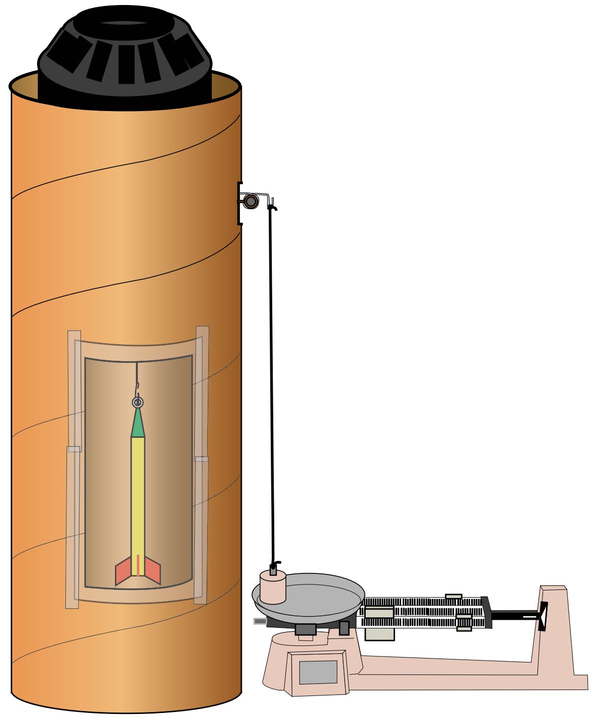


Rocket Activity

Rocket Wind Tunnel

Objective

Students predict the performance of their air rockets by measuring their streamlining properties.

Description

Air rockets are placed inside a wind tunnel, and their resistance to the flow of air in the tunnel is measured in tenths of grams. The more streamlined the rocket designs are (less resistance to the air flow), the better their potential flight performance. Students will use data generated in the wind tunnel to help them design better rockets.

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
- Measurement
- Data Analysis and Probability

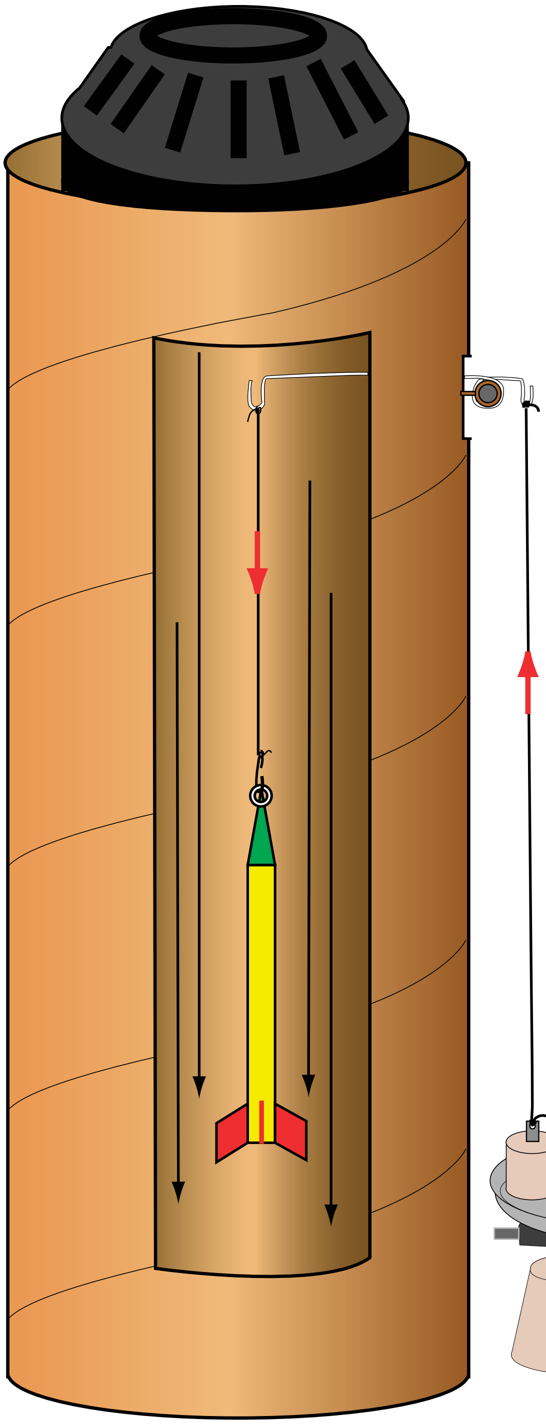
National Mathematics Process Standards
- Problem Solving
- Reasoning and Proof
- Communication
- Connections
- Representations

Materials

Paper concrete tube form (12" by 4')
Beam balance or electronic scale (sensitive to 0.1 grams)
Balance or some other weight
Thin wire coat hanger
Nail (about 16D by 3")
2 small screw eyes
String
Duct tape
Transparency paper or clear cellophane
Small electric fan
Needle-nose pliers and wire cutter
Box cutter
Ruler
Toilet paper roll tubes - about 24
Hot glue
Flashlight
Adhesive or gummed paper reinforcing rings

Management:

The wind tunnel should be constructed prior to the activity. It is simply a measurement tool students can use to evaluate the potential performance of their air rockets.



Cutaway view of the tunnel interior
(The actual door should be smaller.)

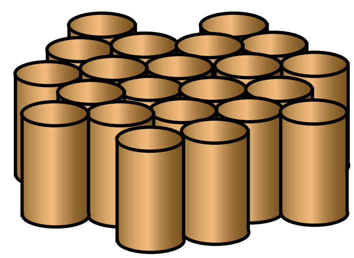
The cardboard cement form is available from large hardware stores. It generally comes in 8” and 12” diameters. You will need a strong fan to power the tunnel. The 12-inch tube provides students with more flexibility in their rocket designs. It permits fin spans of nearly 12 inches.

The length of the lever arm will be determined by the diameter of the tube you use. If using an 8”-diameter tube, the length of the arm inside the tunnel will be 4” and the outside length (on the other side of the fulcrum) will be 1”. If using a 12”-tube, the dimensions should be 6” and 1”.

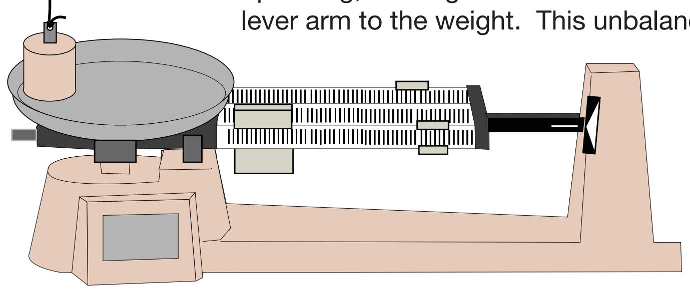
When you use the tunnel, the lower end will have to be supported so that the air flowing through the tube has a clear pathway to leave the tube. The air flow is downward.

An electronic balance is easier to use than a beam balance. However, the beam balance gives students good practice in measuring mass and adding measurements.

Toilet paper tubes glued together form air vanes. Install and glue them inside the top of the wind tunnel.



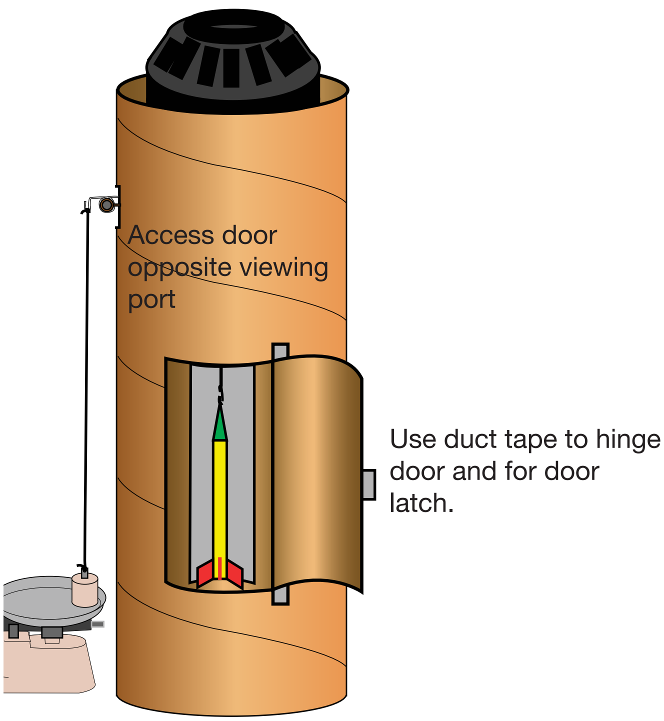
The rocket is supported by the lever arm. The right side of the arm is held by the weight. Prior to testing, the scale is brought to balance. When the tunnel is operating, air drag on the rocket is transmitted by the lever arm to the weight. This unbalances the scale.



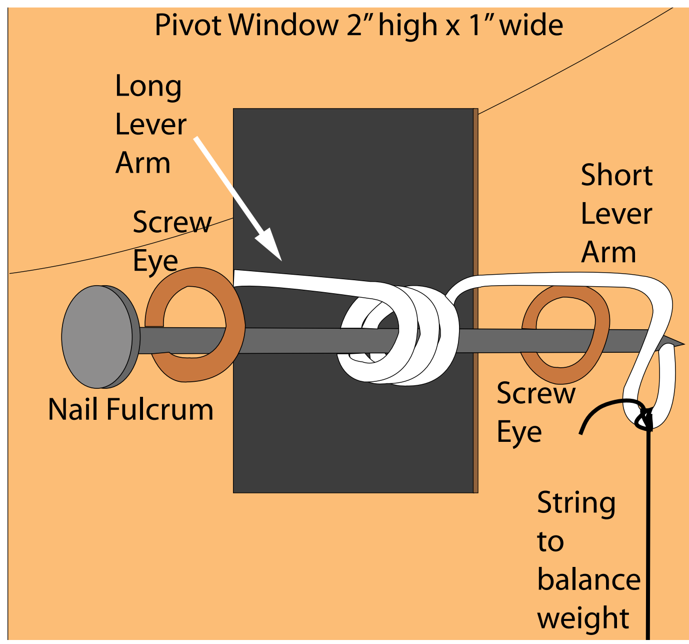
Adjusting the slide weights provides a measure of the force being exerted on the rocket.

Constructing the Wind Tunnel:

1. Using the box cutter, cut three openings in the tube form. The first is a small slot about 2 inches tall and 1 inch wide. Cut it 10 inches below the upper rim of the tube standing upright. This is the pivot hole for the balance lever. The second hole should be 12 by 6 inches. This is the access door hole. Cut it midway down the tube and 90 degrees away from the pivot hole. Use a strip of duct tape to hinge the door along one side. A small flap of duct tape can serve as the latch to hold the door closed during operation. The third opening should be 18 by 6 inches. It should be on the opposite side of the door. This is the viewing port.
2. Cover and tape the viewing port with transparency paper or cellophane.
3. Make the lever arm by cutting off a piece of coat hanger wire with the cutter. Loosely bend the wire around the nail about three times. With the pliers, bend one arm into a hook. The hook should be about 1 inch from the loops. Trim off any excess wire. Make a second hook on the other end about 6 inches away if using the 12" tube, 4 inches if using the 8" tube. The nail becomes the fulcrum for the lever.



4. On either side of the pivot hole, twist screw eyes into the cardboard tube to act as supports for the nail fulcrum. When both eyes are in place, slide the nail through one and through the loops in the lever and then through the other eye. This will allow the lever to tilt like a seesaw.
5. Attach a string to each loop of the lever. Use an additional piece of coat hanger wire to form a small hook, and suspend it inside the tube. With the lever arm level, the hook should just be visible from the top of the viewing port.
6. Using hot glue, glue together several toilet paper tubes. When you have enough glued together to fit across the opening of the tube, slide the assembly about 2 inches down from the top. These serve as vanes that reduce swirling of air coming from the fan. Glue the tubes to the inside wall.

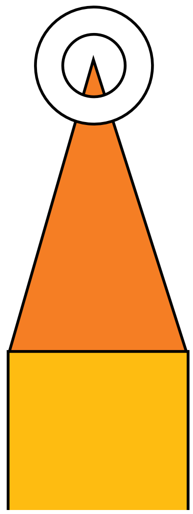


7. Tie the string coming from the outside loop of the lever to a weight that will rest on the balance. The string should be just long enough for the lever to rest horizontally.
8. Set up the tunnel on some supports, such as a couple of books or some cans to raise it up above the floor. The idea is to provide a clear opening below the tunnel. The air blown into the tunnel has to leave at the bottom. The less obstruction, the

better the air flow. Place the fan on the top of the tunnel, aimed downward. The cardboard tubes you installed in step 7 may be sufficient to support it. Otherwise, place a couple of thin strips of wood or other material across the opening to make a platform.

The wind tunnel is ready.

Using the Wind Tunnel



1. Prepare the rocket for hanging in the tunnel by placing two reinforcing rings on opposite sides of the nose cone to form a hanging loop. Squeeze them together.
2. Open the access door to the tunnel and hang the rocket from the hook. Close the door.
3. Adjust the beam balance so that it is level.
4. Turn on the fan. The balance moves as air drag increases on the rocket. Readjust the balance, and determine the difference between the mass without and with the air flow. This indicates the drag force on the rocket.

How the Wind Tunnel Works

It's all a matter of balance. A lever supports the rocket inside the tunnel. The weight of the rocket pulls down on the lever. The other end is pulled up. The shorter end of the lever is attached to a weight resting on the pan of a balance. A small part of the weight is being supported by the force exerted by the rocket's mass. When the air flow is turned on, the drag or friction with the rocket increases that force. The lever provides a 6 to 1 mechanical advantage (or 4 to 1 for an 8" tunnel) that magnifies the force exerted on the outside weight resting on the balance pan. By adjusting the slide weights on the balance, the drag force being exerted on the rocket by the air flow is measured. Rockets that are poorly constructed or have very large fins tend to have more drag than rockets with very straight small fins. Students will discover the optimum design for their rockets by testing them in the tunnel. The object is to reduce drag as much as possible. A more streamlined rocket will perform better under actual flight conditions.

Procedure

1. Have students construct high-performance air rockets (see page 91).
2. Before flight, have them evaluate their rockets using the data sheet. After sketching their rockets and completing the basic data, the rockets should be tested in the wind tunnel. The primary data gained from the wind tunnel is the number of grams of drag (the force exerted on the rocket because of its shape).
3. Have students launch their rockets and evaluate their flights on the data sheets.
4. Based on their first flight results and the wind tunnel data, have students construct a second rocket and try to improve its flight characteristics.
5. Have them repeat step 2 and build one final rocket (use the final data sheet) and test it in the wind tunnel and in actual flight.

Assessment

- Conduct a class discussion on what the wind tunnel data predicted for the student's rocket flights.
- Review student data sheets.
- Have students write a paragraph on how wind tunnels can help in the design of a rocket.

Extensions

- Investigate the wind tunnels NASA uses to evaluate aircraft and rockets. Check the NASA websites or search the Internet under "wind tunnel NASA."

Wind Tunnel Data Sheet

Name: ______________________

Rocket # ____________________

Total length: ____________________

Nose cone length: ____________________

Number of fins: ____________________

Size of fins (measured from
rocket body to fin tip): ____________________

Shape of fins: ____________________

Initial mass (before test): ____________________

Mass (during test): ____________________

Difference between the
two masses: ____________________

Launch Your Rocket

How high or how far
did your rocket go? ____________________

Describe your rocket's flight:

Draw a diagram of your rocket.

What did you learn about your rocket in the wind tunnel? What did you observe through the viewing port?

Wind Tunnel Data Sheet - Final

Name: ____________________

Rocket # ____________________

Total length: ____________________

Nose cone length: ____________________

Number of fins: ____________________

Size of fins (measured from rocket body to fin tip): ____________________

Shape of fins: ____________________

Initial mass (before test): ____________________

Mass (during test): ____________________

Difference between the two masses: ____________________

Launch Your Rocket

How high or how far did your rocket go? ____________________

Describe your rocket's flight:

Draw a diagram of your rocket.

What did you do to your rocket to improve its flight performance?

How did your changes affect your rocket in the wind tunnel?