National Aeronautics and Space Administration

GRADES **K-4**

Bernoulli's Principle

principles of flight

Aeronautics Research Mission Directorate

Museum in a BOX Series

www.nasa.gov

Bernoulli's Principle

Lesson Overview

In this lesson, students will learn about forces and motion as they see how the work of Daniel Bernoulli and Sir Isaac Newton help explain flight. Students will also learn how lift and gravity, two of the four forces of flight, act on an airplane while it is in the air. Additionally, students will experiment with the Bernoulli Principle. Students will relate the Bernoulli Principle to lift. Finally, students will relate the Bernoulli Principle to lift and apply the first and third laws of Sir Isaac Newton to flight.

Objectives

Students will:

1. Explore the Bernoulli Principle, which states that the speed of a fluid (air, in this case) determines the amount of pressure that a fluid can exert. Determine that though two items look identical, they may not have the same density.
2. Relate the Bernoulli Principle to the lift, one of the four forces of flight.
3. Explore, within the context of the Bernoulli Principle activities, how Newton's first and third laws of motion contribute to flight.

Materials:

In the Box

Large paper grocery bag

Scissors

Tape or glue stick

Ruler

Variety of balloon shapes (optional)

2 large balloons

2 lengths of string 30cm each

Straight straw (optional)

1 large trash bag

1 hair dryer or small fan with at least two speeds

1 ping-pong ball

Provided by User

Paper

Assortment of large felt tip markers (washable)

GRADES

Time Requirements: 3 hours

Background

How is it that today's airplanes, some of which have a maximum take off weight of a million pounds or more, are able to get off the ground in the first place, let alone fly between continents? Surprisingly, with today's technological advances, airplanes use the same principles of aerodynamics used by the Wright brothers in 1903. In order to gain an understanding of flight, it is important to understand the forces of flight (lift, weight, drag, and thrust), the Bernoulli Principle, and Newton's first and third laws of motion. Although the activities in this lesson primarily focus on the role the Bernoulli Principle plays in the ability of aircraft to achieve lift, the Bernoulli Principle is not the only reason for flight.

The Forces of Flight

At any given time, there are four forces acting upon an aircraft. These forces are lift, weight (or gravity), drag and thrust. Lift is the key aerodynamic force that keeps objects in the air. It is the force that opposes weight; thus, lift helps to keep an aircraft in the air. Weight is the force that works vertically by pulling all objects, including aircraft, toward the center of the Earth. In order to fly an aircraft, something (lift) needs to press it in the opposite direction of gravity. The weight of an object controls how strong the pressure (lift) will need to be. Lift is that pressure. Drag is a mechanical force generated by the interaction and contract of a solid body, such as an airplane, with a fluid (liquid or gas). Finally, the thrust is the force that is generated by the engines of an aircraft in order for the aircraft to move forward.

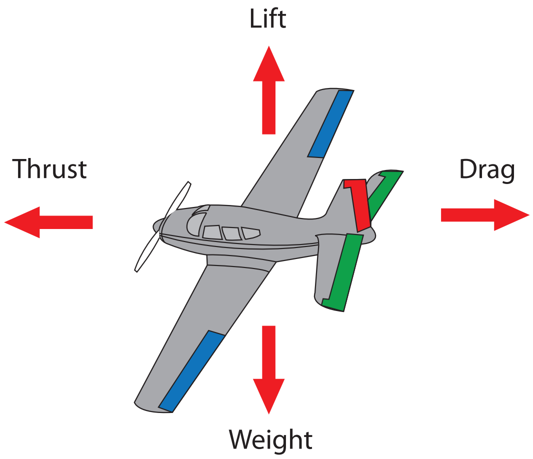
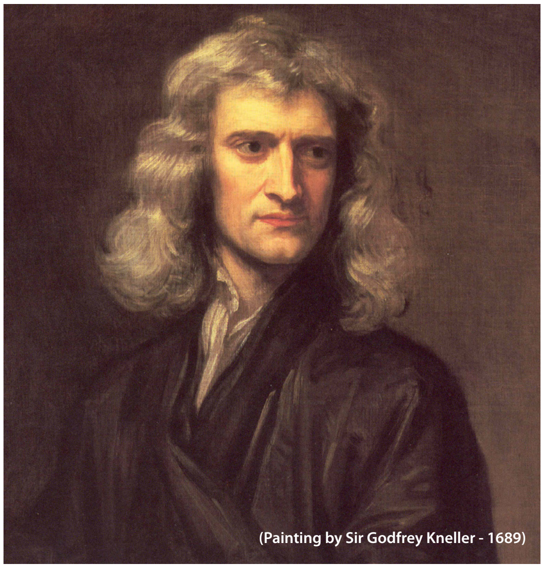


Fig. 1 Four forces of flight

Newton's Laws of Motion

Another essential that applies to understanding how airplanes fly are the laws of motion described by Sir Isaac Newton. Newton (1642 -1727) was an English physicist, mathematician, astronomer, alchemist, theologian and natural philosopher. He has long been considered one of the most influential men in human history. In 1687, Newton published the book "Philosophiae Naturalis Principia Mathematica", commonly known as the "Principia". In "Principia", Newton explained the three laws of motion. Newton's first and third laws of motion are especially helpful in explaining the phenomenon of flight. The first law states that an object at rest remains at rest while an object in motion remains in motion, unless acted upon by an external force. Newton's second law states that force is equal to the change in momentum per change in time. For constant mass, force equals mass times acceleration or $F=m\cdot a$. Newton's third law states that for every action, there is an equal and opposite reaction.



Img. 1 Sir Isaac Newton (age 46)

The Bernoulli Principle

Daniel Bernoulli (1700 – 1782) was a Dutch-born scientist who studied in Italy and eventually settled in Switzerland. Born into a family of renowned mathematicians, his father, Johann Bernoulli, was one of the early developers of calculus and his uncle Jacob Bernoulli, was the first to discover the theory of probability. Although brilliant, Johann Bernoulli was both ambitious for his son Daniel and jealous of his son's success. Johann insisted that Daniel study business and later medicine, which Daniel did with distinction. It was mathematics, however, that really captured Daniel's interest and imagination. Despite Daniel's best efforts, Johann never acknowledged his son's brilliance and even tried to take credit for some of Daniel's most important ideas.

Img. 2 Daniel Bernoulli

After Daniel's studies, he moved to Venice where he worked on mathematics and practical medicine. In 1724, he published Mathematical exercises, and in 1725 he designed an hourglass that won him the prize of the Paris Academy, his first of ten. As a result of his growing fame as a mathematician, Daniel was invited to St. Petersburg to continue his research. Although Daniel was not happy in St. Petersburg, it was there that he wrote "Hydrodynamica", the work for which he is best known.

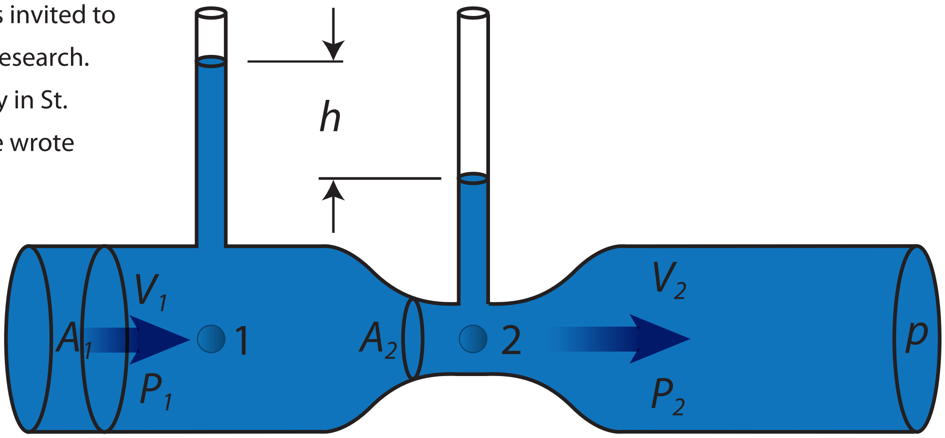


Fig. 2 Bernoulli fluid experiment

Bernoulli built his work off of that of Newton. In 1738, he published "Hydrodynamica", his study in fluid dynamics, or the study of how fluids behave when they are in motion. Air, like water, is a fluid; however, unlike water, which is a liquid, air is a gaseous substance. Air is considered a fluid because it flows and can take on different shapes. Bernoulli asserted in "Hydrodynamica" that as a fluid moves faster, it produces less pressure, and conversely, slower moving fluids produce greater pressure.

We are able to explain how lift is generated for an airplane by gaining an understanding of the forces at work on an airplane and what principles guide those forces. First, it takes thrust to get the airplane moving - Newton's first law at work. This law states that an object at rest remains at rest while an object in motion remains in motion, unless acted upon by an external force.

Then because of the shape of an airplane's wing, called an airfoil, the air into which the airplane flies is split at the wing's leading edge, passing above and below the wing at different speeds so that the air will reach the same endpoint along the trailing edge of the wing at the same time. In general, the wing's upper surface is curved so that the air rushing over the top of the wing speeds up and stretches out, which decreases the air pressure above the wing. In contrast, the air flowing below the wing moves in a straighter line, thus its speed and pressure remain about the same. Since high pressure always moves toward low pressure, the air below the wing pushes upward toward the air above the wing. The wing, in the middle, is then "lifted" by the force of the air perpendicular to the wing. The faster an airplane moves, the more lift there is. When the force of lift is greater than the force of gravity, the airplane is able to fly, and because of thrust, the airplane is able to move forward in flight. According to Newton's third law of motion, the action of the wings moving through the air creates lift.

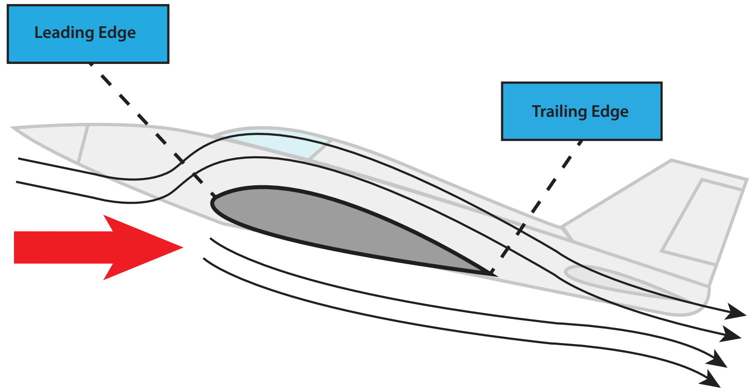


Fig. 3 Airfoil

Activity 1 Bernoulli and the Paper Bag Mask

GRADES K-4

Time Requirements: 45 minutes

Materials:

Note to the Teacher: Decide if you are going to present this activity as a demonstration or as a hands-on learning experience for the whole class. For a demonstration, you will only need one of each item. For a hands-on class activity, you will need one set of the materials for every two students so that your students may work in pairs.

In the Box

Large paper grocery bag

Scissors

Tape or glue stick

Ruler

Variety of balloon shapes (optional)

Provided by User

Paper

Assortment of large felt tip markers (washable)

Worksheets

Bernoulli Experiment Log (Worksheet 1)

Student Activity Directions (Worksheet 2)

Reference Materials

None

Objective:

Students will learn about the position and motion of objects as they:

1. Create a paper bag mask to experiment with the Bernoulli Principle.
2. Explain how the Bernoulli Principle applies to the movement of the paper tongue attached to the paper bag mask.
3. Explain how the phenomenon they experienced in the paper bag mask activity relates to flight (lift).
4. Understand the effect of air flowing over a curved surface.

Activity Overview:

Students will make a paper bag mask with a protruding paper tongue, which they will use to experiment with the Bernoulli Principle. The students will be able to explain the Bernoulli Principle after they have observed it in action during the experiment.

Activity:

1. **If all of your students are going to participate in this activity, have the directions for the activity written on the board or make a copy of the direction sheet for each student or pair of students.**

2. **Ask the students this question: *How do airplanes, some of which weigh a million pounds, fly?***
   Students' responses will vary but look for and encourage a response that includes weight or gravity. Tell the students that in order to fly, airplanes must overcome gravity, a force that wants to keep the airplane on the ground.

3. **Explain to the students that in order to overcome gravity, airplanes have to achieve lift, a force that opposes (or pushes against) gravity.** The greater the weight of the airplane, the greater the lift required.

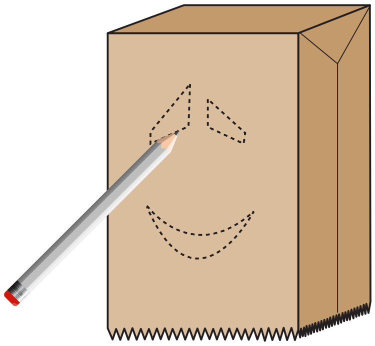
4. **Explain to the students that today they will learn about a scientific principle that will help them understand lift.** Tell the students that the principle is called the Bernoulli Principle; it is named after the man who discovered it. (Here you can give the students some simple background information about Daniel Bernoulli. You may also show the students his picture.)

Key Terms:

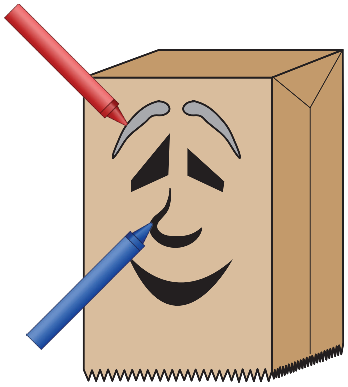
Air pressure
Air foil
Bernoulli Principle
Fluid
Force
Gravity
Lift

5. **Explain that the Bernoulli Principle states that slower moving fluids create greater pressure (force) than faster moving fluids.** Tell the students that air is a fluid because it flows and can change its shape. Inflate balloons of different sizes and shapes to make this point. You may also need to clarify your students' understanding of the concept of "pressure" by comparing pressure to a push. A push may be light, or a push may be hard.

6. **To begin, place a large paper grocery bag over the head of a student and have a second student use a felt tip marker to carefully draw small dots where the eyes, nose, and mouth of the student are located.**



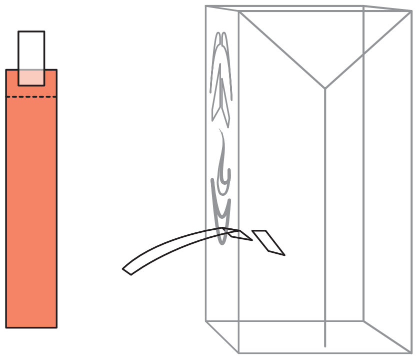
7. **Remove the bag from the student's head and draw a face around the marks made in step 1.**



8. **Cut out holes (approximately 1 inch in diameter) for each eye.**

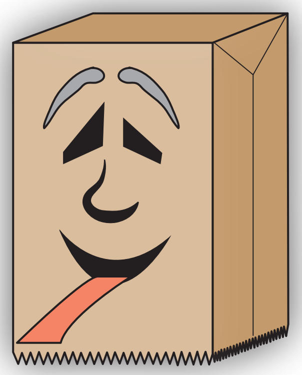
9. **Next, cut a mouth-shaped hole approximately 2 inches in height at the widest point, the middle, of the mouth.** *Have the students use safety scissors for this portion of the activity or have additional adults in the room to supervise.*

10. **To make the tongue, cut a strip of printer/ copier paper approximately 1½ inches wide and 8 inches long.**



11. **Fold down one end of the tongue to create a ¼ inch tab.** Tape or glue the tab to the inside of the bag along the lower middle edge of the mouth. The rest of the tongue should be hanging out of the mouth.

12. **Place the bag over a student's head and instruct the student to blow through the mouth hole with an even stream of air while the rest of the students observe the movement of the tongue.** (If this is being done in pairs, the partner who is not wearing the bag will do the observing.) Have the student wearing the bag vary the strength with which he or she blows. Remind students to keep a steady flow of air and to not just give a quick burst of air. Students will compare the effect of a gentle blow to the effect of a harder blow. If students are working in pairs, have them take turns wearing the bag and observing. (Students will notice that a gently blown stream of air will cause the tongue to rise, but a more forcefully blown stream of air will not lift the tongue at all.)



13. **Students record their observations on the Bernoulli Experiment Log.**

14. **After the experiment, show a diagram of the cross-section of an airplane wing (also called an airfoil).**

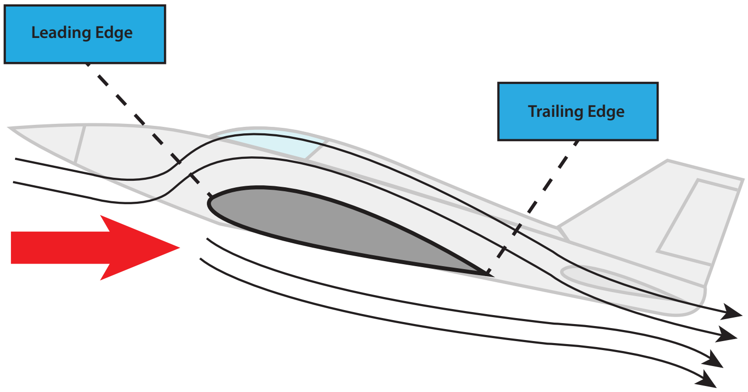


Fig. 3 Airfoil

15. **Tell the students that the wing of an airplane is shaped in order to control the speed and pressure of the air flowing around it.** Air moving over the curved upper surface of the wing will travel faster and thus produce less pressure than the slower air moving across the flatter underside of the wing. This difference in pressure creates lift which is a force of flight that is caused by the imbalance of high and low pressures.

16. **Relate this information to the paper bag mask by saying this: Another example of Bernoulli's Principle was seen in our paper bag mask(s).** When the air we blew over the curved surface of the paper tongue was faster than the air under the tongue, the unequal air pressure lifted the tongue in the same way an airplane wing produces lift.

NATIONAL SCIENCE STANDARDS K-4

SCIENCE AS INQUIRY

• Abilities necessary to do scientific inquiry

• Understanding about scientific inquiry

PHYSICAL SCIENCE

• Position and motion of objects

SCIENCE AND TECHNOLOGY

• Abilities of technological design

• Understanding about science and technology

Activity 2 Balloon Magic

GRADES K-4

Time Requirements: 60 minutes

Materials:

Note to the Teacher: Decide if you are going to present this activity as a demonstration or as a hands-on learning experience for the whole class. For a demonstration, you will only need one of each item. For a hands-on class activity, you will need one set of the materials for every two students so that your students may work in pairs.

In the Box

2 large balloons

2 lengths of string 30cm each

Straight straw (optional)

1 large trash bag

Provided by User

None

Worksheets

Bernoulli Experiment Log (Worksheet 1)

Student Activity Directions (Worksheet 2)

Reference Materials

None

Objective:

Students will learn about the position and motion of objects as they experiment with the Bernoulli Principle using a pair of inflated balloons that are suspended at the same height though several inches apart. By blowing air directly between the balloons, students will demonstrate the Bernoulli Principle and then explain the phenomenon to their classmates.

Activity Overview:

In this activity, students will experiment with the speed of the airflow between two suspended balloons, observing how fast moving air creates an area of low pressure and how high pressure moves toward low pressure.

Activity:

1. **Review what the students have learned so far about the Bernoulli Principle.** *Faster moving air equals less air pressure than slower moving air.*

   Also review what the students have learned so far about lift. *Lift is the force that opposes gravity and helps an airplane to fly. Lift is achieved in part by the design of an airplane's wing. Air moves more quickly over the curved upper surface of the wing than it does under the wing, which has a flatter surface. The faster moving air produces less pressure than the slower moving air, causing the wing to lift toward the area of low pressure.*

2. **Now tell the students that they will explore the Bernoulli Principle again, but this time the activity will involve balloons.** If you are going to allow pairs of students (3rd and 4th grade) to construct their own experiment, caution the students about over-inflating the balloons.

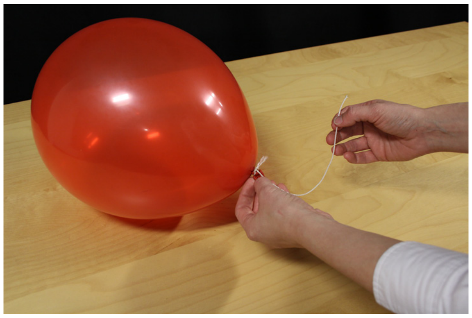
Key Terms:

Air flow
High pressure
Low pressure

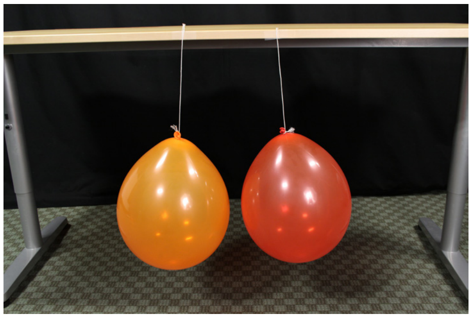
3. **Follow these directions below to conduct the experiment.**
   a. Inflate two balloons, tying off the end of each balloon.
   Teachers may wish to do this in advance. It is a good idea to keep the inflated balloons together by placing them in a large trash bag.

   b. Cut two pieces of string each 30 cm in length.
   Teachers may wish to have the strings cut in advance, too.

   c. Tie the end of each string to one balloon so that when you are finished, you have each balloon tied to its own string (students may need help).



   d. Tape the loose end of each string to the underside of a table, to a window or doorframe, or to any other ledge that will allow the balloons to dangle in an open space about 5 cm apart.



   e. Use the straw to blow between the balloons, varying the amount and the speed of the airflow.

   f. Observe what happens.
   Note: The balloons will come together when the students blow more forcefully.

   g. Record your results .

4. **After the experiment, have the students share their observations and any of their conclusions.**

5. **Explain that the balloons came together when the students blew through the straw with greater force because of the Bernoulli Principle, which states that faster moving air exerts lower pressure.** Tell them that when they blew air more forcefully between the two suspended balloons, they created an area of low pressure. Since the air pressure between the two balloons was not as great as the air pressure around the rest of each balloon, the balloons move toward each other because high pressure pushes toward low pressure.

6. **Relate this experiment to the paper bag mask. Ask:** ***How are the results of this experiment similar to those of the paper bag mask?***
   Answers will vary but may include ideas such as faster moving air exerts lower pressure and slower moving air exerts higher pressure.

NATIONAL SCIENCE STANDARDS K-4

SCIENCE AS INQUIRY

• Abilities necessary to do scientific inquiry

• Understanding about scientific inquiry

PHYSICAL SCIENCE

• Position and motion of objects

SCIENCE AND TECHNOLOGY

• Abilities of technological design

• Understanding about science and technology

Activity 3 — The Floating Ball Demonstration

GRADES K-4

Time Requirements: 30 minutes

Materials:

In the Box

1 ping-pong ball

1 hair dryer or small fan with at least two speed

Provided by User

None

Worksheets

Bernoulli Experiment Log (Worksheet 1)

Reference Materials

Photo of Sir Isaac Newton (Image 1)

Key Terms:

Airstream

Discrepent event

Gravity

Newton's Laws of Motion

Objective:

In this activity students will learn about position and motion of objects as they observe a discrepant event in which the Bernoulli Principle and Newton's First Law of Motion are demonstrated. Students will analyze what they learned from this activity and classify that information according to two criteria:

1. What previously learned information was reinforced from this activity?
2. What new information was learned from this activity?

Activity Overview:

In this activity students will observe a discrepant event in which the Bernoulli Principle and Newton's first law of motion will be demonstrated. The discrepant event will involve placing a ping-pong ball into a stream of air generated by a hair dryer and exploring the conditions under which the ball "floats" in the air.

Activity:

Note: Prior to starting this activity, you may wish to practice balancing the ping pong ball in the air stream to ensure a seamless demonstration.

1. **Review the Bernoulli Principle with the class.** Write the explanation in the students' words on the board.
2. **Review the two vertical forces at work on an airplane in flight.** Students may need prompting, but get them to identify gravity and lift. Again, write the definitions for those two terms on the board using the students' words.
3. **Tell the students that the class will explore Bernoulli again, but this time the teacher will demonstrate the activity.**
4. **Show the students the materials for the activity, and explain that you are about to show them a trick that will almost look like magic, but what they are about to see can be explained by the science they have been learning.**
5. **Begin by asking the students if the hair dryer can make the ping-pong ball float?** Discuss students' responses, prompting them to elaborate and clarify by asking "why" and "how" when appropriate.

6. **Turn the hair dryer on and aim it toward the ceiling, producing a vertical stream of air.**

7. **Place a ping-pong ball directly over the nozzle of the hair dryer and into the stream of air.** The ball will appear to be floating in the air.

8. **Ask the students to explain what the ball is floating on (air).**

9. **Ask: Which air is moving faster, the air coming from the hair dryer or the air around the hair dryer?**
   The air coming from the hair dryer.

10. **Ask: Which air is exerting a greater amount of pressure?**
    The air around the hair dryer.

11. **Ask the students if they can explain why the ping-pong ball stayed in place while the hair dryer was on?**
    The slower moving air around the ball is holding the ball in place because the slower moving air exerts a greater amount of pressure than the faster moving air coming from the hair dryer.

12. **Ask: What will happen if we turn off the hair dryer? What will happen if we turn the hair dryer down?**
    The ball will fall because there is no air flow there to hold it up.

13. **After changing the direction of the hair dryer and turning if off and then on again, check to see of your students' predictions are correct.** Remind the students that there is another force acting on the ball, a force that acts on all things – gravity. Ask students to define gravity. (Though their understanding will be limited, they may say that gravity is the force that causes things to fall.) Remind students that gravity is one of the four forces of flight they have been learning about (lift is another). Gravity wants to pull everything toward the center of the earth.

14. **Explain that when the force of gravity becomes greater than the force of the air, the ball falls.**

15. **Turn the hair dryer on again, "float" the ping-pong ball, and tilt the hair dryer slightly at first, then more severely.** The ball should move along with the hair dryer for a while, but when the hair dryer is tilted too far, the ball will fall to the ground. This will be the point at which gravity will have overtaken the lift produced by the faster moving air.

16. **Ask the students why the ping-pong ball eventually fell when the hair dryer was tilted too far toward the floor.** Answers will vary and it is likely that you will need to explain that gravity will have overtaken the lift produced by the faster moving air coming out of the hair dryer.
    Explain that as long as there was equilibrium, or a correct balance between the forces acting on the ball, the ball stays floating in place, but when equilibrium is lost and one force becomes greater than another, the greater force takes over. When the force of gravity became greater than the force of the air around the ball, gravity took over, causing the ball to fall.

17. **Show the students a picture of Sir Isaac Newton.** Introduce him as the scientist who can offer a explanation for what we just observed in procedures 7 – 10 of the experiment. Tell the students that Newton wrote special laws called the Laws of Motion. Sir Issac Newton's laws of motion help us predict and explain the motion of objects and the forces that act on those objects, causing them to move.

18. **Ask the students how this particular law relates to our experiment.** Which part of our experiment might we identify as the object from Newton's first law?
    Students may identify the ping-pong ball as the object.

    Which part of our experiment provided the force acting on the ball?
    Students may identify the hair dryer as the source of the force.

19. **Ask the students if the ping-pong ball in our experiment acted according to the first part of the law.** In other words did it stay in motion?
    Students will say yes.

20. **Ask the students to identify the point at which ball changed its motion.**
    When we tilted the dryer, turned off the dryer or turned the force of the dryer down.

21. **Ask the students to identify the point in the experiment when the forces became unbalanced.**
    This occurred when the force of gravity became greater than the air pressure from the hair dryer.

22. **Ask: What did you observe today that supported what you already knew from this lesson?**
    Students may talk about the speed of air and air pressure.

23. **Ask: What did you learn today that you didn't know before?**

24. **List students' answers to these two questions on the board on a T-chart:**

What did I observe today that reinforced what I already knew?	What new information did I learn today?

NATIONAL SCIENCE STANDARDS K-4

SCIENCE AS INQUIRY

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

PHYSICAL SCIENCE

- Position and motion of objects

SCIENCE AND TECHNOLOGY

- Abilities of technological design
- Understanding about science and technology

Activity 4 — A Letter to the Teacher

GRADES K-4

Time Requirements: 45 minutes

Materials:

In the Box

None

Provided by User

Paper

Notes taken from the previous activities

Worksheets

Bernoulli Experiment Log (Worksheet 1)

Student Activity Directions (Worksheet 2)

Reference Materials

None

Key Terms:

None

Objective:

Students will write a paragraph about what they have learned in this lesson, incorporating new vocabulary and concepts.

Activity Overview:

In this activity students will recall all that they have learned from the previous activities about the forces of flight, the Bernoulli Principle and Newton's Laws of Motion.

Activity:

1. **To conclude the lesson, have the students write a brief paragraph (3 – 5 sentences) that answers the question asked at the beginning of the lesson:** ***How do airplanes fly?***

2. **In their paragraphs, students may include any of the ideas the teacher recorded on the board during activities or any ideas the students recorded on their Bernoulli Experiment Logs.**

3. **In order to help the students recall what they have learned, provide a word bank with the following words and terms:**

Air pressure	Airstream	Force	Lift
Airflow	Bernoulli Principle	Gravity	Low pressure
Airfoil	Fluid	High pressure	Newton's Laws of Motion

NATIONAL SCIENCE STANDARDS K-4

SCIENCE AS INQUIRY

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

SCIENCE AND TECHNOLOGY

- Abilities of technological design
- Understanding about science and technology

Reference Materials

Glossary

Air pressure:
The amount of pressure air is able to exert on substances or objects; air pressure can be high or low, depending on the speed at which it travels

Air flow:
The air flowing past or through a moving object

Airfoil:
Any surface designed to help lift an aircraft with the use of air current

Airstream:
A current of air

Bernoulli Principle:
The principle that states that as the speed of a moving fluid (liquid or gas) increases, the pressure within the fluid decreases law that pressure in a fluid decreases

Discrepent event:
An event that goes against what is expected

Fluid:
A substance that can easily change its shape and is capable of flowing

Force:
A push or pull on an object

Gravity:
A pull between two objects based on their mass

High pressure:
Having a high barometric pressure

Lift:
Lift is the force that directly opposes the weight of an airplane and holds the airplane in the air. Although generated by every part of an airplane, wings generate the most lift. Lift is a mechanical aerodynamic force produced by the motion of the airplane moving through the air.

Low pressure:
Having a low barometric pressure

Newton's Laws of Motion:
Newton's laws of motion are three physical laws that describe the relationship between the forces acting on an object and the object's motion due to those forces. The laws can be summarized as follows:

First law: The velocity of a body remains constant unless the body is acted upon by an external force.
Second law: The acceleration of a body is parallel and directly proportional to the net force (F) and inversely proportional to the mass (m). Therefore $F = m \cdot a$.
Third law: The mutual forces of action and reaction between two bodies are equal and opposite.

Fig. 1 Four forces of flight

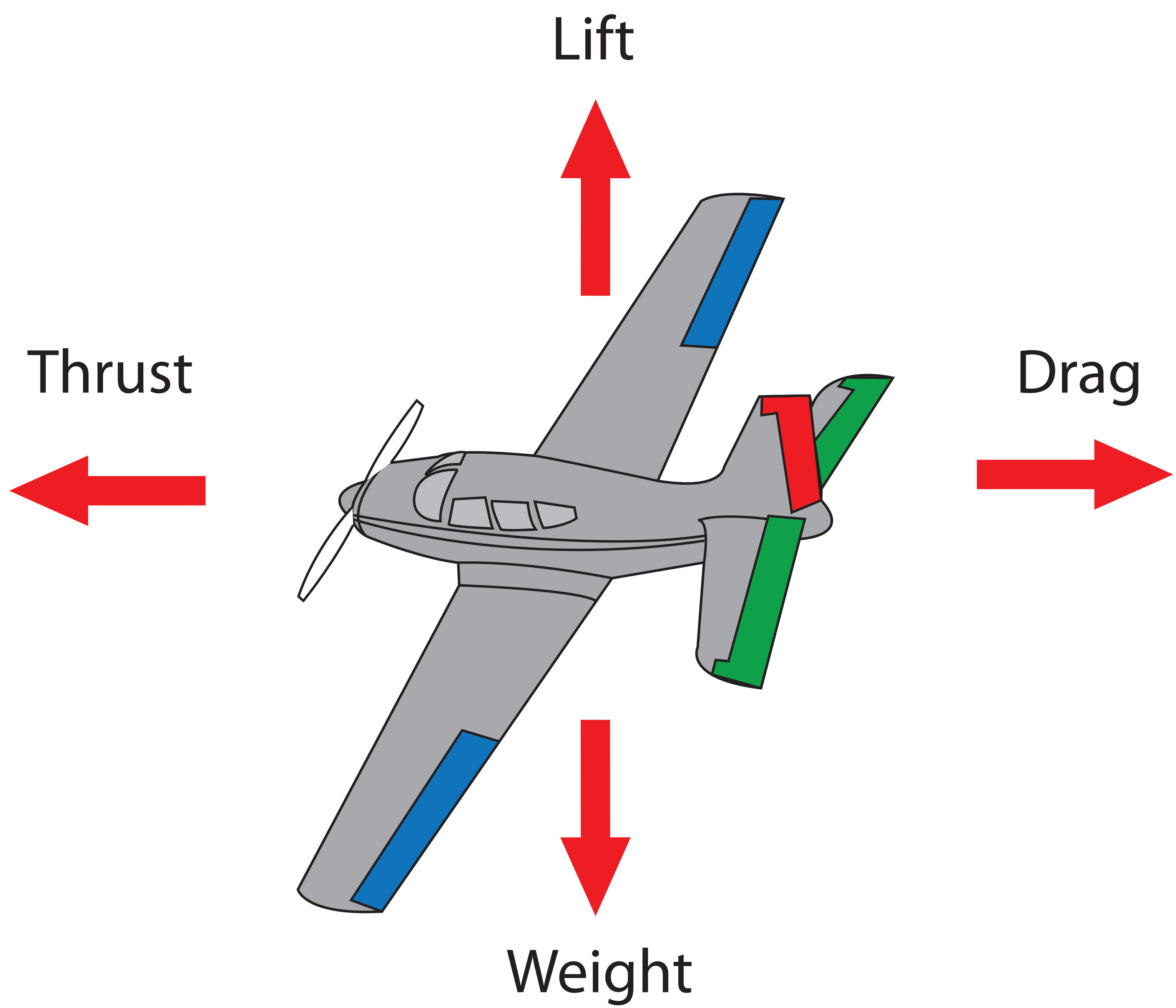


Fig. 2 Bernoulli fluid experiment

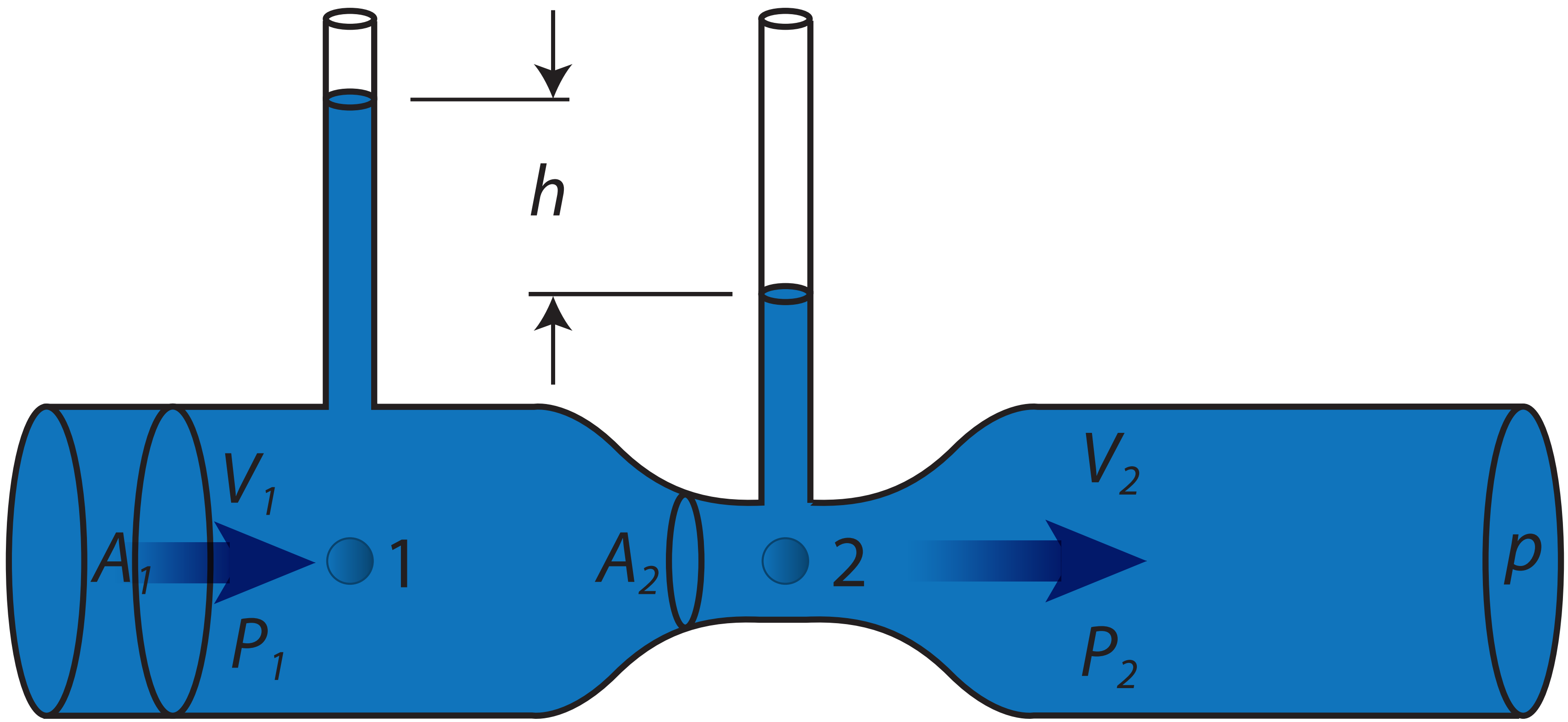
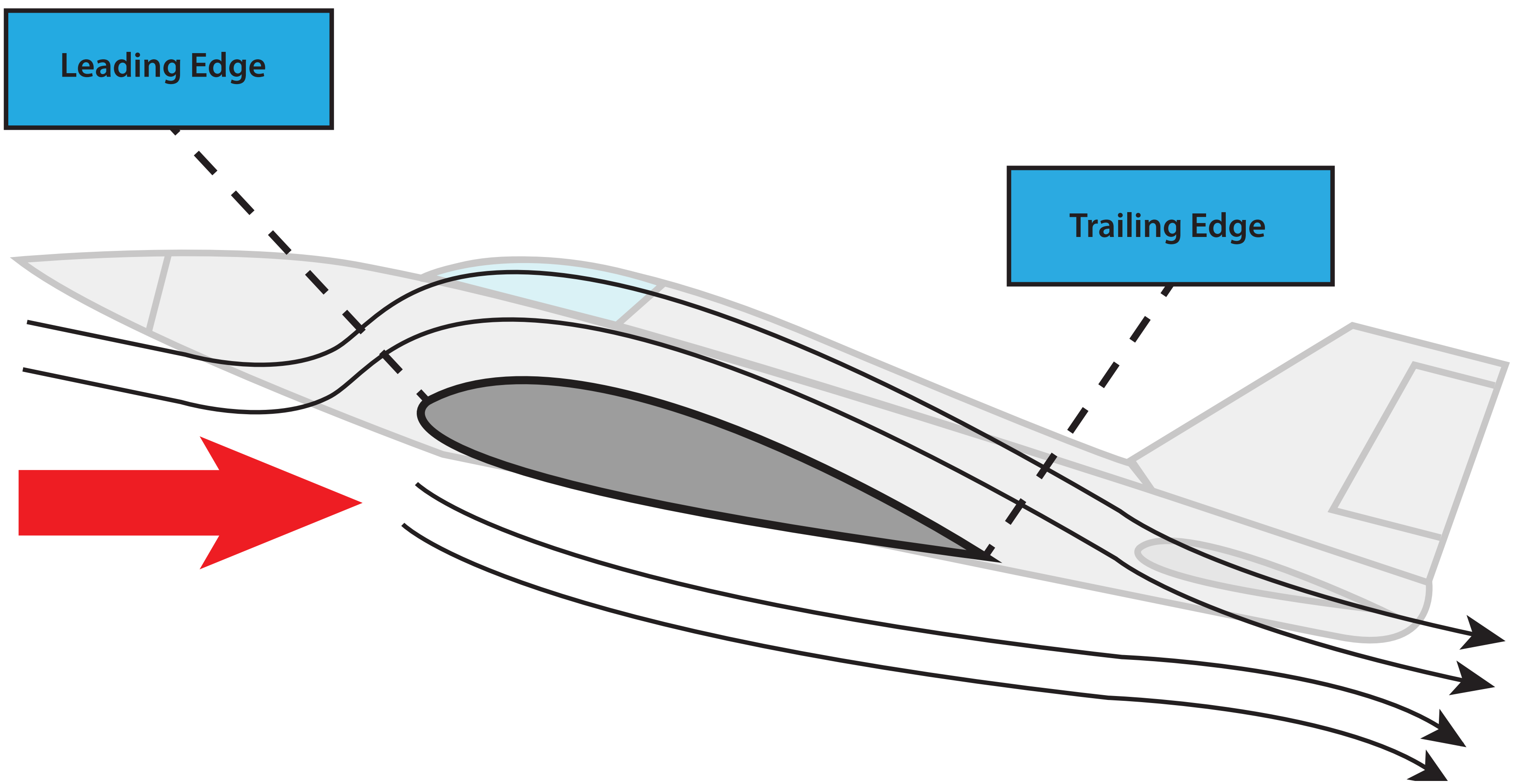


Fig. 3 Airfoil



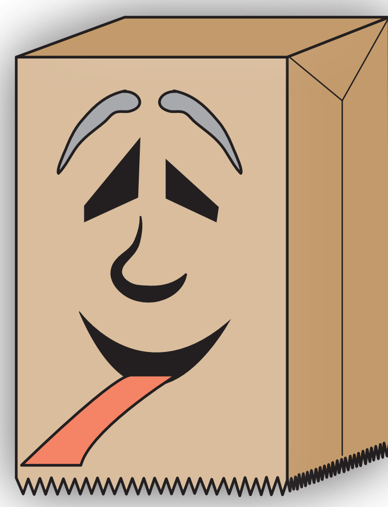
Worksheets

Worksheet 1 Bernoulli Experiment Log

After your teacher introduces the activity and you have read the Student Activity Instructions Page, predict what you think will happen in each activity. Then after you complete each activity, record what you observed during the activity. Finally, after you learn more about the Bernoulli Principle, give reasons for the outcome of each activity including how the outcome relates to the Bernoulli Principle. Write all of your responses in the boxes below.

Activity	**What do you think will happen?** ***Predict***	**What happened?** ***Observe***	**Why did it happen?** ***Conclude***
Paper Bag Mask			
Balloon Magic			
Floating Ball			

Worksheet 2 Student Activity Instructions



Activity #1 Paper Bag Mask

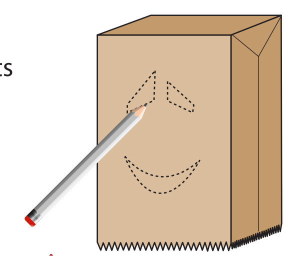
Materials:

One set per pair of students

- Large paper grocery bag
- Scissors
- Tape or glue stick
- Paper
- Ruler
- Assortment of large felt tip markers (washable)
- Variety of balloon shapes (optional)

Instructions for the Activity:

1. Place a bag over the head of one student and have a second student carefully draw small dots where the eyes, nose, and mouth are located.



2. Remove the bag from the head and draw a face around the marks made in step 1.

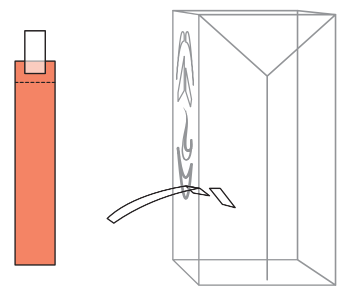
Worksheet 2 (cont.)

Student Activity Instructions

3. Cut out two holes (approximately 2 cm diameter) for the eyes.

4. Cut a hole (approximately 4 cm diameter) for the mouth.

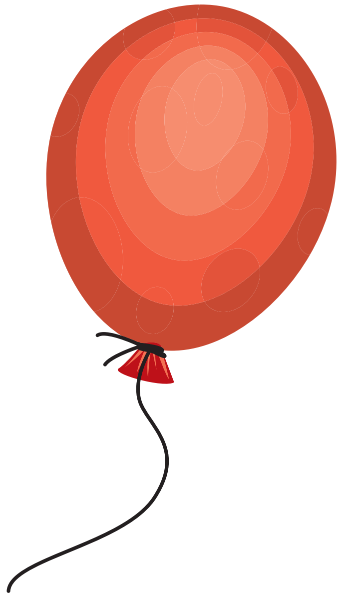
5. To make the tongue, cut a strip of paper, approximately 3 cm wide and 20 cm long.



6. Tape or glue one end of the tongue inside the bag at the bottom of the mask's mouth. Allow the tongue to droop through the mouth on the outside of the bag.

7. Place the bag over the head and blow through the mouth hole. Observe the movement of the tongue.

Student Activity Instructions



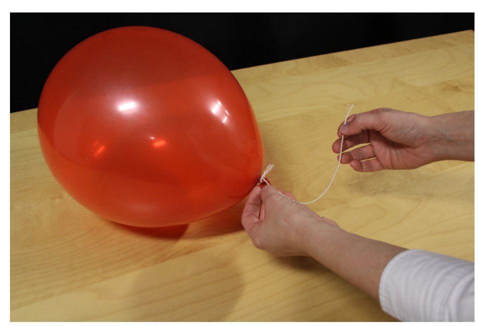
Activity #2 Balloon Magic

Materials:

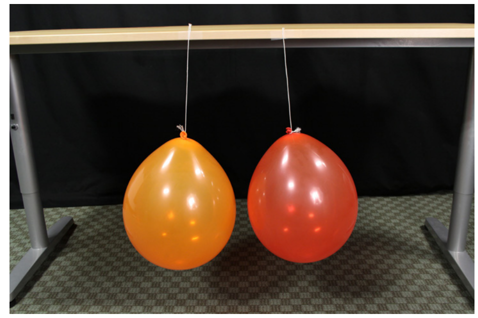
- 1 hair dryer or small fan with at least two speeds
- 1 ping-pong ball

Instructions for the Experiment:

1. Inflate two balloons, tying off the end of each balloon.
2. Cut two pieces of string each 30 cm in length.
3. Tie the end of each string to one balloon so that when you are finished you have each balloon tied to its own string.



4. Tape the loose end of each string to the underside of a table, to a window or doorframe, or to any other ledge that will allow the balloons to dangle in an open space about 5 cm apart.



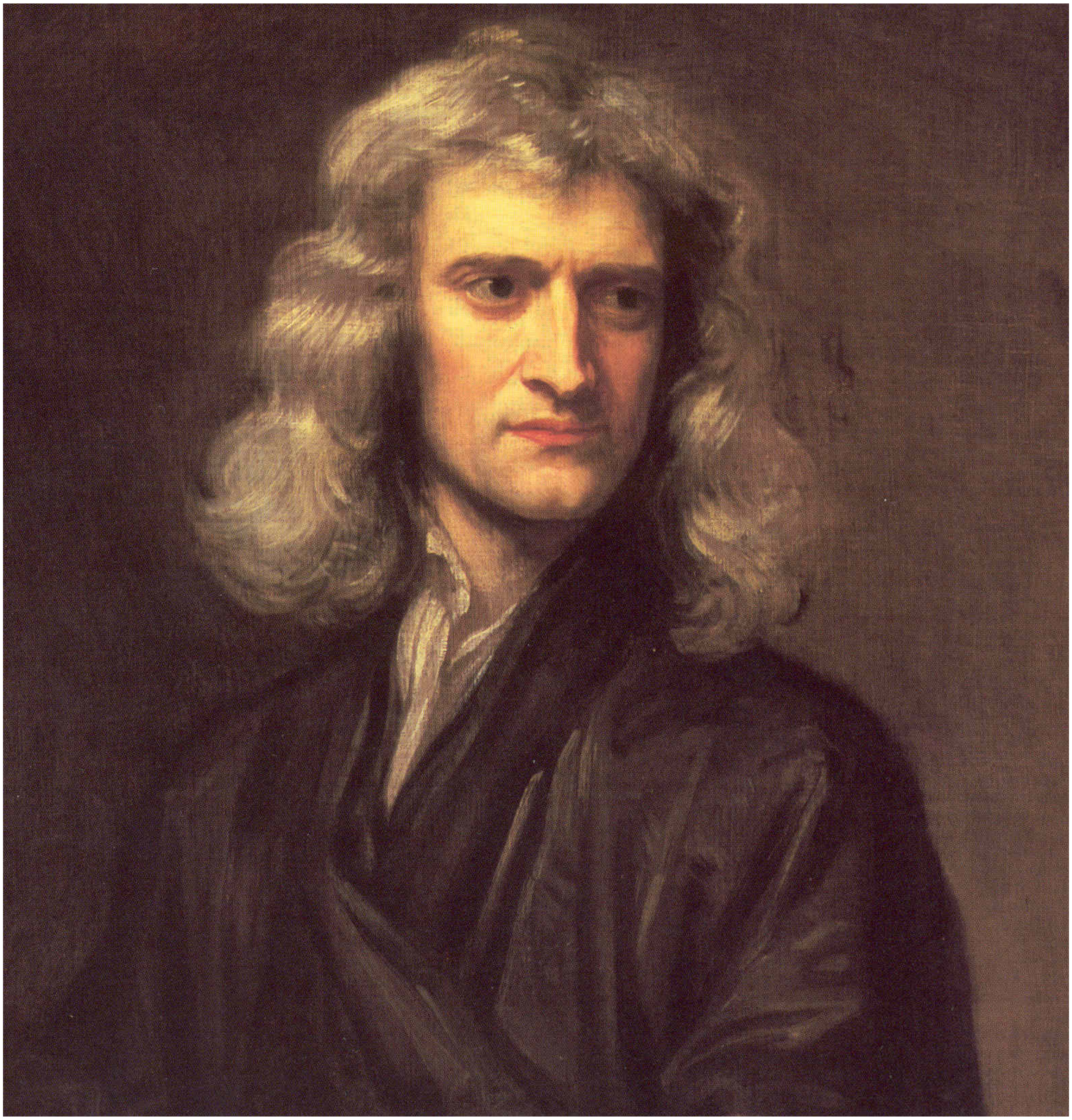
5. Use the straw to blow between the balloons, varying the amount and the speed of the airflow.

6. Observe what happens.

7. Record your results.

Images

Img. 1 Sir Isaac Newton (age 46)



(Painting by Sir Godfrey Kneller - 1689)

Img. 2 Daniel Bernoulli

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