**Ride the Wind: Compressed Air Rocketry**

**LESSON DESCRIPTION**
Students construct rockets from simple materials to test engineering designs that affect the dynamics of flight.

**OBJECTIVES**
Students will
- Construct and launch simple card stock rockets
- Apply engineering design skills to the design of high-power paper rockets, evaluate their flights, and modify their design to improve flight performance.

**NATIONAL STANDARDS**

**National Science Education Standards (NSTA)**
- Unifying Concepts and Processes
  - Evidence, models, and explanation
  - Change, constancy, and measurement
- Science as Inquiry
  - Abilities necessary to do scientific inquiry
- Physical Science
  - Position and motion of objects
  - Motions and forces
- Science and Technology
  - Abilities of technological design

**Principles and Standards for School Mathematics (NCTM)**
- Math as Problem Solving
- Geometry
- Measurement
- Number and Operations
- Data Analysis and Probability
- Reasoning and Proof
- Communication
- Connections
- Representations

**National Technology Standards (ITEA)**
- Creativity and Innovation
- Research and Information Fluency
- Critical Thinking, Problem Solving, and Decision Making
MANAGEMENT

Pop! Rockets is a simplified rocketry activity. Rockets are made by cutting out three rocket-shaped pieces of paper or card stock and joining them together.

The activity requires a PVC launcher be constructed in advance. This is something that should be done by the instructor. With the proper one-half-inch PVC pipe cutter, the process takes very little time. The same PVC pipe cutter can be used to cut the 30 centimeter (12 inch) lengths of pipe the students will use as a frames on which to construct the high-powered rocket designs.

High-Powered Paper Rockets:

The paper rocket designs can be launched by the same Pop! Rocket launcher described above or by a more impressive compressed air launcher. Following their rocket’s flight, students rethink their rocket designs, modify them, and fly them again to determine how their changes have affected the rocket’s performance. Students conclude the activity by writing a post-flight mission report.

The construction of these rockets will take slightly longer than the Pop! Rockets as students may be encouraged to offer more of their personal inquiry into the designs of fins and nose cone designs.

The construction of this launcher will take more skill to construct and some knowledge of cutting, gluing, and assembling PVC pipe materials. The results are significantly more impressive when the valve is quickly opened when releasing the pressure for a launch.

CONTENT RESEARCH

High-power paper rockets are a slightly more sophisticated version of the paper rockets constructed in the Pop! Rockets activity presented in the introduction.

The main difference is in how the rockets are launched. These rockets may be launched on the 2-liter bottle launcher or a much more powerful blast of air provided by an air-powered cannon style launcher. The rocket surrounds the one-half-inch PVC launch rod (similar to a cannon barrel). High-pressure air fills the rocket. If the rocket were firmly attached to the rod, the nose cone and the forward end of the rocket would blow apart. Instead, the rocket begins sliding along the rod as it continues to fill with air. Immediately after clearing the end of the rod, air inside the rocket expands backward out the lower end. The action-reaction effect (Newton’s third law) adds thrust to the already moving rocket.

If the rocket is well designed and constructed, flights of more than 100 meters are possible. The primary determining factor for performance is drag or friction with the air. Rockets with very big floppy fins have a great amount of drag, and flights are usually short. Very squat nose cones also increase drag. The idea is to design a rocket that is streamlined so that it slices cleanly through the air. Through repeated flights, students discover that small and very straight fins are preferred along with long nose cones.

LESSON ACTIVITIES

Pop! Rocket: The basic pattern is a long rectangle with a triangle on one end. When the three rocket sides are taped together, the triangles are bent inward and taped to form a three-sided pyramid that serves as the rocket’s nose cone. At the opposite end are geometric shapes such as...
triangles or parallelograms that extend from the sides of the rectangles to form the fins. The fins are glued or taped together face-to-face to make them stiff. The entire procedures are located at the url below.

**High-Powered Paper Rockets:** Where the Pop! Rocket activity provides a template and predesigned rocket
High-Powered Paper Rockets permits the students more designer freedom with which to experiment and move through the engineering design process. The multiple one-half-inch PVC pipe sections are used to form the body tube for the rocket. Students may choose to make the rocket body longer or shorter depending upon the direction they choose to roll up the copy paper on the tube. If a single sheet is used, the mass of the paper will be the same for either design. Pictorial construction directions may be found on page 94 of the NASA Educator Rocket Guide.

While not included in the original directions, it is advised to have the students slide the paper tube back down the PVC pipe approximately one-half inch and use the thumb to fold inward the edges of the paper tube, sealing the top of the tube. Apply cellophane tape to completely seal the end of the tube. With an open hand over the opposite end, blowing into the remaining open end of the tube will serve as a static test to determine if the tube is completely sealed.

The nose cone will be placed over this sealed end. The directions for the nose cone included in the activity online are very clear; however, there are other design considerations. For younger students, using prefabricated paper cones used for drinking fountains aids younger students in cutting the cone to size.

For more advanced projects comparing surface area of specially designed nose cones, the students may use centimeter graph paper and simply count the number of square centimeters visible once constructed. This may be done more scientifically with the formula for the area of a cone (3.14 by radius by slant height). With the exceptional designs involving nose cone variables, the students may need to determine the mass of the parts of the rocket to shorten the body tube for additional mass added to the more extended nose cone designs.

The rigid fins used to guide the rocket during flight offer a great deal of creative design opportunities to the student engineers. Applying the aerodynamic observations made during earlier activities, the students should identify that larger bulkier fins create increased drag and often catch the wind more easily during flight. While the high-powered paper rockets are very forgiving in their design, the placement of the fins along the body tube directly affects the center of balance and distribution of pressure on the rocket as it flies.

**RELATED RESOURCES**

**Pop! Rockets:** [http://www.nasa.gov/pdf/295791main_Rockets_Pop_Rockets.pdf](http://www.nasa.gov/pdf/295791main_Rockets_Pop_Rockets.pdf)


See launcher design Web addresses in the materials listing.

**Glenn research Center Practical Rocketry Resource:**

**Coach-Class Tickets for Space:** [Article](http://www.nasa.gov/pdf/295789main_Rockets_High_Power_Paper_Rocket.pdf)

**DISCUSSION QUESTIONS**

1. The activities in this lesson offer different rocket designs. How are the rocket parts similar and different from one design to another? *Compare the body tube, fins, and nose cone.*

2. How can air rockets be modified to improve their flight performance? *Answers will vary. Better alignment of the nose cone and fins, smaller more rigid fins, longer or shorter nose cones, longer or shorter body tube, different masses, etc.*

**ASSESSMENT ACTIVITIES**

- Review student mission reports and their conclusions.
- Implement the engineering design process. Design, test, evaluate, redesign, retest, and reevaluate.
- Ask students to write a paper explaining the principles of rocket flight as they apply to their paper rockets.
ENRICHMENT

• Lead students to the Teaching From Space Rocketry Overview Web site: http://www.nasa.gov/audience/foreducators/rocketry/home/index.html

Students may choose to explore Rocket Science 101 and build a simulated rocket online or read a variety of articles that discuss the major rockets that NASA has used during the past 50 years.

• Instruct students to draw one to three imaginative air rocket designs and speculate on how they would perform in flight. Ask them to build one of their designs and test it.

• Reconstruct historic NASA rockets from images online.

• Investigate fin placement on air rockets. Ask students to construct a new rocket by placing the fins in different locations such as near the nose cone and test the rockets and discuss their performance.

• Quantify the area of the nose cones tested and apply tests from other engineering activities to measure the drag of each design. Predict flight differences and conduct controlled flight tests.