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Harbottle Air Differential Demonstration

AIR-275

Introduction to Air Pressure

We live on the bottom of an ocean of air. At sea level, we have 14.7 pounds of pressure pushing on every square inch of surface. We tend not to notice this until we find ourselves driving up a very steep hill in our car, riding in a fast elevator, or flying in a plane.

The effects of air pressure can be persuasively displayed in your classroom by conducting experiments such as this Harbottle air differential demonstration. Your students are sure to be impressed by this graphic illustration of how air pressure works.

How does the Harbottle work?

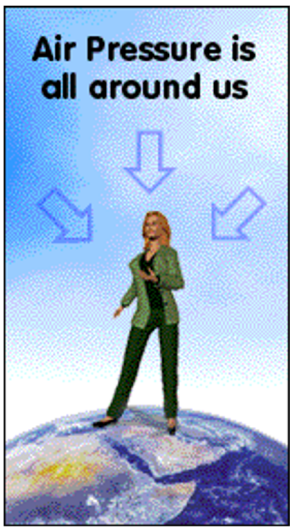
A Harbottle apparatus demonstrates fluid pressure and pressure reduction. When the balloon in the Harbottle is filled with air and the hole in the bottom is plugged, the balloon stays filled due to the applied absence of atmospheric pressure between the bottle and balloon.

When the hole is plugged, the balloon remains inflated, as the air pressure between the balloon and the glass is reduced and cannot act on the balloon. The glass in the Harbottle acts as a barrier between the atmosphere and the balloon.

When the hole is unplugged, air rushes into the hole to equilibrate the pressure; this pressure increase forces the air out of the balloon and the balloon deflates.

What's Going On?

How much pressure are you under? Earth's atmosphere is pressing against each square inch of you with a force of 1 kilogram per square cm (14.7 pounds per square inch). The force on 1,000 square centimeters (a little larger than a square foot) is about a ton!



Why doesn't all that pressure squash me? Remember that you have air *inside* your body, too—air that balances the pressure outside your body.

Source: NASA's Earth Science site, http://kids.earth.nasa.gov/archive/air_pressure/

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NGSS Correlations

Our Harbottle Air Differential Demonstration and these lesson ideas will support your students' understanding of these Next Generation Science Standards (NGSS):

Elementary

K-2-ETS1-3
Students can use the Harbottle to analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

K-ESS2-1
Students can use and share observations of local weather conditions to describe patterns over time. Students can apply knowledge gained from the Harbottle demonstration to understand the power of air pressure and its effects on weather.

K-ESS3-2
Students can ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather. Students can apply knowledge gained from the Harbottle demonstration to understand the power of air pressure and how Air Pressure is a factor in forecasting weather.

3-ESS2-1
Students can represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. Students can apply knowledge gained from the Harbottle demonstration to understand the power of air pressure and its effects on weather/seasons.

3-PS2-1
Students can use the Harbottle in a plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

5-ESS2-1
Students can develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. Students can apply knowledge gained from the Harbottle demonstration to understand the power of Air pressure and how it interacts on Earth.

Middle School

MS-PS2-2
Students can use the Harbottle to plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

MS-ETS1-1
Students can use the Harbottle in an investigation to define simple design problems reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

MS-ESS2-6
Students can use the Harbottle to develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determines regional climates.

High School

HS-ETS1-2
Students can use the Harbottle in an investigation to design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ESS2-4
Students can apply knowledge gained from the Harbottle demonstration to use a model to describe how variations in the flow of energy into and out of Earth systems results in changes in climate.

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Suggested Science Idea(s)

K-ESS2-1 • K-ESS3-2 • 2-PS1-2 • 3-ESS2-1 • 3-PS2-1 • 5-ESS2-1 • MS-PS2-2 • MS-ESS2-6 • and • HS-ESS2-4

The Harbottle will help students to feel the power of air pressure. Use it to teach students the 'truths' about air pressure, 'There is no suction!' Students can calculate based on the area of the mat and the standard air pressure to calculate how much force is required to pull the mat up.

Common Units of Force and Pressure

1 atmosphere = 760 millimeters of mercury (Hg)
= 1.013 x 105 pascals
= 14.70 pounds per square inch
1 torr = 1 millimeter of mercury (Hg)

K-2-ETS1-3
3-5-ETS1-1
HS-ETS1-2

Students can use the Harbottle in a number of different investigations on air pressure. Use spring scales to acquire quantitative data and make measurements of the pull. With the manipulation of variables, students get real world and inquiry engineering learning opportunities.

Harbottle Demonstration

The Harbottle is an excellent way to demonstrate air pressure to your students!

1. Before starting the demonstration, show your students the glass Harbottle, the uninflated balloon and the rubber stopper.

2. Place the balloon into the Harbottle (as shown at right), leaving the balloon's mouth outside the bottle's neck. Stretch the mouth of the balloon over the neck of the bottle so there is a clear opening into the balloon.

What's Going On?

With the stopper removed from the Harbottle, the balloon deflates because its elastic pulls it back to its original shape.

3. Make sure the stopper is removed from the bottom of the Harbottle before you inflate the balloon by mouth. The students will see the balloon inflate inside the Harbottle. However, as soon as you remove your mouth from the balloon, the balloon will deflate.

4. Firmly insert the stopper into the bottom of the Harbottle and once again try to inflate the balloon. Students will observe that you are unable to get the balloon inflated. Why? Because the air pressure inside the bottle is greater than the pressure (from your lungs) that it would take to inflate the balloon and—in the process—compress the air between the balloon and the Harbottle.

5. Remove the rubber stopper and once again inflate the balloon by mouth. As you're doing so, instruct a student to hold his/her hand near the opening of the Harbottle. The rush of the air moving from the opening will be easily felt. This is because the balloon is taking the place the air once occupied.

6. While the balloon is inflated, firmly place the rubber stopper in the opening of the Harbottle. When you remove your mouth from the balloon, this time the balloon will remain inflated.

What's Going On?

The balloon remains inflated without being knotted or tied because the pressure inside the balloon is greater than the pressure between the balloon and the Harbottle.

Harbottle Demonstration

continued

7. Some students may suspect the balloon is staying inflated due to some hidden mechanism inside the balloon. To dispel their suspicions, insert a long, smooth stick or dowel into the mouth of the inflated balloon inside the Harbottle. This will show students there is no trickery going on. The balloon really IS staying inflated even though its mouth is still wide open.

8. If you want to have some fun, pour water into the inflated balloon. As described above, use the stick to prove that the only thing keeping the water in the balloon is the pressure differential between the inside of the Harbottle and the outside air.

9. Have a student look into the mouth of the Harbottle to attest that there is no plug keeping the water in.

10. Then, as the student peers into the balloon, remove the stopper… and the water will shoot out of the balloon into the face of the unsuspecting student. (Be sure your volunteer is wearing goggles—and has a good sense of humor!)

Preview the Harbottle in action:

You can view a video of the Harbottle demonstration our YouTube channel:

https://www.youtube.com/watch?v=vvwAEGFU7dU

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To extend your lesson, consider these Educational Innovations products:

Milk Bottle and Egg Demo (BOT-800)
Use this sturdy glass milk bottle for an egg-cellent demonstration of air pressure. All you need is a hardboiled egg and a bit of fire. If you drop some lit paper inside the milk bottle and then place the egg on top, the fire goes out and the egg is mysteriously pushed into the bottle, intact! Warm air expands, cool air contracts—it's the cooling of the heated air inside the bottle that allows the atmosphere to 'push' the egg inside.

Microscale Vacuum Apparatus (VAC-10)
By reducing the pressure in the microscale bell jar, they can expand a balloon, boil warm water, and even transfer liquids from one pipet to another. They can watch a marshmallow or shaving cream increase in volume as the pressure is reduced and learn about how extremely low pressure affects the world around them. Instead of passively observing a demonstration, students can actively experiment on their own and observe the results right before their eyes.

Cloud Bottle (AIR-285)
Making a cloud with this palm-sized pump is easy. Remove the top and put a few drops of water inside the bottle. Add air to the bottle using the pump and watch: as the pressure increases, so does the temperature. Actuate the quick-release top and due to rapid decompression, a cloud forms instantly inside the bottle! A Liquid Crystal thermometer strip measures temperature changes throughout the experiment. This hands-on activity teaches the relationship between pressure and temperature in a closed container. Approx. 26 cm (10.5") tall.

* If you come up with an idea for another lesson for the Harbottle or one of our other products, please write to us at **info@TeacherSource.com**