tightly about the button. Let the balloon go. It will go off in a fairly direct line. The stretched rubber of the balloon puts pressure on the air inside, but the button openings control the thrust of the rocket.

WHY? When the inflated balloon is closed, the air inside is pushed equally in all directions. As the air leaves the balloon, it pushes the balloon forward. The balloon, like a rocket, moves because of Newton’s Third Law of Motion, which states that for every action there is an equal and opposite reaction. In the case of the balloon, the rubber pushes on the air inside (action), forcing it out the opening. The air pushes on the balloon (reaction). The reaction force of the air pushes the balloon in the opposite direction of the action force. Like the balloon, spacecraft are able to move forward due to action-reaction forces. The engines of a rocket produce gases that are pushed out the exhaust (action), and the gas applies a force on the rocket (reaction). The reaction force pushes against the rocket, causing it to lift up.

Safety precautions: Consult the Jr. Engineering Staff for launch site advice and launch operations. **DO NOT** scratch or puncture the bottle in any way. **DO NOT** approach the bottle rocket when it is under pressure. **DO NOT** allow the students to view the launch from any less than 25 feet away from the launch area. **DO NOT** attempt to catch the rocket as it falls. **DO NOT** put any heavy objects inside the nose cone. Prepare to get WET!

References:

Popular Mechanics v174, Feb. ’97, p.67-9 “Rocketeers”

In this article amateur rocket scientists gathered in Nevada to attempt to launch the world’s highest flying, kit-built rocket.

The Futurist v30, July/August ’96, p.50 “Amateurs in Space”

A group in California tries to launch a 7.5 foot rocket that will leave the earth’s atmosphere and return to earth, ready for another launch.

Model Rockets by Gregory Vogt 629.47 v8 68

This book explains what rockets are, gives a brief history, discusses practical designs for conducting experiments to understand the principles of rockets, and tells how to build your own.

Please make your students aware that this lesson relates to the following:

Career Fields: SCIENCE, TECHNICAL

Occupations: Aeronautical Engineer: Design, construct, and test aircraft, missiles, and spacecraft.



They might also conduct basic and applied research to evaluate adaptability of materials and equipment to aircraft design and manufacture. They also may assist in planning the technical phases of aircraft systems, flight operations, and logistics.

Education: Bachelor's Degree

Astronaut: Working with the National Aeronautics & Space Administration (NASA), astronauts man the various space projects. NASA primarily seeks candidates with a military background that have jet aircraft flight experience and engineering training.

Several Requirements:

1. Have at least a bachelor's degree from an accredited institution in engineering, biological science, physical science, or mathematics.
2. Have three years of related professional experience following the degree.
3. An advanced degree is recommended, but could be substituted with additional years of work.
4. Must be between 5'4" and 6'4".
5. Have at least 1000 hours pilot-in-command time in a jet aircraft.
6. Be able to pass a NASA Class I Space physical or an equivalent exam.

Mathematician: Create new mathematical theories and techniques involving the latest technology and solve economic, scientific, engineering, and business problems using mathematical knowledge and computational tools.

Education: Bachelor's Degree

Physicist: Explore and identify basic principles governing the structure and behavior of matter, the generation and transfer of energy, and the interaction of matter and energy. Some use these principles in theoretical areas, such as the nature of time and the origin of the universe; others apply their physics knowledge to practical areas such as the development of advanced materials, electronic and optical devices, and medical equipment. They design and perform experiments with lasers, cyclotrons, telescopes, mass spectrometers, and other equipment. They attempt to discover laws that describe the forces of nature, such as gravity, electromagnetism, and nuclear interactions. They also find ways to apply physical laws and theories to problems in nuclear energy, electronics, optics, materials, communications, aerospace technology, navigation equipment, and medical instrumentation.

Education: Doctor of Philosophy

How it relates: Mathematicians develop theories which physicists and astronomers may use to calculate speeds, acceleration, and distances that relate to objects in space.

BACKGROUND INFORMATION: ROCKETS

Terminology:

1. *Mass*: The amount of matter contained within an object.
2. *Thrust*: Force which makes the rocket move upwards.
3. *Drag*: Force which opposes thrust.

Principles of Motion:

1. Objects at rest stay at rest, objects in motion stay in motion unless a force is applied to that object.
2. Force is equal to mass times acceleration.
3. For every action there is an equal and opposite reaction.

How these principles apply to the water rocket:

1. The water rocket will not move until a force is exerted on the rocket. The force used to thrust the rocket upward is pressurized air. Air is placed into the rocket. The more air you put into the rocket the closer the air molecules are squeezed together. Therefore, when the flaps of the launch pad are released the air forces its way out of the bottle and the acceleration of the air causes thrust.
2. Force equals mass times acceleration. Water contains 773 times more mass than air. The acceleration of the water and air downward due to pressurization is only slightly less than that of air alone. Therefore, by adding water the force increases dramatically.

Mathematical illustration – (not actual calculation)

Air	Force = $1\text{g} \times 10\text{ m/s/s}$	Force = 10 newtons
Water and air	Force = $774\text{g} \times 8\text{ m/s/s}$	Force = 6,192 newtons

This becomes confusing for students because the rocket is not a simple system containing one measurable force. The student must consider the water they add in terms of two forces:

- a. The force the water exerts downward creating thrust.
- b. The additional weight water adds to the rocket. If you increase the mass of the rocket, a greater force is required for thrust. This weight contributes a large portion to the amount of drag.

Therefore, an ideal amount of water added to the rocket exists. This can be illustrated in launching two bottles, one $\frac{3}{4}$ full of water and one that is $\frac{1}{4}$ full of water. With equal amounts of air pressure, the rocket $\frac{1}{4}$ full should go higher because it provides more total force. (Total force = thrust – drag).

The amount of water is only one component to drag. The fins and the cone placement will also determine the amount of drag. Properly attached fins will prevent the rocket from wobbling. A properly centered nose cone will cause the rocket to fly straight. Cones that are off-centered will cause the rocket to veer reducing maximum height.

3. Opposite forces cause the thrust of the rocket. The force of the air and water is downward against the launch pad. Therefore the launch pad exerts an equal force upward onto the bottle rocket. This is easily demonstrated by releasing a filled balloon. The elastic force creates high air pressure inside the balloon. When the valve to the balloon is opened the air moves to lower pressure outside. This exerts a force against the outside air. In turn the outside air exerts an equal force which moves the balloon in an opposite direction.

Review Questions:

1. How did we launch the rockets?
2. Which rocket goes higher? A rocket with only air, or a rocket with air and about 1/4 filled with water? Why?
3. What's the purpose of the cone and wings on the rocket?
4. What atmospheric forces affect the rockets in-flight behavior?
(gravity, air friction, wind, atmospheric pressure)

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