Bernoulli and More Bernoulli

NASA SUMMER OF INNOVATION

UNIT
Physical Science - Aeronautics

GRADE LEVELS
4th – 6th

CONNECTION TO CURRICULUM
Science, Mathematics, and Technology

TEACHER PREPARATION TIME
1 hour

LESSON TIME NEEDED
1 hour *Complexity: Basic*

LESSON THEME
Six easy and simple experiments that explain Bernoulli's principle

OBJECTIVES
The students will
- Construct devices that demonstrates Bernoulli's Principle
- Investigate how each device operates
- Explore the effect of air flowing over a curved surface
- Apply the experimental experiences to understand Bernoulli's Principle

NATIONAL STANDARDS

National Science Education Standards (NSTA)
Science as Inquiry
- Understanding of scientific concepts
- An appreciation of "how we know" what we know in science
- Understanding of the nature of science
- Skills necessary to become independent inquirers about the natural world
- The dispositions to use the skills, abilities, and attitudes associated with science

Physical Science Standards
- Motions and forces
- Transfer of energy

Science and Technology Standards
- Abilities of technological design
- Understanding about science and technology

History and Nature of Science Standards
- Science as a human endeavor

Common Core State Standards for Mathematics (NCTM)
Operations and Algebraic Thinking
- Use the four operations with whole numbers to solve problems
- Generate and analyze patterns

Operations and Algebraic Thinking
- Analyze patterns and relationships
- Write and interpret numerical expressions
- Analyze patterns and relationships

ISTE NETS and Performance Indicators for Students (ISTE)
Creativity and Innovation
- Create original works as a means of personal or group expression
- Use models and simulations to explore complex systems and issues

Communication and Collaboration
- Contribute to project teams to produce original works or solve problems

Research and Information Fluency
- Plan strategies to guide inquiry
- Process data and report results

Critical Thinking, Problem Solving, and Decision Making
- Identify and define authentic problems and significant questions for investigation
- Plan and manage activities to develop a solution or complete a project
- Collect and analyze data to identify solutions and/or make informed decisions

Technology Operations and Concepts
- Understand and use technology systems
- Select and use applications effectively and productively
- Troubleshoot systems and applications

MANAGEMENT

There is no separate student data sheet for this activity, which will require the teacher to generate one. The scientific methodology looks at a research question, generates a hypothesis, conducts an experiment, and reaches a conclusion.

MATERIALS
- Sheets of paper
- Straight straws
- Flex straws
- String
- Round balloons
- Ping-pong balls
- Coins
- Scissors

CONTENT RESEARCH

Key Concepts:
- Airflow is the motion of air molecules as they flow around an object, such as a wing.
- Air pressure is the weight or force of air pressing on a surface.
- Bernoulli's Principle. When a fluid moves faster, the molecules inside the fluid exert less pressure on the objects around them; as the speed of a moving fluid increases, the pressure within the fluid decreases. This applies to all fluids, including water, air, and gases.

Misconceptions:
- Many books state that air speeds up over a wing because it has farther to travel than air moving under the wing. This statement implies that air separates at the front of the wing and must rejoin behind the wing, but this isn't true. Air moving over the top of a wing speeds up so much that it arrives behind the wing sooner than air that travels beneath the wing.
- Inflating a balloon: Equalization always occurs from areas of high pressure to low pressure. An inflated balloon has higher air pressure inside than outside, the balloon will pop when the pressure difference becomes too great for the material.
- There are actually two science processes occurring that make an airplane rise. The force of lift that causes an airplane to rise in the atmosphere is the Bernoulli Principle. Faster air going over the curved surface has less pressure than slower moving air. Additional lift is generated by flying the plane so that the wing meets the air at a slight angle. This is Newton's Third Law of Motion. The law states that for every action, there is an equal and opposite reaction.
- Fluid is either a liquid or gas whose molecules move freely past one another.

LESSON ACTIVITIES

The NASA "Why" Files: The Case of the Challenging Flight
Program 4 in the 2000–2001 Series
Six activities to better understand Bernoulli's Principle.
http://scifiles.larc.nasa.gov/docs/guides/guide4_00.pdf (pg. 28)

Tent with a Straw
- Fold a 20- by 13-cm piece of paper in half to make a tent.
- Place the paper tent on the desk.
- Using a straw, blow under the tent and observe what happens.
- Blow harder and observe what happens.
- Try blowing hard against the side of the tent and observe what happens.

Balloon Blow
- Blow up two balloons and tie off the ends.
- Cut two pieces of string 30 cm each.
- Tie one end of each string to each balloon.
- Hold the balloons in front of you by the strings about 5 cm apart.
- Blow very hard between the two balloons and observe what happens.
- What did the balloons do?

Ping Pong
- Place two ping pong balls on a table about 2 cm apart.
- Using a straw, blow very hard between the two balls and observe what happens.
- Did the balls move closer together or farther apart?

Paper Paper
- Hold two pieces of notebook paper in front of you about 5 cm apart.
- Blow hard between the papers and observe what happens.
- Which way did the papers move?

Stuck to It
- Cut out a square of paper approximately 3 by 3 cm.
- Place the paper in the palm of your hand, and using your thumb and middle finger, hold a quarter (or nickel) about 1 cm above the paper.
- Place your mouth above the coin and blow hard.
- Observes what happens.

Ball and Straw
- Bend a flexible straw so that the short end is pointing up.
- Hold a ping pong ball over the opening of the straw and blow.
- Let go of the ball and observe what happens.
- What happens if you tilt the straw?

ADDITIONAL RESOURCES
Aeronautics Educator Guide
- Paper Bag Mask activity
  http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Paper_Bag_Mask.html
- Rotor Motor activity
  http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rotor_Motor.html

The Courage to Soar Educator Guide
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/The_Courage_to_Soar.html
Activity Eight—The Four Forces of Flight
- Lesson 17—It Lifts Me Up—The Force of Lift
  - Vocabulary list, student text, diagram, and six lift experiments
    - Lift Experiment 1— Chin Ups
    - Lift Experiment 2—Paper Pull
    - Lift Experiment 3—Can It

- Lift Experiment 4—Ping-pong Funnel
- Lift Experiment 5—Air Dance
- Lift Experiment 6—Wing It

The Beginner's Guide to Aeronautics Homepage:
http://www.grc.nasa.gov/WWW/K-12/airplane/index.html
Lift

- interactive FoilSim III Interactive Simulator
- Bernoulli and Newton
- Objects with Lift Interactive Simulator
- Factors That Effect Lift
- Shape Effects On Lift
- Size Effects On Lift

DISCUSSION QUESTIONS

- What is airflow? *Airflow is the motion of air molecules as they flow around an object, such as a wing.*
- What is air pressure? *Air pressure is the weight or force of air pressing on a surface.*
- What is the Bernoulli Principle? *When a fluid moves faster, the molecules inside the fluid exert less pressure on the objects around them; as the speed of a moving fluid increases, the pressure within the fluid decreases. This applies to all fluids, including water, air, and gases.*
- Attach a lightweight streamer to a fan. Ask the students to observe and describe what happens. *Lift is caused by air moving over a curved surface.*
- What are some other common examples of Bernoulli's Principle? *Flags waving, sails, an umbrella that becomes impossible to hold in a strong wind.*
- What happens when you blow harder? *The curved surface creates unequal air pressure and a lifting action. Blowing harder will cause the different curved surfaces to either move up and down or move together faster.*

ASSESSMENT ACTIVITIES

- Take a blank piece of paper, diagram a cross section of each experiment, and use arrows to show fast and slow moving air and the direction of the force of lift.
- Take a blank piece of paper and diagram a cross section of a wing, and use arrows to show fast and slow moving air and the direction of the force of lift.

ENRICHMENT

- Design a simple force of lift experiment that will demonstrate Bernoulli's Principle.
- Take a blank piece of paper and diagram a cross section of the experiment and use arrows to show fast and slow moving air and the direction of the force of lift.