Principles of Flight

Lesson Plan: Bernoulli's Lift

Grade Level: 5-6

Subject Area: Science

Time Required: ***Preparation:*** 30 minutes
Activity: 3 40-minute classes

National Standards Correlation:

Science (grades 5-8)

- Physical Science Standard: Motions and forces.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- History and Nature of Science Standard: Nature of science.
- Science in Personal and Social Perspectives Standard: Science and technology in society.

Summary:

Students will investigate air pressure and how it is used in flight. The students will work in cooperative groups of 3-4 students, and use brainstorming sessions and investigations to apply Bernoulli's Principle to the real world. They will construct two styles of airplane wings, and develop an understanding of how airplanes use air pressure to lift them off the ground. Day 1 includes three short activities, Day 2 involves an experiment with air pressure differences and on Day 3 students build models of wings.

Objectives:

Students will:

- Differentiate between high and low air pressure.
- Explain the concept of lift.
- Apply Bernoulli's Principle to flight.

Background:

Bernoulli's Principle states that when air flows around an object the air pressure changes as the speed of the air changes. When air moves faster over an object it lowers the pressure, and when air moves slower over an object it raises the pressure.

Materials:

Activity I (per group):

- Small funnel
- Ping-pong ball

Activity II (per group):

- 2 sheets of notebook paper

Activity III (per group):

- Hair dryer
- Ping-pong ball

Activity IV (per group):

- 1 long thin 8' plastic bag/tube (a diaper disposal plastic tube cut to 8' length or a commercial "windbag" from a science materials supplier)
- Meter stick

Activity V (per group):

- 2 sheets copy paper
- Tape
- Modeling clay

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- 3 drinking straws
- Glue
- 2-foot long section of an 1/8 inch dowel rod

Safety Instructions: Be sure that students do not put straws in their mouths and/or share straws.

Procedure:

A. Warm-up

Ask students what they know about the speed of air and air pressure.

B. Activity I: Lift

1. Give each cooperative group a small funnel and a ping-pong ball.
2. Have the students place the ball inside the small funnel. Ask them to turn the funnel over. (The ball will fall to the ground due to the force of gravity.)
3. Have the students place the ball in the small funnel again.
4. Challenge students to keep the ping-pong ball in the funnel for five seconds after turning the funnel over again. Nothing may touch the ball.
5. After an appropriate amount of time, instruct students to turn the funnel upside down.
6. Instruct students to hold the ball in the funnel with their fingers. Then have only one student in each group blow air into the narrow end of the funnel continuously for about ten seconds.
7. While they are blowing air through the funnel have them remove their fingers from the ball. *(Note: Funnels should be only one student then washed thoroughly for each additional student.)*

C. Activity I Wrap-up

1. Ask students to explain what happened.
2. The ball should have floated in the funnel because the faster moving air on top of the ball has less pressure. The bottom of the ball has more pressure and is holding the ball up.

D. Activity II: Air Pressure

1. Have one student per group hold two sheets of notebook paper about four inches apart in front of his/her mouth. The sheets should hang down so the pages face each other.
2. Blow between them. Encourage students to try blowing gently at first, and then with more force.
3. Instruct students to observe what happens to the papers.

E. Activity II Wrap-up

1. Ask students to explain what happened: Instead of flying apart, the papers come together. The air moving rapidly between the two pieces of paper has less pressure than the air pressing on the outer sides of the paper.
2. Have students compare results. Was the resulting lift better when the students blew gently or when they blew with more force?

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F. Activity III: Lift and Air Pressure

1. Have the students hold a hair dryer vertically so the stream of air goes straight up.

2. Release a ping-pong ball into the stream of air about a foot from the hair dryer. (Using a cool setting will work without the chance of overheating the dryer.) The ping-pong ball should stay suspended in the air stream.

3. Have students slowly tip the hair dryer so that the air shoots at an angle. The ball should stay suspended until the force of gravity makes it drop.

G. Activity III Wrap-up

1. Ask students to explain what happened: The fast moving air stream causes low air pressure especially on top of the ball. This area of lowest pressure causes lift. This demonstration shows Bernoulli's Principle at work.

H. Activity IV: Differences in Air Pressure

1. Show the students the bags.

2. Give each cooperative group one bag. Have them tie one end of the bag close to the end.

3. Students will then brainstorm the various ways the bag could be inflated without actually doing so. See attached worksheet.

4. Share these ideas with the entire class and have each group pick one way to inflate the bag.

5. They will do this method as a demonstration to the rest of the class.

6. Allow the students to discuss the particulars of their demonstration and give them a few minutes to practice.

7. At least one group will choose the method of blowing the bag up like a balloon. Allow this group to demonstrate that method last. Before they do so, have the class estimate how many breaths it will take to blow up the bag. Record those estimates on the board.

8. After each group has blown up their bags, record their method of inflation, the amount of time it took to inflate the bag and the length of the inflated part of the bag on a chart on the board.

9. Discuss the various ways they inflated the bags. Compare the methods in terms of length of inflated bag and the amount of time it took to blow up the bag. Which method was most efficient in terms of the amount of air in the bag and which was most efficient in terms of the time it took to inflate the bag?

10. After this discussion, tell the students you can blow up the bag with only one breath.

11. Ask for comments.

12. Demonstrate. Have a student help you by holding one end of the bag and you hold the other so the bag is stretched out. Blow into the bag with a large puff of air. Have the students time you and also measure the length of the inflated part of the bag.

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I. Lift-Off Activity!

1. In your groups, brainstorm ways to inflate the airbag. Record them.

2. Choose a method your group will use to inflate the airbag. Practice your method and prepare to demonstrate it to your class. After your demonstration is complete, record the results of your experiment on the graph below. As the other groups demonstrate their methods, record those results also.

3. Which method showed the fastest way to inflate the airbag?

4. Which method inflated the airbag to the longest length?

5. Which method was the most efficient way of inflating the airbags? Support your answer.

J. Activity V: Applying Bernoulli's Principle to Flight

Step 1: Flat Wing

1. Cut a strip of paper 8 x 2 1/2 inches.

2. Fold the strip in half lengthwise. Tape the unfolded edge. Crease the folded edge.

3. Use a hole punch and make a hole one-inch from the folded edge. Make sure to punch through both sheets and that the hole is centered.

4. Cut a drinking straw to the length of 4 inches. Push the straw through the hole. Secure the straw with a little glue.

Step 2

1. Place the end of a 2 ft. 1/8" dowel rod in a ball of clay about 2" in diameter. The clay is used to support the dowel rod.

2. Cut a drinking straw to a 3" length. Slide the straw on the dowel rod and let it fall to the bottom.

Step 3

1. Slide the flat wing structure over the dowel rod.

2. Use a hair dryer to blow over and under the structure.

3. Observe results. Has your flat wing lifted? Ask students to explain what happened.

Step 4: Airfoil Wing

1. Cut a strip of paper 8" x 2 1/2".

2. Label one side of the strip **A**. Using a ruler, measure a 1/2" from the side of the strip and draw a line.

3. Turn strip over and label the opposite side **B**.

4. Carefully pull edge **B** over to the **A line** to bend paper. Do Not Fold. This will create a bowed figure similar to an airplane wing.

5. Tape the edges together.

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6. Use a hole punch and make a hole 1” from the bowed or curved edge. Make sure to punch through both sheets and that the hole is centered.

7. Cut a drinking straw to the length of 4”. Push the straw through the holes. Secure the straw with a little glue.

Step 5

1. Slide the airfoil wing structure over the dowel rod.

2. Use a hair dryer to blow over and under the structure.

3. Observe results. Has your airfoil wing lifted?

K. Wrap-up

1. Ask students to explain what happened. The flat wing did not create lift. Why?

2. In groups, have students make a drawing of a cross-section of both the flat wing and the airfoil wing. Prompt them to draw in the airstreams around the wings. Show how the airfoil wing is designed to accommodate Bernoulli’s principle.

Assessment/ Evaluation:

Students should be evaluated on their ability to understand and explain each activity, and on the accuracy of their drawings.

Extensions:

1. Have the students write to a local airline and acquire information dealing with the flight of an airplane.

2. Ask students to investigate how Bernoulli’s principle applies to a bird’s wing?

Resources/ References:

Devonshire, Hilary. *Flight.* New York: Franklin Watts Inc., 1992.

Dixon, Malcolm. *Flight.* New York: The Bookwright Press, 1991.

Hixson, B.K. *Bernoulli’s Book.* Salt Lake City: The Wild Goose Company, 1991.

Maurer, Richard. *Airborne.* New York: Simon & Schuster Inc., 1990.

Taylor, Kim. *Flight.* New York: John Wiley & Sons Inc., 1992.

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Flat Wing

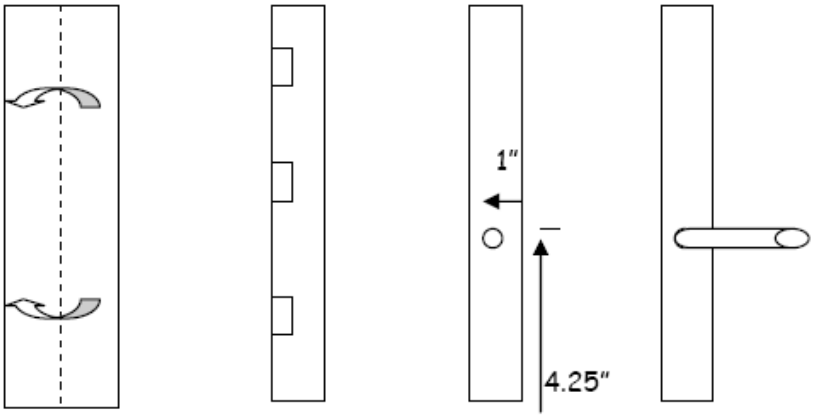

Fig.1 Fig. 2 Fig. 3 Fig. 4

1. Fold a 8.5"x2.5" strip of paper in half lengthwise.
2. Tape the unfolded edge to hold it together.
3. Use a hole punch to make a hole in the center of the length and 1" from the folded edge.
4. Push a 4" piece of a straw through the hole.

Airfoil Wing

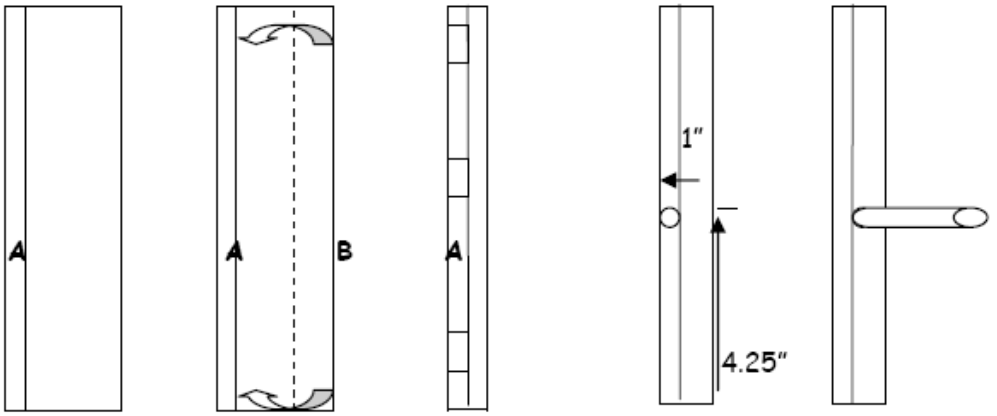

Fig.1 Fig. 2 Fig. 3 Fig. 4 Fig. 5

1. Measure .5" from edge **A**. and draw a line the length of the strip of paper.
2. Fold the paper lengthwise so the edge **B** touches **line A**. Do not push down on the folded side. It should form an arc.
3. Tape the unfolded edge at **line A** to hold it together.
4. Use a hole punch to make a hole in the center of the length and 1" from the folded edge.
5. Push a 4" piece of a straw through the hole.

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