NATIONAL MUSEUM
OF THE UNITED STATES AIR FORCE™

Forces and Motion: The Bernoulli Principle and Flight

Students will learn about forces and motion in flight in regards to the Bernoulli Principle's relationship to lift.

Learning Objectives:

The students will:

- Learn how forces and motion affect flight
- Learn the relationship of the Bernoulli Principle to lift
- Explore and demonstrate lift as a force in flight through a series of activities

Purpose:

During this lesson, students will learn about the Bernoulli Principle and lift. Students will increase their knowledge of forces and motion in relationship to flight. The Bernoulli Principle helps explain how an aircraft can achieve lift.

Background:

This lesson plan will help to explain how the Bernoulli Principle contributes to lift. It is important to note that the Bernoulli Principle is only one part of all the scientific principles that explain lift. Other principles include the Coanda Effect and Newton's Third Law of Motion. Again, this lesson plan will only concentrate on an explanation and demonstrations of Bernoulli.

Procedure:

A. Warm-up

Review the Bernoulli principle. Students need to understand that faster moving air (such as that moving over the top of the wing) has lower pressure relative to the slower moving air under the wing. Demonstrate by having the students hold the short end of a strip of paper (4" x 11") at both corners and placing the shorter edge just under their bottom lip. As they blow air over the top of the piece of paper, it will lift upwards.

Grade Level: 5-8

Ohio Learning Standards/Science (2018)
Expectations for Learning
Nature of Science

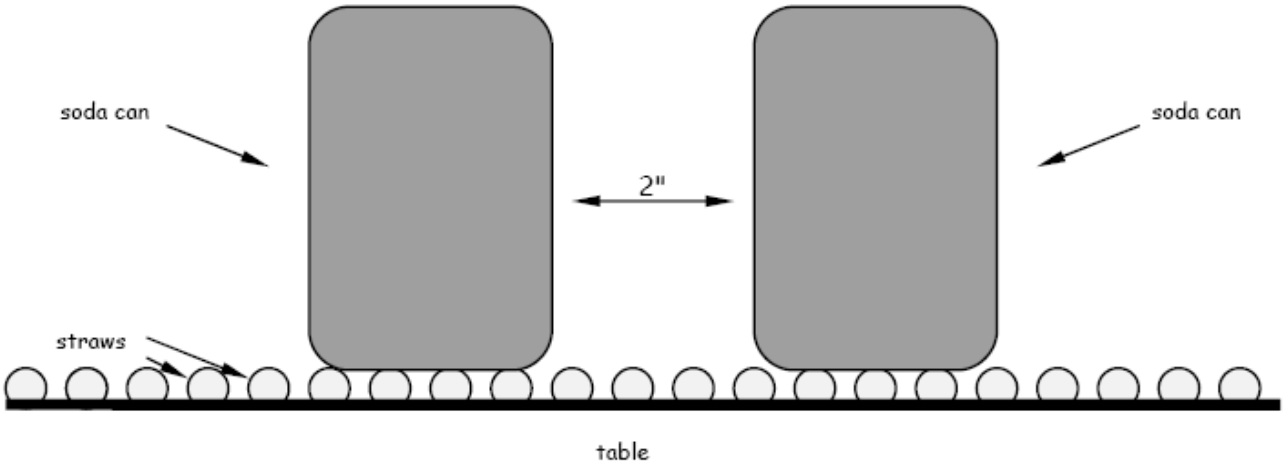
Physical Science:
5.PS.1: Change in movement force exerted
6.PS.4: Object's motion: speed and direction
8.PS.2: forces can change motion of object

Materials Required:

- A paper strip (4" x 11") per student
- 25 or more drinking straws
- 2 empty soda cans
- Index cards (4" x 6")
- Duct tape
- One drinking straw
- Fishing line
- Hair dryer
- Table

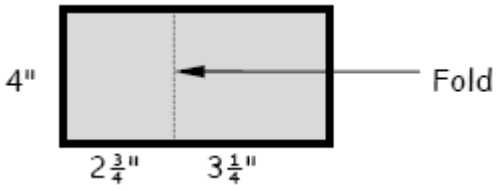
B. Activity I

1. Place 25 straws in a row on a tabletop, making sure the straws are very close together (¼" apart).
2. Place two soda cans on top of the straws approximately 2" apart. The cans should be free to roll.
3. Have students predict what will happen when air is blown between the cans.
4. Blow between the cans, using a straw to blow air through. The Bernoulli Principle will be demonstrated when the cans move closer together.
5. Record results.
6. Experiment changing the distances of straws and cans. Predict and record results.



C. Activity II: Making an Airfoil

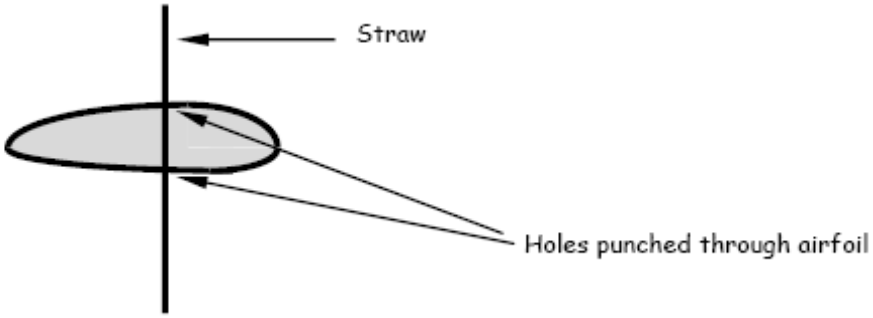
1. Review the concept of an airfoil (using information in Resources).
2. Fold a 4" x 6" index card in two, leaving an overlap of about ½".



3. Push the overlapping ends together. One side of the folded index card will curve up.
4. Tape the ends together.

5. Punch 2 holes through the middle of the airfoil (one hole on the top and one on the bottom).

6. Carefully push a drinking straw through the holes.

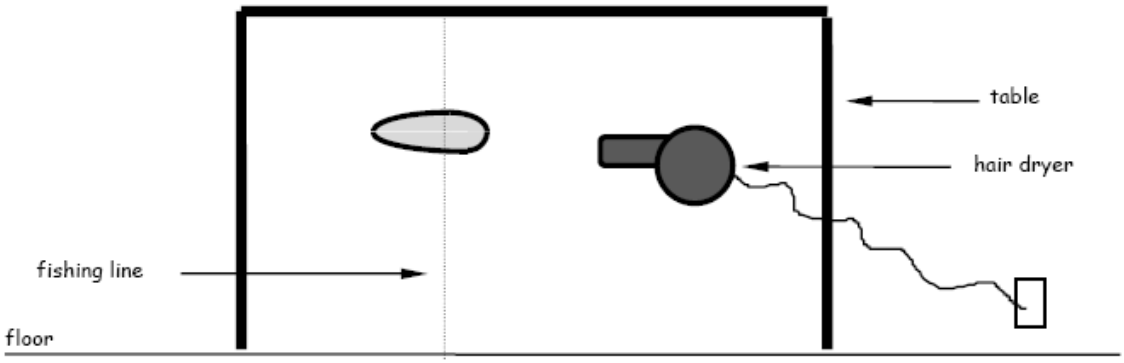


7. Pull a piece of fishing line through the straw. Cut the fishing line long enough to fit between the underside of a table and the floor. Hold the fishing line in place, making sure it is perpendicular (90°) to the floor and table.

8. Tape the fishing line in place between the table and floor. The "wing" should be able to slide freely up and down.

9. Lift the wing up slightly and aim the hair dryer at the folded edge.

10. Turn the dryer on (cool setting). The wing should lift. Point the dryer straight for the best lift.



D. Activity III: Angle of Attack

1. Using the airfoil set-up from Activity II, experiment with angle of attack by moving the string to an 80° angle rather than 90° angle. Turn hair dryer on. Observe results.

2. Move string to 70° and 60°. Observe results.

Assessment/Evaluation:

Students should be able to predict the outcome of each activity based on their understanding of Bernoulli's principle.

Extensions:

1. Change the size and shape of the airfoils in Activity II.
2. Turn the airfoil upside down and test it again in Activity II.
3. Try to move the hair dryer further away in Activity II.
4. Research Daniel Bernoulli's life and present a report to the class.

Resources:

Four Forces of an Airplane, NASA: https://www.grc.nasa.gov/WWW/K-12/airplane/forces.html

Four Forces, NASA: https://www.hq.nasa.gov/office/aero/pdf/four_forces_5_8.pdf

The Beginner's Guide to Aeronautics, NASA: https://www.grc.nasa.gov/www/k-12/airplane/index.html

Bernoulli and Newton, NASA: https://www.grc.nasa.gov/WWW/K-12/airplane/bernnew.html

What is Lift? NASA: https://www.grc.nasa.gov/www/k-12/airplane/lift1.html

Airfoil: http://www.aviation-history.com/theory/airfoil.htm