Straw Rockets

Teacher Copy

Lesson Focus

This lesson focuses on the "push" (force) needed to move the straw rocket through the air and allows students to adjust their "push" to get the rocket through obstacles. This relates to the four forces of flight (thrust, drag, lift, and gravity) by describing thrust. The lesson also covers stabilization of flight and center of mass.

This lesson also covers Newton's third law of motion, as the students should realize through the activity that more force will give their straw rockets more distance.

Grade Levels

6-12

Objectives

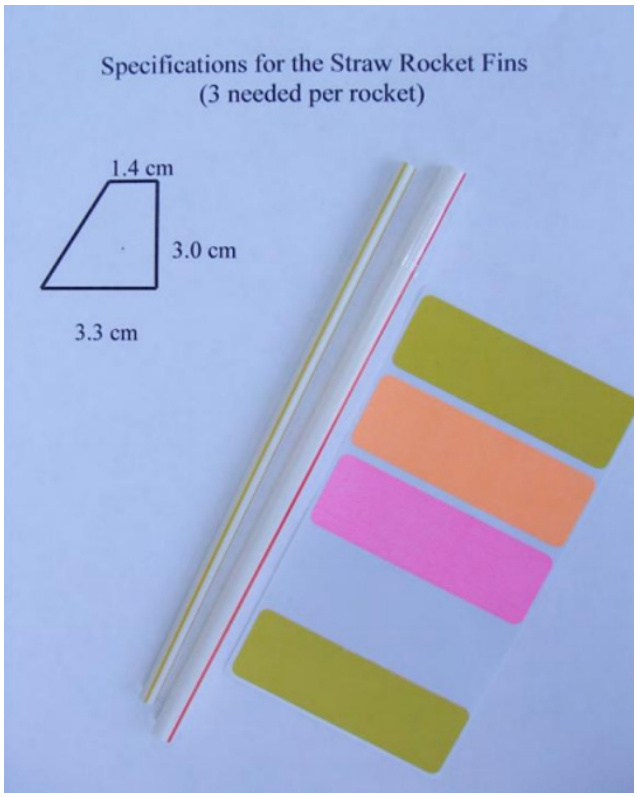
During this lesson students will:

- Build their own straw rocket
- Adjust flight performance by balancing
- Record observations
- Adjust design
- Communicate results

Materials

(Materials for a group of 20 students)

1. 5 rolls of Scotch tape
2. 20 pairs of two different sizes of drinking straws
3. Sheet of label stickers (or use tape)
4. 20 simple fin patterns (see photo below)
5. Scissors
6. 10 balloons
7. Hoops or cardboard cutouts to use as targets
8. 5 tape measures to measure diameter of balloon or make one from a strip of paper
9. Tape measure or meter sticks laid out in testing area for students to measure their flights



Pre-Lab Questions

1. What is the Bernoulli principle? Look it up and paraphrase it in your own words.

   Within a flow of fluid (or air), points of higher fluid speed will have less pressure than points of slower fluid speed. The higher-pressure areas will want to move to the lower-pressure areas.

2. What is Newton's third law of motion? Look it up if you don't know it.

   Every action has an equal and opposite reaction.

3. What is the formula for volume of a sphere? $V = (4/3) * Pi * R^3$

4. Define "fluid." Is air considered a fluid in this experiment? *A substance that has no fixed shape and yields easily to external pressure; a gas or (especially) a liquid. Yes.*

5. What are the four forces of flight?

   Thrust: *The force that moves an aircraft through the air.*
   Drag: *The force that resists movement through the air, air resistance.*
   Lift: *The force that directly opposes the weight of an airplane and holds an airplane in the air.*
   Gravity: *The force that holds all objects to the Earth.*

Procedure

1. Wrap a label sticker or a 7.5 cm piece of tape over one end of the larger straw to close off the opening.
2. Carefully cut out three fins.
3. Using two pieces of tape approximately 1.25 cm long, tape each fin about 2.5 cm from the back opening of the straw.
4. Place the smaller straw into the larger straw rocket and blow into the smaller straw.
5. If the straw does not fly level, add tape near the front or just behind the fins.
6. Fill a balloon with air until the measurement of its diameter is 40 cm.
   a. If we assume that an air balloon is a sphere, then the volume of the balloon is:

      $V = (4/3) * Pi * R^3$

      where R is the radius of the balloon and the radius is half the diameter
   b. So, $(4/3) \times 3.14 \times (20\ cm)^3$
   c. $(4/3) \times 3.14 \times 8000\ cm^3$
   d. $(4.19) \times 8000\ cm^3$
   e. $33{,}520\ cm^3$ volume of air in the balloon
7. Fill the balloon to the desired diameter and wrap the mouth of the balloon tightly around the inner straw, releasing the air to propel the outer straw.
8. Measure how far the straw traveled.
9. Repeat with 50 cm diameter of balloon and 60 cm diameter of balloon.

   For 50 cm diameter, volume would be $4.19 \times 15{,}625\ cm^3 = 65{,}468.75\ cm^3$ of air

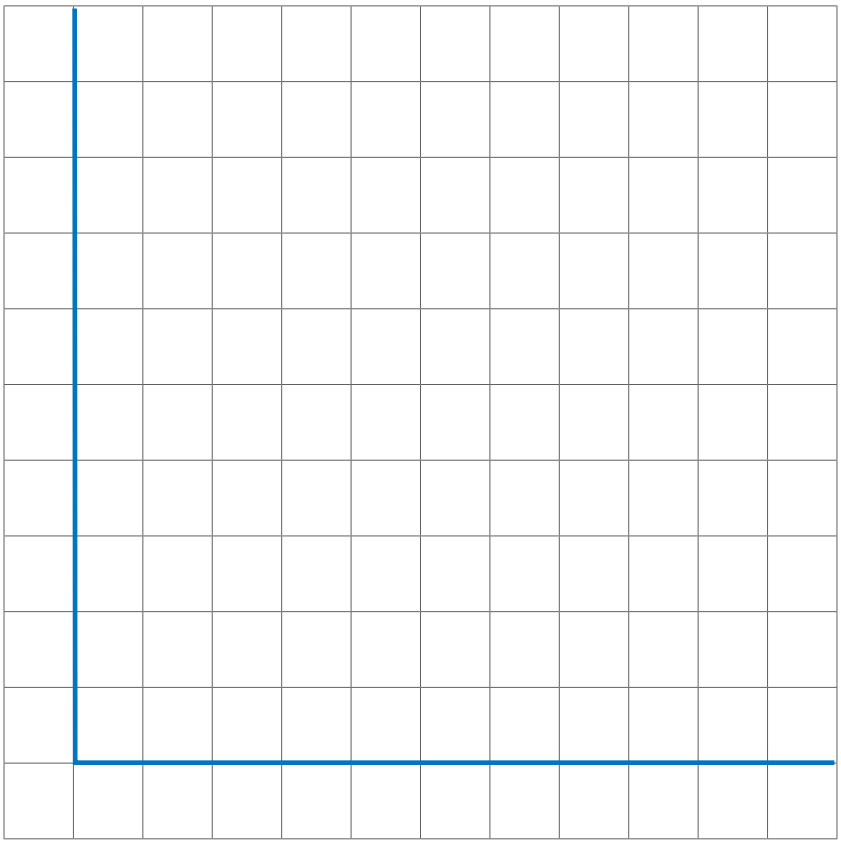
   For 60 cm diameter, volume would be $4.19 \times 27{,}000\ cm^3 = 11{,}313.0\ cm^3$ of air
10. Guess what another one would be and test to confirm your idea.

Data

Sample Data Table: The Effect of Air "Push" on a Straw Rocket

Trial	Volume of Air in Balloon (cm^3)	Distance (cm)	Observations
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Graph



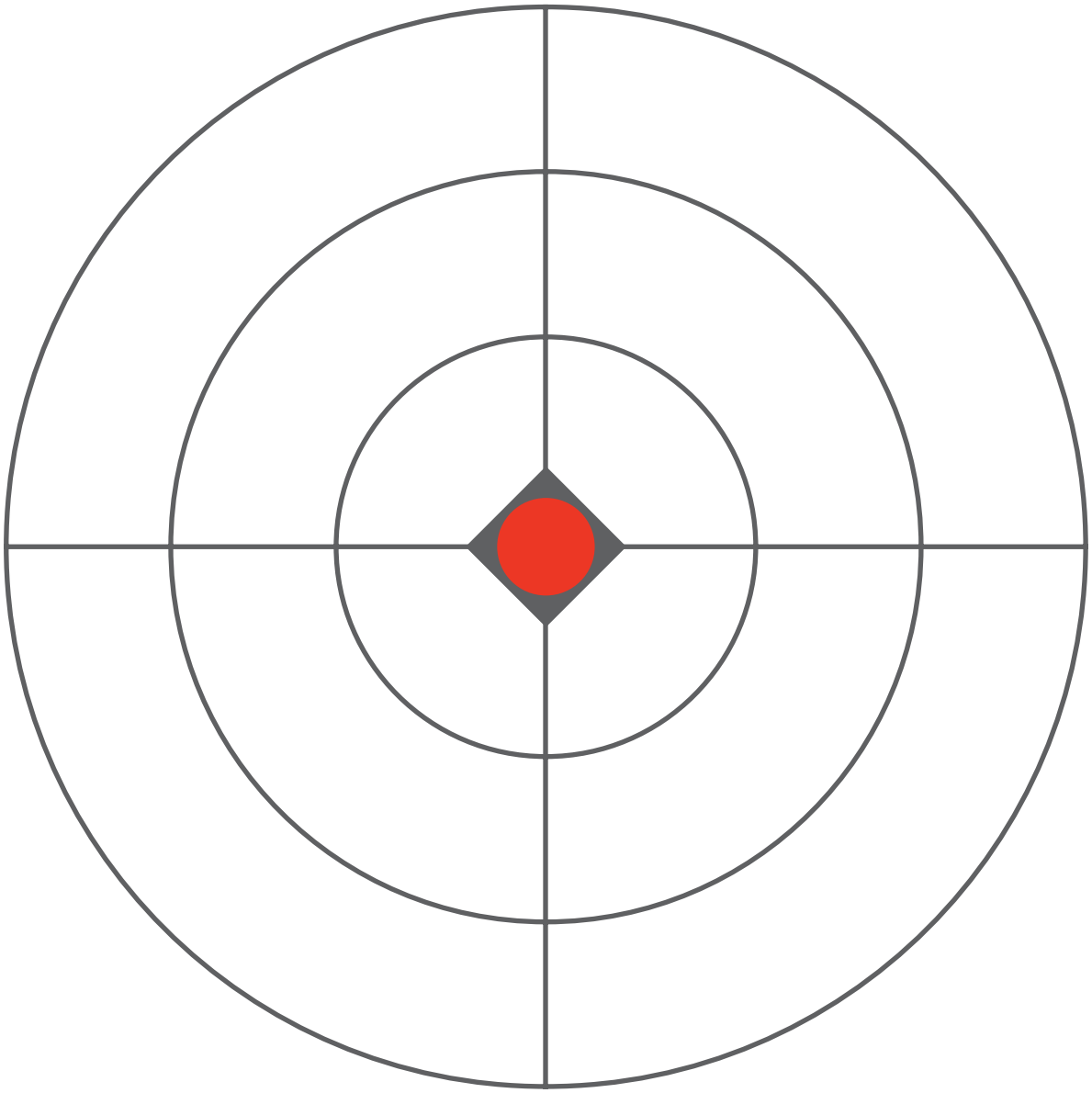
Analysis Questions

Grades 6-8

1. Did your graph make a straight line? What do you theorize that 80 cm might result in?
2. What is your independent variable *(x-axis)* and which is your dependent variable *(y-axis)*? *(IV is cm of air; DV is how far the straw traveled in cm.)*
3. Is using the volume of a sphere an accurate way to measure the balloon? Why or why not? *(It is approximate because the balloon is not a perfect sphere.)*
4. What amount of air made your rocket easiest to control?
5. What other variables could introduce error into your experiment? *("wearing out" the balloon through number of trials, saliva expelled into balloon per trial, etc.)*
6. Explain the application of Bernoulli's principle in what happened in your experiment.
7. What factors could give you a different graph than your fellow students?
8. How would you improve the design of this lab? What part of it gave you the most problem while doing it? How would you fix it?
9. What provided the thrust for the rocket? *The air.*

Grades 9-12

1. Did your graph make a straight line? What can you theorize from your limited data?
2. Is the straw/balloon system open or closed? Why?
3. What is the independent variable and the dependent variable?
4. Which goes on the x-axis and which on the y-axis?
5. Is lift provided by Newton's third law or by Bernoulli's principle? Defend your answer using illustrations from your lab. *(can be either, just defend answer)*
6. What factors could give you a different answer than your fellow students?
7. How would you improve the design of this lab? What gave you the most problems while doing it? How would you fix it?
8. What provided the thrust for the rocket? *The air.*



Alignment to Curriculum Frameworks

NGSS Engineering Practices

- MS-PS2-2. Plan an investigation individually and collaboratively, and in the design: Identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data is needed to support a claim.
- MS-PS2-5. Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.

Common Core —ELA

- RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.