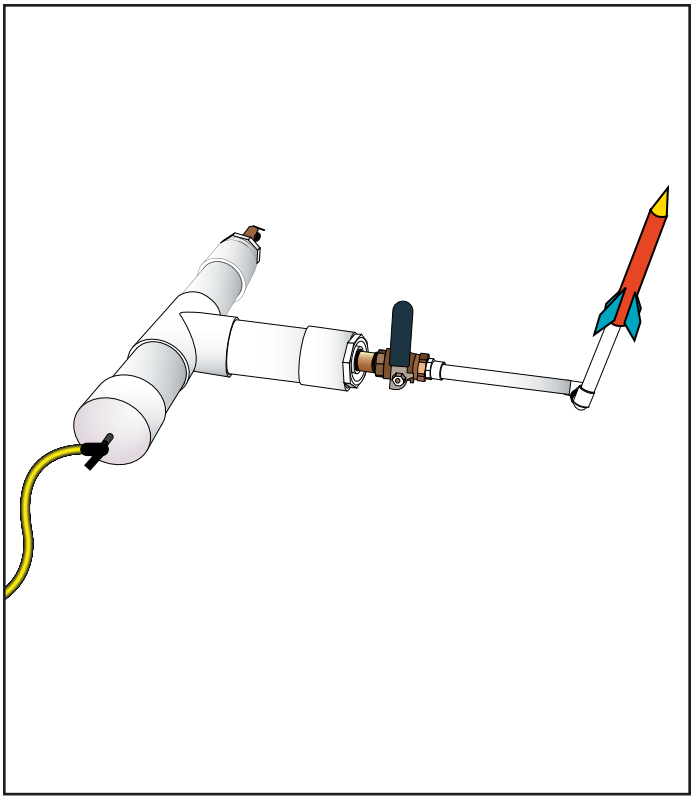


Rocket Activity

High-Power Paper Rocket Launcher

Objective

Construct a launcher for use with the High-Power Paper Rocket activity.

Description

Using air pressure, large paper rockets can be launched to altitudes of between 50 and 100 meters. The launcher is a chamber in which air is pressurized with a bicycle pump or small electric compressor. Paper rockets are slipped over a launch rod tube. A lever-valve releases the air that propels the rocket. The launch rod can be tilted to various angles to launch vertically or horizontally. The launcher is easy to construct and requires few skills. The parts are available from a hardware or plumbing supply store and are inexpensive.

National Science Content Standards

Physical Science
- Position and motion of objects
- Motions and forces

Science and Technology
- Abilities of technological design

National Mathematics Content Standards

- Measurement

National Mathematics Process Standards

- Connections

Materials

Refer to the shopping list (see page 90)
Saw
Drill
Bicycle pump or small electric compressor

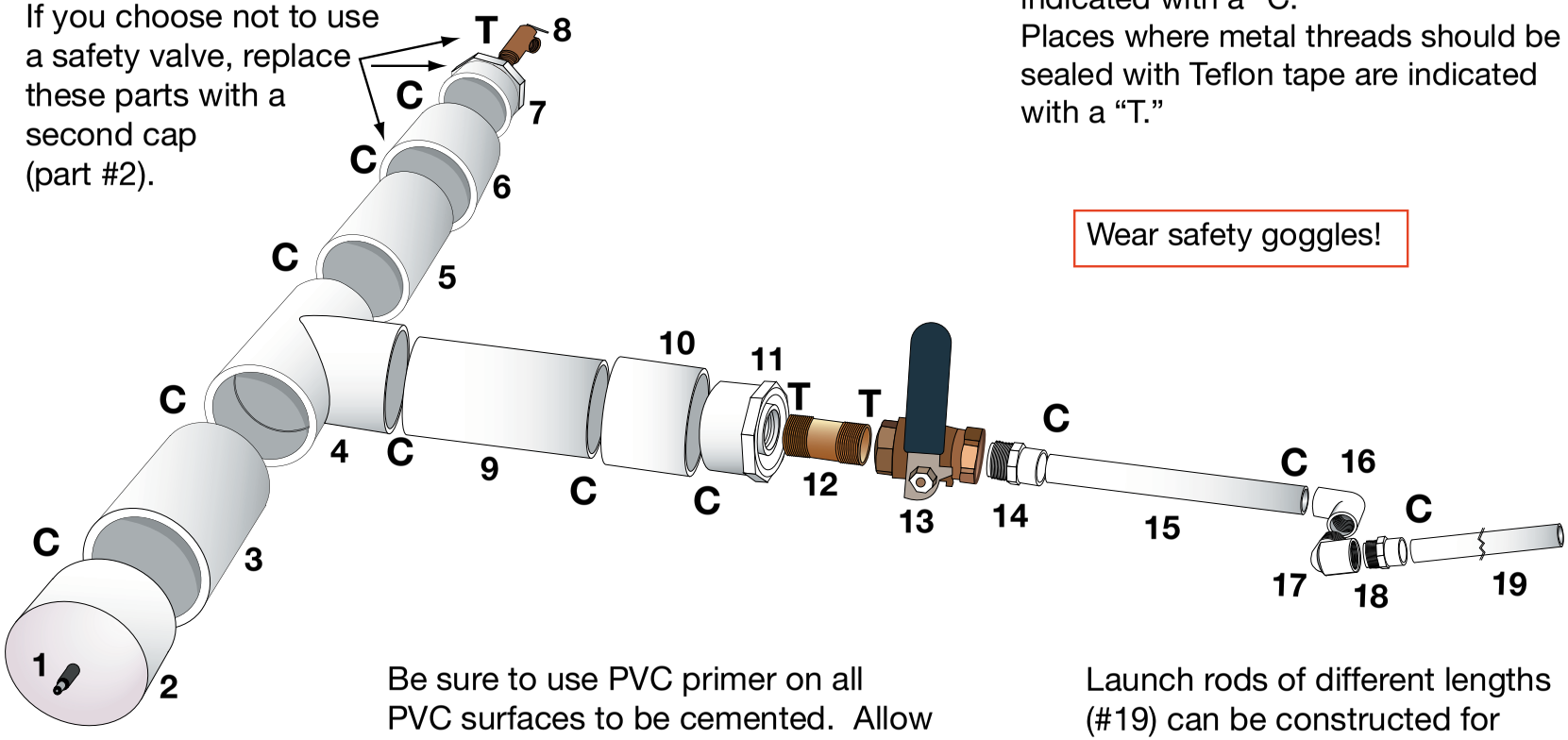
Management

One launcher is sufficient for an entire class, and the launcher can be used year after year. The launcher is easy to construct and will take about 30-60 minutes to complete. Cementing the pieces is a quick operation, but the cement should be allowed to set overnight. When cementing, be sure to have adequate ventilation. A window fan blowing over the work area is advisable. Use eye protection when cutting pipe and cementing pieces.

High-Power Air Rocket Launcher Assembly Diagram

Numbers in the diagram are keyed to the parts on the shopping list.
Two parts #6 and 7 are required.
Places where parts must be cemented are indicated with a “C.”
Places where metal threads should be sealed with Teflon tape are indicated with a “T.”

If you choose not to use a safety valve, replace these parts with a second cap (part #2).



Wear safety goggles!

Be sure to use PVC primer on all PVC surfaces to be cemented. Allow to dry before applying PVC cement.

Use adequate ventilation when cementing!

Launch rods of different lengths (#19) can be constructed for launching short or long rockets. Cement the different rods into extra #18 parts and screw them into part #17 when needed.

If you do not have the tools to construct the launcher, a school volunteer should have them and may be willing to do the entire construction job for you.

The instructions include diagrams to make assembly of the parts easy. The assembly diagram below has numbers for each of the parts that are keyed to numbers on the shopping list. Take the shopping list to the hardware or plumbing supply store and the staff can help you select the parts. The 2-inch diameter tube may be available in a 5-foot length. You will need two or three of the 1/2-inch tubes. The tire valve can be obtained at an auto parts store. Select a valve with a long rubber-coated stem.

Assembly Instructions

1. Drill a hole in the center of one of the 2-inch caps (part #2). The hole should be just smaller than the diameter of the tire valve stem.
2. Remove the stem cap and jam the stem into the hole from the inside. Push it in as far as it goes. It is important to get a tight seal.
3. Cut the lengths of 2" pipe. Cut two pieces 8" long (parts #3, 5) and 1 piece 15" long (part #7). Clean the pipes and remove any burrs from the cutting process.
4. Cement parts #3 and 5 to the tee (part #4) as shown in the diagram. When cementing, the parts must first be primed with clear primer. This prepares the surfaces to be joined for bonding. Coat the surfaces that will be cemented. There is a brush inside the primer can lid. Let the primer dry before cementing. **Remember** to have adequate ventilation and wear eye protection!
5. Coat the primed surfaces with cement (ends of tubes and inside of the tee). There is a brush inside the cement can lid. **Quickly** shove the tubes into the tee as far as they go. Use a twisting motion for a better bond.
6. Repeat the cementing process with the 2" cap with the tire valve installed (part #2).
7. Cement the first 2" connector to the open end of piece #5. Cement the 2" to 3/4" flush bushing to the connector.
8. Install the safety valve into the flush bushing and seal it with Teflon tape. Do not use pipe joint compound. Be careful to align the threads so as not to strip the PVC threads.
9. Cement part #9 into the remaining opening of the tee.
8. Cement the remaining coupling (part #10) on to the end of part #9.
9. Cement the remaining 2" to 3/4" flush bushing into the open end of the coupling (part#10).
10. Thread the nipple into the threaded opening of part #10. Use Teflon tape to seal the threads to prevent air leaks.
11. Wrap tape on the other end of the nipple and attach the valve (part #13). The valve should be positioned so that when the lever is pulled down, it pulls towards the back (towards the tee).
12. Lightly screw part #14 into the other end of the valve. This part should not be sealed with tape. It is the beginning of the launch rod and can be removed for storage purposes.
13. Cement part #15 into the non-threaded end of part#14.
14. Cement part #16 on to the other end of the tube (part #15).
15. Join parts #16 and #17 by threading them together. Do not join them tightly.
16. Cement the ends of the three launch rods (part #19) into the three 1/2" to 1/2" adapters (part #18). Pick one of the launch rods and screw it into part #17.

After allowing time for the cement to set, the launcher is ready.

Notes

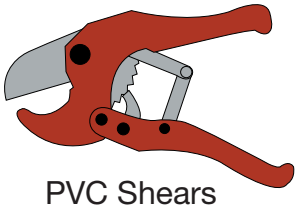
- The launcher can be used for many years. Store it in a cool place. Be careful not to drop it. The plastic will crack if treated roughly. If you notice any cracks, discard the launcher. The metal parts and the launch rod can be saved and used for a new launcher. **DO NOT** try to remove any pieces that have been cemented. If pieces are cemented improperly, discard them. The process of

removing cemented pieces will damage the pieces they were cemented to.

- When shopping, check the operation of the valve lever (part #10). Pick one that moves easily. A sluggish valve lever can be loosened by adding a few drops of lubricating oil to the shiny ball inside and working the valve several times.
- Part 16 and 17 permit tilting of the launch rod. Do not thread them together too tightly. A small amount of bar soap rubbed on the threads can help them move smoothly.
- Hardware stores carry shears for cutting up to 1”-diameter PVC pipe. They are optional but really nice to have available.
- Use some sandpaper or a file to bevel the open end of the launch rod to make it easier to slip paper rockets on to it.
- When using the launcher, have students practice pulling the lever. A slow pull will allow the air to slowly hiss out and not propel the rocket very far. A fast pull provides a whoosh and a great launch.
- Select a launch rod that best matches the size of the student rockets. Rockets made from a single piece of paper can be launched with a small rod. Use the longer rods for bigger rockets.
- If the launch rod is sticky or rough, smooth it out to reduce friction. A coat of wax rubbed on from an old candle makes a slick rod.

Using the High-Power Launcher

1. Lay the launcher on the ground in a wide open space.
2. Attach the bicycle pump or small electric compressor.
3. Set up a clear area around the launcher. Have students not launching rockets stand back.
4. Have the first student put on safety goggles and slide his or her rocket over the launch rod. The rod can be tilted to any desired angle, but it should not be tilted to below 30 degrees. To aim the launcher in a different direction, pick up the launcher and move it.
5. Have the student work the pump to pressurize the launcher to 30 psi. This is sufficient for dramatic launches. If you have not included a safety valve, keep the pressure to under 50 psi to provide a wide safety factor.
6. When ready, have the student brace the launcher by pushing down on the tube (part #9) with one hand. The student should do a short countdown and pull the launch lever back quickly with the other hand. Launch!
7. Close the valve for the next student.



PVC Shears

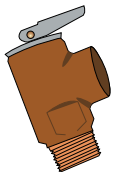
Tapered Launch Rod

Shopping List

1 - Tire Valve (rubber stem)
TR425 or similar
Auto parts store

1

Pressure Operated Relief Valve (safety valve) (Wilkins) P1000A-50
Hardware store or plumbing supply
(See note below.)



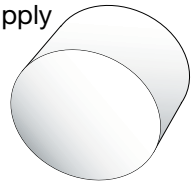
8

1 - 1/2" 90° Elbow (PVC)
Slip and Thread
Hardware store or plumbing supply

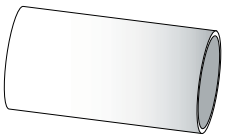
16

2 - 2" Caps (PVC)
Slip
Hardware store or plumbing supply
(See note about pressure operated relief valve below)

2, 6



1 - 2" Pipe (PVC)
15" long
Hardware store or plumbing supply

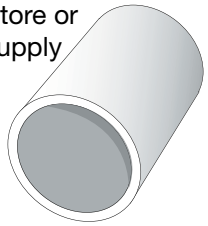


9

1 - 1/2" inch 90° Elbow (PVC)
Thread and Thread
Hardware store or plumbing supply

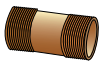
17

2 - 2" Pipe (PVC)
8 inches long
Hardware store or plumbing supply



3, 5

1 - 3/4" Brass Nipple
MIP X 2"
Hardware store or plumbing supply

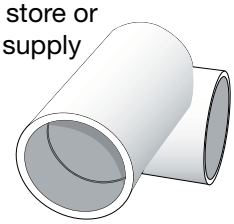


12

2 or 3 - 1/2" to 1/2" Adapter (PVC)
Slip and Thread
Hardware store or plumbing supply

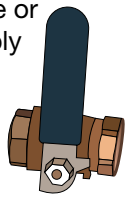
18

1 - 2" Tee (PVC)
Slip
Hardware store or plumbing supply



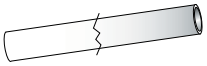
4

1 - 3/4" Ball Valve
Threaded ends
Hardware store or plumbing supply



13

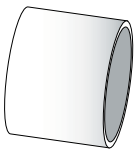
1 - 1/2" Pipe (PVC)
12", 24", 36" long
Hardware store or plumbing supply



19

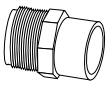
Additional 1/2" Pipe (PVC)
24"-36" long (1 per student team)

2 - 2" Connectors (PVC)
Slip
Hardware store or plumbing supply



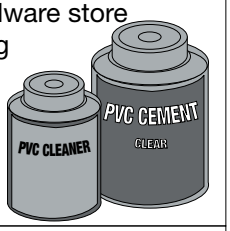
6,10

1 - 3/4" to 1/2" Adapter (PVC)
Slip and Thread
Hardware store or plumbing supply



14

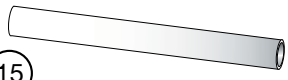
1 - PVC (primer) and **Cement**
(clear) Hardware store or plumbing supply



2 - 2" to 3/4" Flush Bushing (PVC)
Slip and Thread
Hardware store or plumbing supply

7,11

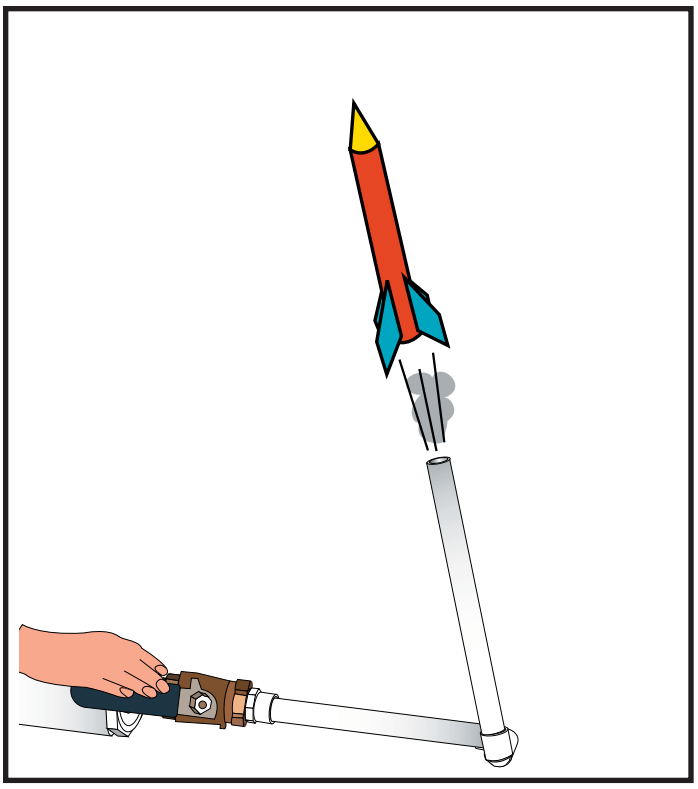
1 - 1/2" (PVC)
12 inches long
Hardware store or plumbing supply



15

Teflon Tape
(Not plumber's joint compound!)
Hardware store or plumbing supply

The Pressure Operated Relief Valve (also called Popoff Valve) is a recommended safety feature. The PVC pipe is rated at 280 PSI. The valve increases the safety factor by limiting the maximum pressure inside the launcher to 50 psi. This part, though inexpensive, may have to be special ordered.



Rocket Activity

High-Power Paper Rockets

Objective

Construct and launch high-power paper rockets, evaluate their flights, and modify their design to improve flight performance.

Description

Students construct large paper rockets and test fly them using the high-power paper rocket launcher. Following their rocket's flight, students rethink their rocket designs, modify them, and fly them again to determine if their changes have affected the rocket's performance. Students conclude the activity by writing a post-flight mission report.

Materials

High-Power Paper Rocket Launcher (see activity)
Bicycle pump with pressure gauge or small electric compressor
Paper 8 1/2 X 11" (white or color)
Cellophane tape
Ruler
Protractor
Scissors
1/2" PVC pipe 24" long
Student sheets

Management

Make sure that the rocket body tubes students roll are slightly loose. They should slide freely along the construction form tube. If not, it will be difficult to slide the completed rockets over the launch rod. Also make sure that students attach their nose cones securely to the body tubes.

National Science Content Standards

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

National Mathematics Content Standards
- Number and Operations
- Geometry
- Measurement
- Data Analysis and Probability

National Mathematics Process Standards
- Problem Solving
- Reasoning and Proof
- Communication
- Connections
- Representations

Two sheets of paper are sufficient for making a rocket. If colored paper is used, students can trade scraps with each other to have different colored nose cones and fins.

Background

High-power paper rockets are merely a large version of the paper rockets constructed in the 3, 2, 1, Puff! activity presented earlier. The main difference is in how the rockets are launched. These rockets are propelled by the air rocket launcher constructed in the previous activity. A much more powerful blast of air is achievable than with lung power through a straw. The launcher is like an air-powered cannon. However, the rocket surrounds the 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.

Tip Make sure students launch their rockets at the same angle and use the same pressure each time (experiment control).

Procedure Constructing the Rocket

1. Begin construction by rolling a cylinder of paper around the 1/2" PVC pipe. The paper can be rolled the long or short direction to make a tube 11 1/2" long or 8 1/2" long. Tape the seam.
2. Demonstrate how the nose cones are formed. Cut the half circle and curl its corners to form the cone shape. The round edge forms the base of the cone. The straight edge folds in the middle to form the apex as the sides overlap. Tape the seam.
3. Place the nose cone over the paper body tube (keep the PVC pipe inside for support). Fit the cone to the outside dimension of the body tube. Trim off the excess paper and tape the cone securely.
4. Cut rocket fins and tape them to the lower end of the body tube. The rocket is ready for launch.
5. Have students launch their rockets two or more times. Before the second launch, students should do something to modify their rockets to improve their flight performance. After their flights, they should record their observations on the mission report.

Discussion

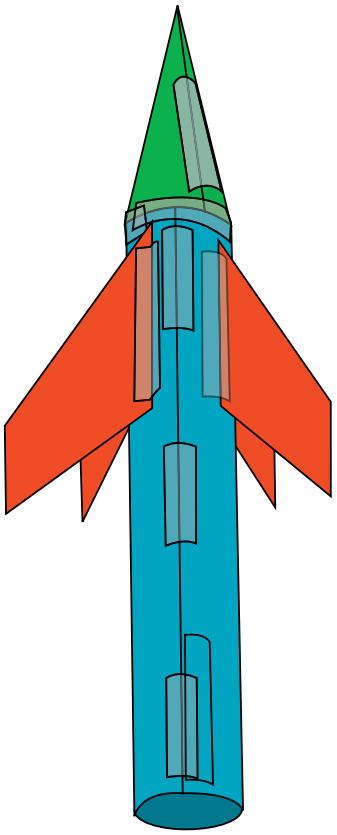
- *How can air rockets be modified to improve their flight performance?*
  There are several possible adjustments to the air rocket design. How loose or tight the tube is in relation to the launch rod affects air flow. The size and shapes of the fins affect air drag. Having fins mounted straight on the body of the rocket also affects drag. The length of the cone, squat or slender, affects how the rocket slices through the air.
- *Is it OK to change the fins and the nose cone at the same time?*
  Yes. However, it will not be possible to attribute improvements in flight performance to the changes that made a difference. Think of the design/redesign process as a controlled experiment where only one variable is changed at a time.

Assessment

- Review student mission reports and their conclusions.
- Have students write a paper explaining the principles of rocket flight as they apply to their paper rockets.

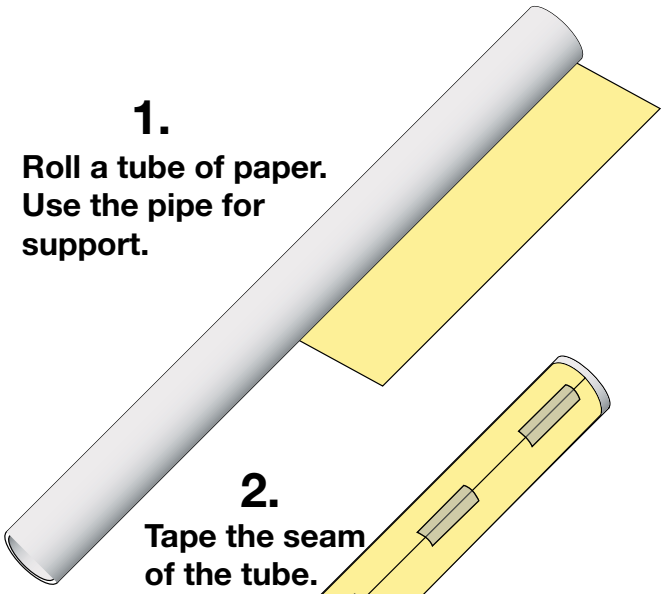
Extensions

- Have students draw one to three imaginative air rocket designs and speculate on how they would perform in flight. Have them build one of their designs and test it.
- Investigate fin placement on air rockets. Have students construct a new rocket but place the fins in different locations such as near the nose cone. Have them test the rockets and discuss their performance.
- Have students personalize their rockets with colored markers.

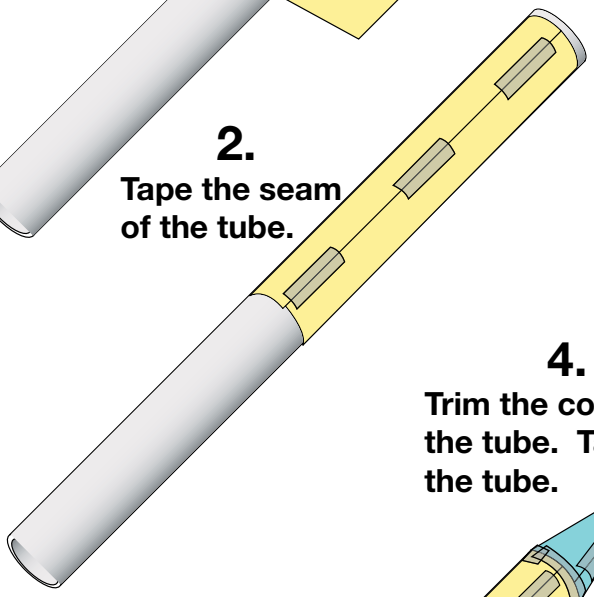


How well will a rocket designed like this fly?

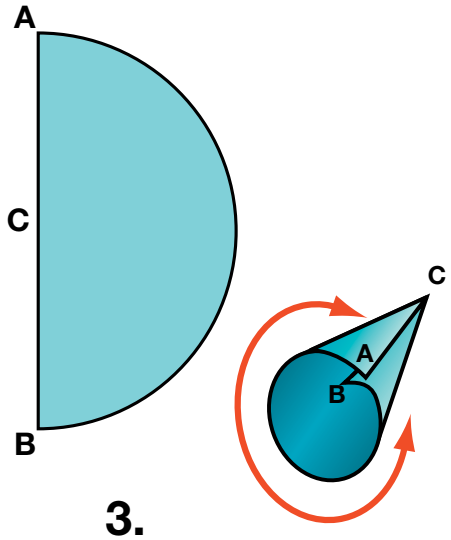
Making a Basic High-Power Air Rocket



1.
Roll a tube of paper. Use the pipe for support.

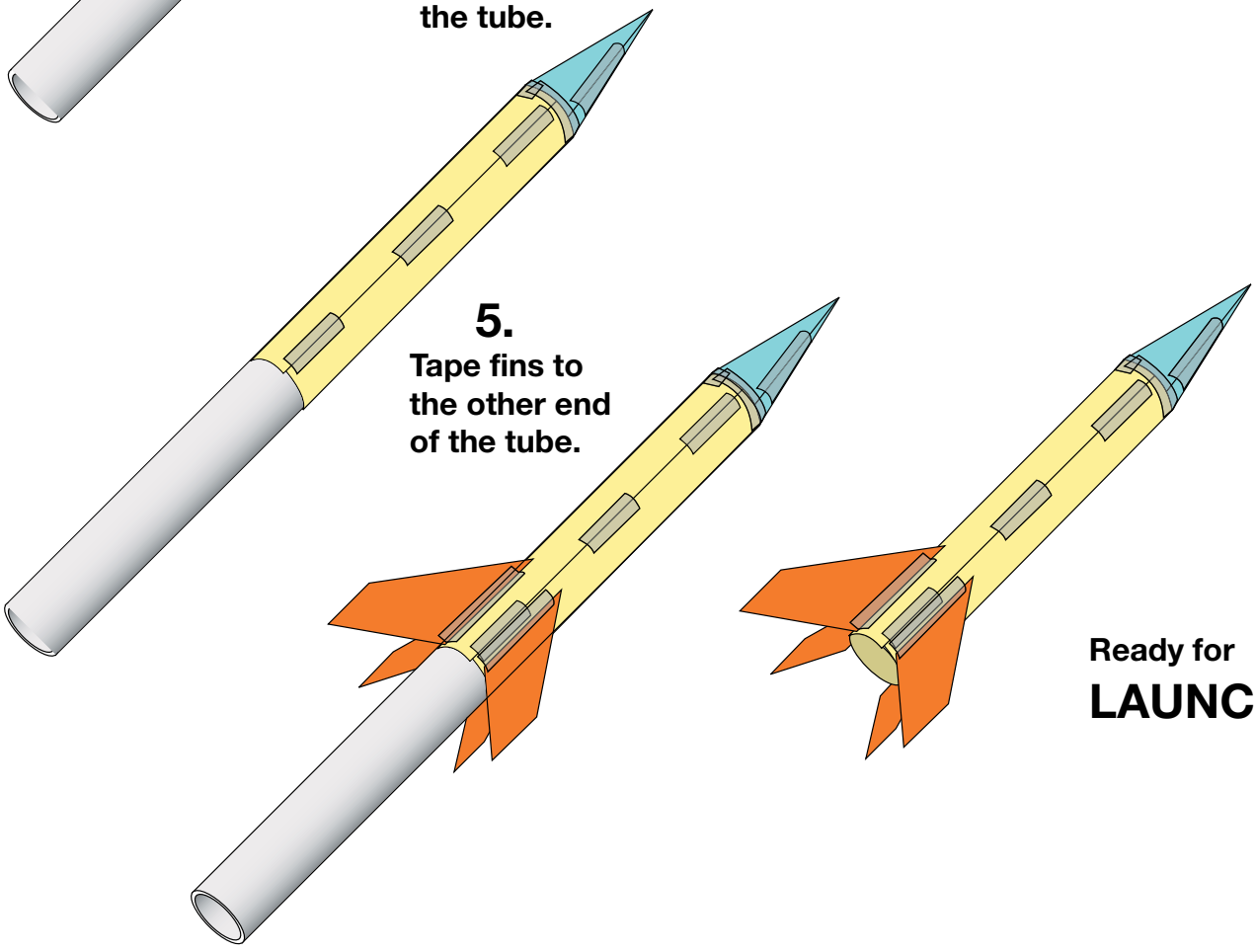


2.
Tape the seam of the tube.



3.
Curl a nose cone from a semicircle. Tape the seam.

4.
Trim the cone to fit the tube. Tape it to the tube.



5.
Tape fins to the other end of the tube.

Ready for
LAUNCH!

Air Rocket Mission Report

Name: _____

Test Flight 1 Summary:

Body Tube Length: _____ cm

Nose Cone Length:_____ cm

Number of Fins:_____

Area of 1 Fin: _____ square cm

How far did the rocket travel? _____

Describe the flight of the rocket. (Did it fly straight, wobble, drop quickly to the ground, etc?)

Test Flight 2 Summary:

Body Tube Length: _____ cm

Nose Cone Length:_____ cm

Number of Fins:_____

Area of 1 Fin: _____ square cm

What did you do to improve the rocket?

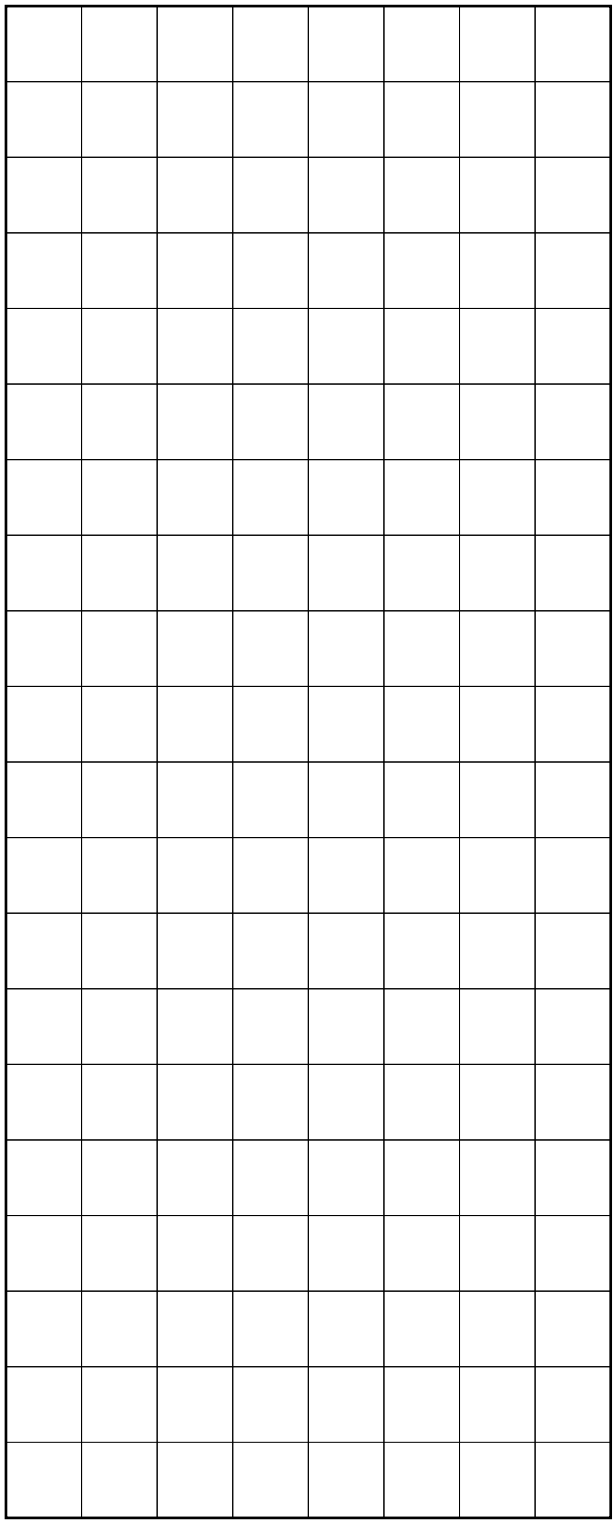
Predict how far the rocket will fly. _____

Describe the flight of the rocket.

How far did the rocket travel? _____

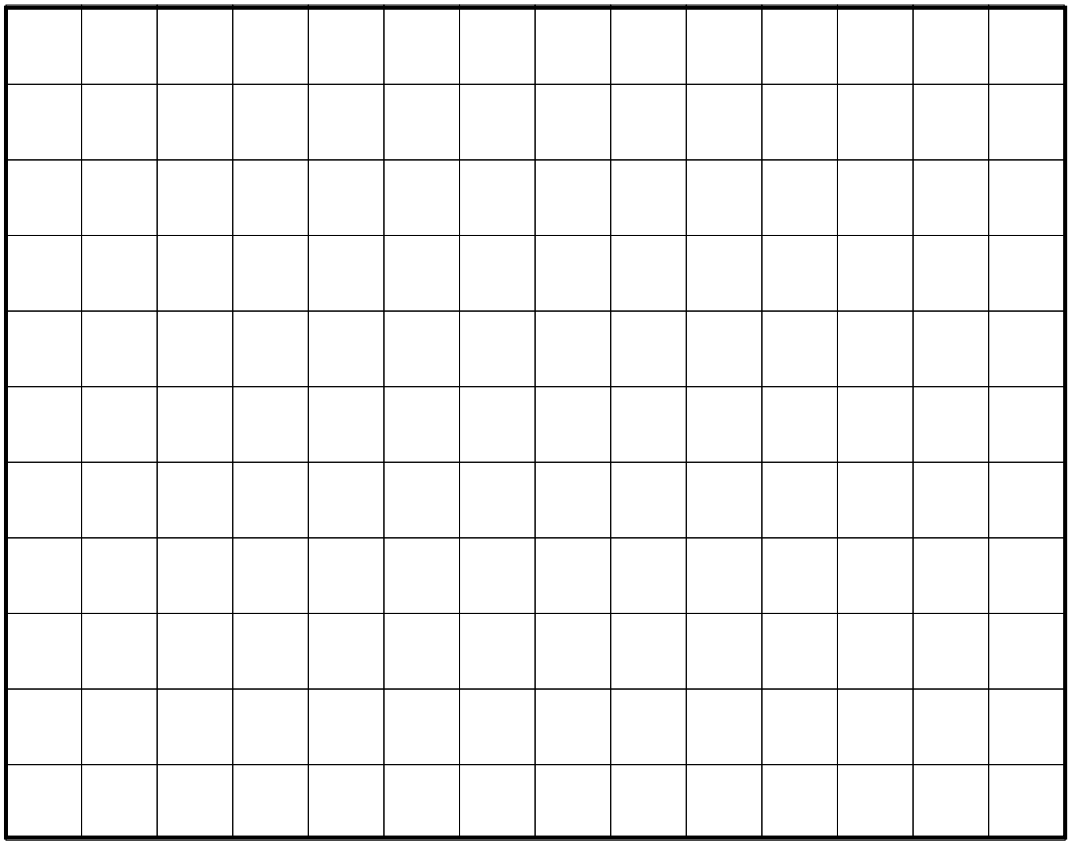
Did your improvements work? Why or why not?

Final Rocket Design



Rocket Fin Design

Design your fin on the first graph. Estimate its area by counting the number of whole squares it covers. Look at the squares partially covered. Estimate how many whole squares they are equal to. Add the two numbers together.

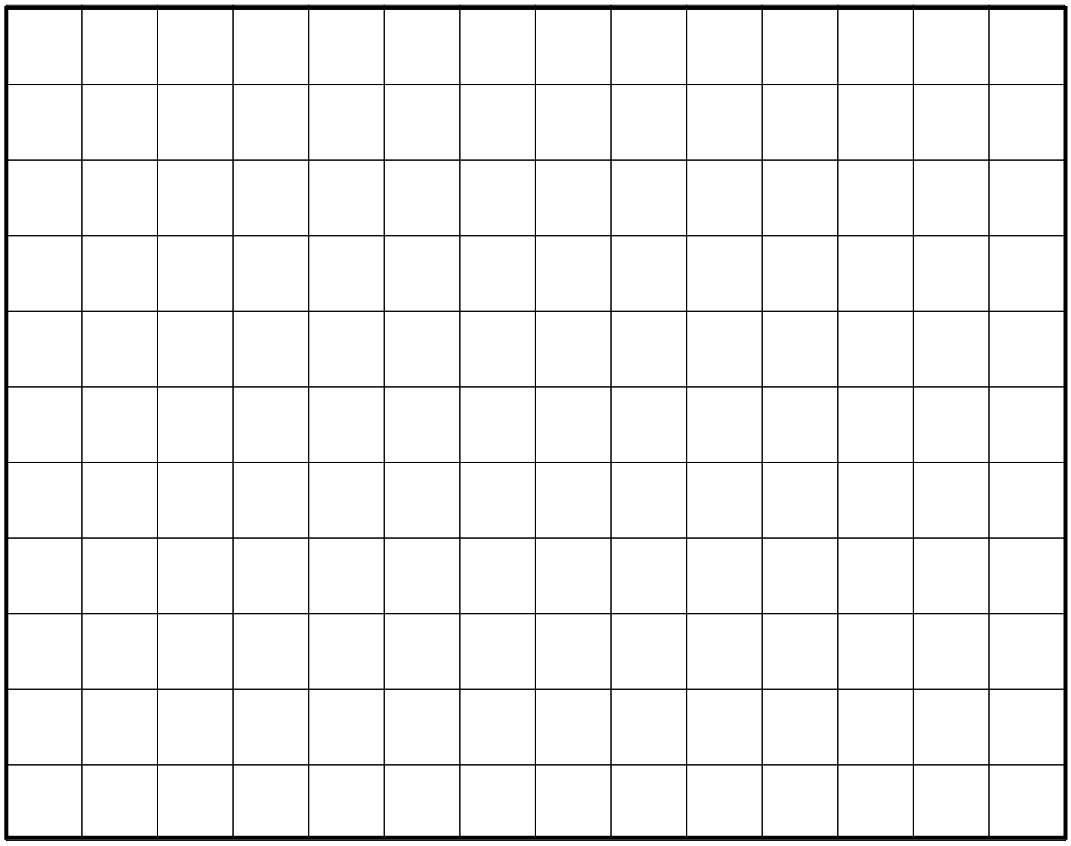


Area =

_____

square cm

Redesign your fin.



Area =

_____

square cm