# Air Pressure

## Materials Needed

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| One pound butter containers (or some containers of similar size) (12) | Index cards (2) |
| Small child’s block (about one inch to a side) | Small glass bottle |
| Masking tape | Balloon |
| 250 mL graduated cylinder | Hotplate |
| 1000 mL graduated cylinder | Large container |
| Oven mitts | Tongs |
| Aluminum can | Extension cord |

## Procedure

The air is all around but most of the time, except for windy days, we hardly notice it. But the air exerts a pressure on us all the time. Pressure is a force that is applied over some area. Scientists measure pressure in many different types of units, but one very common unit is pounds per square inch. We measure force in pounds. When you weigh yourself on a scale, you are really measuring how strong the force of gravity is pulling down on you. To visualize air pressure, we can use a child’s block. Each side measures about an inch so that any face of the block (or cube) has an area of one inch times one inch or one square inch (1 $in^2$). If we put this butter container, which weighed one pound when it was full, on top of the block, then we have a pressure of 1 pound per square inch. [*Place the* *butter container on top of the block*.] Do you think that this is how large the air pressure is? Well it's not. We need to place another butter container so that now we have 2 pounds per square inch. Is this enough? [*Get some response from the audience*.] Well air pressure is still larger. We can place five more butter containers on the block so that we now have 7 pounds per square inch. [*Place the 5 taped together butter containers on the block; see if you can balance them, otherwise hold onto the stack of containers*.] Is this enough? [*Again, get some audience response*.] Well, air pressure is still stronger. We need to place another five butter containers so that we now have 12 pounds per square inch. [*Place the second set of five taped together butter containers on top of the other butter containers*.] At sea level, we would have to add another three containers on top of this stack. At our altitude of about 5,000 feet, air pressure is about 12 pounds per square inch. At sea level, it is about 15 pounds per square inch. We don't feel this pressure because the air inside of us is at the same pressure. We are living at the bottom of an ocean of air that does exert a pressure on us.

To further demonstrate how strong air pressure is, we can use this graduated cylinder. If I fill it to the very top with water and place an index card over it, watch what happens as I turn it upside down. [*Using a pitcher, fill the graduated cylinder to the very top with water. There should be no air space. Carefully place the index card on top (some water may spill) and tip the cylinder upside down holding onto the index card. When it's upside down, you can remove your hand. If you did it right, the index card should stay in place and hold the water in the cylinder*.] The air pressure at 12 pounds per square inch is strong enough to hold the water in the cylinder. We can try the same thing with a bigger cylinder. Here's a 1 liter graduated cylinder. Do you think that I can get the index card to hold the water in it too? [*Get some response from the audience. Fill the 1 L cylinder to the very top, place the index card on the top, and turn it upside down. Remove your hand from the index card, and the card should stay holding the water in place. Try not to move the cylinder around too much*.] Well, the air pressure is still stronger than the weight of the water in the cylinder. [*Now carefully put the top of the graduated cylinder into the big container of water*.] What do you think will happen if I remove the index card? [*Get some response; remove the card. The water will stay in the cylinder*.] You see that the water remains in the cylinder. What I've done is make an instrument called a barometer. Usually barometers use mercury, which is a very heavy liquid. It is about thirteen times denser than water. The air pressure can support a column of mercury about 30 inches tall at sea level. But, because water is so much lighter than mercury, air pressure can support a column of water about 32 feet tall. When you watch the weather on TV, the air pressure or sometimes called the barometric pressure is given. When the pressure is falling, this usually means that storms are here or on their way. High pressure means good, clear weather. The barometer was invented by an Italian physicist named Evangelista Torricelli in 1644. He used mercury in his barometer. Because of his work, scientists named a unit of pressure, called the torr, after Torricelli.

[*Note: While talking about the barometer, you should put the bottle containing a small amount of water on the hot plate*.] Now, to show the effects of air pressure, I'm going to use a bottle and a balloon. You see that the bottle on this hot plate contains a small amount of water. When I get the water hot enough, what will it do? The water boils and turns to steam. I'll let the water boil for a while to force out all the air in the bottle. The bottle will just have hot steam or hot water vapor. I'll take the bottle off the heat, dump out the excess water in it, and fit a balloon over the top. What do you think will happen to the balloon? [*Get some responses from the audience. Most people will think that the hot steam in the bottle will cause the balloon to expand and get bigger. After the water has been boiling for perhaps 30 seconds, take the bottle off the burner using the oven mitts. Tip it upside down over the large container of water very quickly. Put the bottle on the table and quickly place the balloon over the mouth of the bottle. Have the audience take note of what the balloon is doing. While you're waiting, place the aluminum can on the hot plate. When the balloon gets sucked into the bottle, continue with the explanation*.] When the steam cools, it turns back into a liquid. But now there is no air in the bottle, so we have made a vacuum just like in space. The air wants to get back into the bottle and so it pushes the balloon, using the 12 pounds per square inch of air pressure, into the bottle.

For my final demo, I'll show how strong the air pressure is compared to an aluminum can. I'm doing the same thing to the can as I did to the bottle. There's a little bit of water in the can. When it boils and turns to steam, I'll dump out the extra water and dunk the can into the container of water here. What do you think will happen to the can? [*Get responses from the audience; probably, unless they have seen this demo before, nobody will have an idea what will happen to the can. Again, after the water has been boiling for a short time, pick up the can with the tongs, tip it over to dump out the extra water, and quickly stick the can into the big container of water. The can will quickly crush making some noise which will probably surprise some of the people in the audience*.] You can see how strong the air pressure is - the 12 pounds per square inch pressure of the air all around the can easily crushed the can. Remember, the steam in the can condensed - it turned back into a liquid creating a vacuum in the can. The air all around the can pushed it in. Normally, the can has air at the same pressure (or slightly higher) than the surrounding air pressure. This is why the can just doesn't normally crush. So, you can really see that air is a lot stronger than aluminum cans.

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