

THE SCIENCE OF AIR

Credit goes to NASA, Modified for the EAA

Concepts Illustrated:

1. Air possesses mass and weight
2. Gas pressure as force exerted by a gas for every 1in^2 or 1ft^2 or 1m^2 of surface area.
3. Fluids (including gases) exert upward forces due to pressure differences in the fluid called buoyant forces.

Time Requirements: 120 Minutes

Grade Level of Audience: This group of activities are primarily suited for kids in grades 3-5.

Mini Lesson One: Air Takes Up Space

I. Materials and Equipment Utilized

- (Materials needed for a group of 20 students)
- (10) 20 ounce plastic soda bottles
 - (10) small funnels
 - (10) soda straws
 - modeling clay
 - (10) cups (to be filled with water)
 - (20) water glasses
 - (10) large dish pans or other containers filled with water

II. Description of Set-up and/or Construction of Apparatus

1. Seal the funnel tightly into the neck of the bottle with modeling clay. Pour the cup of water into the funnel *quickly*.

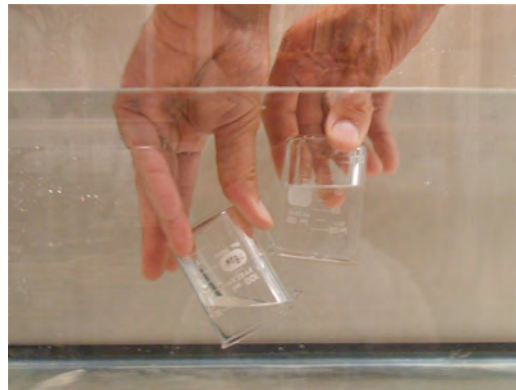


2. The water stays in the funnel because the air in the bottle cannot get out (air takes up space).

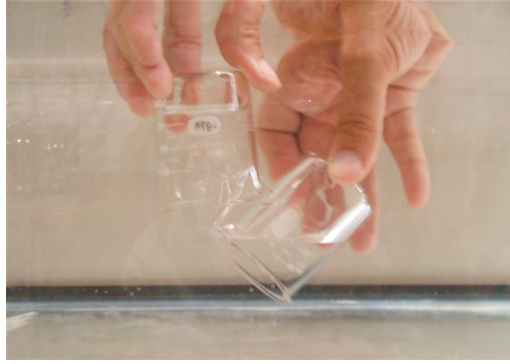
1. Pass the straw through the funnel into the bottle. Suck out a mouthful of air. Some of the water goes down into the bottle, taking the place of the air sucked out.



2. Carefully tilt the air-filled glass under the water filled glass. By doing this, you can pour the air up in bubbles. Each bubble is a little package of air made visible by being in the water.



3. With a little practice, you can keep pouring the air back and forth without losing any of it.



Mini Lesson Two: Air Takes Has Mass (and Therefore, Weight)

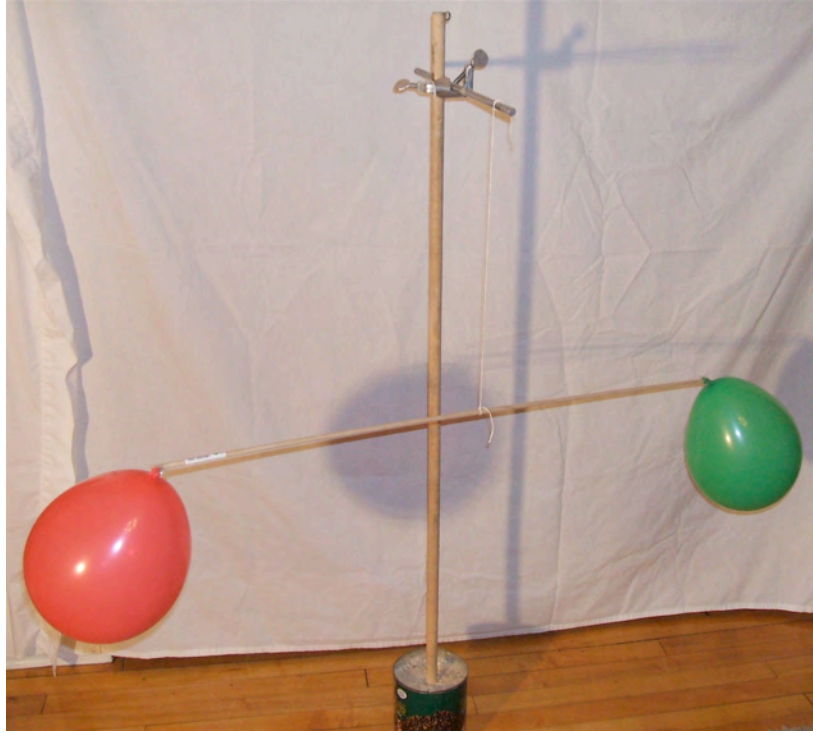
I. Materials and Equipment Utilized

(Materials needed for a group of 20 students)

1. (10) 1' lengths of $\frac{1}{4}$ " dowels
2. (20) identical balloons
3. (10) pins
4. (10) pieces of string, 3' each
5. (10) balls (basketballs, playground kick balls, footballs)
6. electronic balance (mailing grade balances may be obtained at Office Max or Staples)
7. air pump or air compressor with inflation needle

II. Set-up of Apparatus

1. Blow up the balloons to the same size and tie them at their necks with small pieces of string. Tie one balloon to each end of the dowel stick.
2. Attach the remaining string to the center of the dowel and suspend it from the ceiling, a ring stand, or some other convenient location.



3. Balance the dowel. Prick one of the balloons with a pin. As the air rushes out, note which end goes down and which end goes up.



4. Squeeze all of air possible out of the ball and then weigh it.



4. Blow up the ball again and weigh it. Compare the weight of the deflated ball to the weight of the inflated ball.



Mini Lesson Three: Air Exerts Pressure

I. Materials and Equipment Utilized

(Materials needed for a group of 20 students)

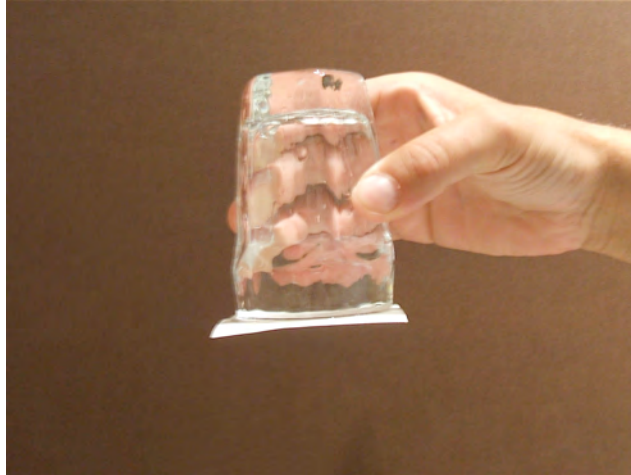
1. (10) water glasses
2. (10) small pieces of cardboard
3. (10) square, flat, rubber floor mats
4. 10 small dowels
5. 10 small washers and 10 flat head, 1" screws
6. (20) large, flat rubber sink stoppers
7. 3 aluminum cans (instructor demo)
8. small ice water bath (instructor demo)
9. hot plate or burner
10. Hot Hand or tongs to move hot aluminum can (instructor demo)

II. Description of Set-Up and/or Construction of Apparatus

1. Fill the glass to the top with water. Place the small piece of cardboard over the glass. Carefully turn the glass upside down, holding the cardboard tightly to the glass.



2. Take your hand away from the cardboard. The cardboard stays in place against the glass. Tilt the glass or hold it sideways, and the cardboard still remains in place.



3. Poke a small hole in the center of the rubber floor mat using a nail or an awl. Drill a small pilot hole in the center of one end of the dowel. Place the screw through the washer and hole in the rubber mat and screw into pilot hole in the dowel. The dowel will serve as a handle for your pressure mat.



4. Wet the surface of the two flat rubber sink stoppers. Press the stoppers together, such that there is no remaining air between them. It is now difficult to pull them apart until some air is introduced between them.
5. Put about a $\frac{1}{4}$ " of water in the aluminum can and heat over the burner or hot plate until the water is boiling and you clearly see water vapor coming out of the opening of the can.



Carefully, but quickly, remove the can and invert the opening in an ice water bath. The can will implode nearly instantaneously.



III. Details of Student Implementation

1. The air envelope around the earth extends about 500 miles above us. It is made of very tiny molecules barely measurable. One column of air, one square inch from earth to outer space weighs about 15 pounds. Since moving air particles have mass, they exert a force against anything they touch as a result of the collisions they have with all surfaces. Air presses upward, downward, sideways-every way. In fact, air presses on all sides of our bodies, but we do not notice it because our bodies are created, develop, and grow subject to this constant application of force.
2. **Pressure** is defined as the force exerted for each standard surface area of 1 square unit. Therefore, the atmospheric pressure near the surface of the earth is approximately 15 pounds for every 1 square inch of surface area.
3. Application of the rubber mat to smooth surfaces results in the removal of air between the rubber mat and the smooth surface. The atmospheric pressure on the bottom side of the smooth surface and on the top side of the rubber mat, with the lower pressure between the rubber mat and the smooth surface, allows for the mat to be stuck to the surface. The difference in pressure may even allow a metal stool to be picked up by the mat.
4. This same phenomena occurs with the two flat, rubber sink stoppers.
5. When the aluminum can has boiling water inside of it, the temperature of the air and the water vapor inside of the can is much higher than the air outside of the can. As a result, fewer particles are needed inside of the can to maintain atmospheric pressure through the open top.
6. Once the open end of the can is submerged in an ice water bath, two important things happen. First of all, the pressure inside the can rapidly drops as the water vapor condenses from gas to liquid (taking up much less space). Secondly, with the open end of the can under water, air is prevented from quickly entering the can to equalize the pressure (although, a small amount of water does enter the can).
7. The result: The higher atmospheric pressure outside the can implodes the much lower pressure inside of the can.

Mini Lesson Four: Moving Air Exerts A Lower Pressure, Resulting In Lift

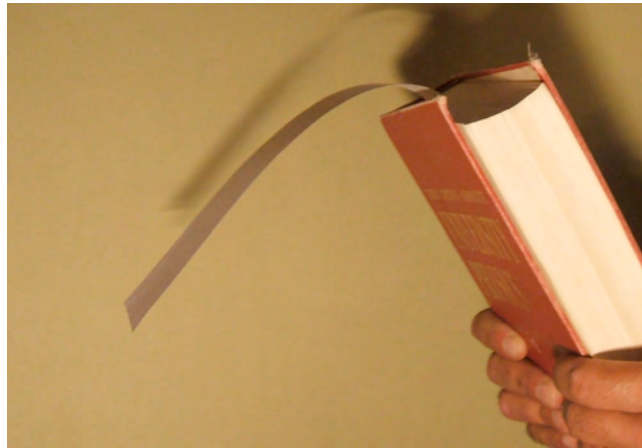
I. Materials and Equipment Utilized

(Materials needed for a group of 20 students)

1. (10) books
2. (10) strips of paper Notebook or newspaper, 10" x 2"
3. (40) small paper clips
4. (10) spools
5. (10) pins
6. (10) 3" x 3" pieces of lightweight, but firm cardboard

II. Description of Set-Up and/or Apparatus

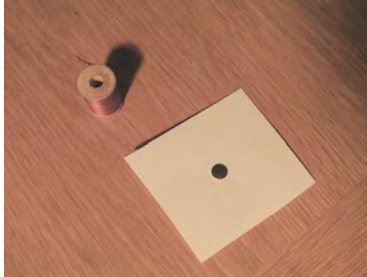
1. Make an airfoil by placing one end of the 10" strip between the pages of a book so that the other end hangs over the top of the book.



2. Move the book swiftly through the air or blow across the top of the strip of paper. The paper should flutter upwards.



3. Hold the book in the breeze of a fan so the air blows over the top of the paper.
4. Place the pin through the center of the cardboard. Place the spool over the pin so that the pin goes into the hole in the spool.



5. Blow through the spool with the card in place. Let go of the card. It doesn't fall.



III. Details of Student Implementation

Bernoulli's principle states that an increase in the velocity of any fluid is always accompanied by a decrease in pressure. Air is a fluid. If you can cause the air to move rapidly on one side of a surface, the pressure on that side of the surface is less than on its other side. Bernoulli's principle works with an airplane wing. In motion, air hits the leading edge (front edge) of the wing. Some of the air moves under the wing and some of it goes over the top. The air moving over the top of the curved wing must travel farther to reach the back of the wing; consequently it must travel faster than the air moving under the wing to reach the trailing edge at the same time. Therefore, the pressure on the top of the wing is less than the pressure on the bottom of the wing.