



Portable Potable Pressure

Bring your own water to a pressure bar

Steel bars can be purchased from science supply companies that are 1 square inch and weigh 14.7 lbs. These bars can be used to demonstrate one atmosphere of pressure at sea level. However, these bars can be cumbersome to transport and expensive to purchase. An alternative can be made with plastic water bottles, wood and water



Note: For simplicity and consistency, most measurements in this lab are in the English system. However, metric units can be adapted to this activity - see **options** section.

Materials:

- 1 inch square by 2 to 3 feet long piece of wood.
- 4 2-liter plastic bottles (or 2 2-liter and 2 1.5-liter plastic bottles) all bottles must be empty, clean and dry.
- Duct tape
- Water



Assembly:

1. Tape your bottles to your piece of wood.
 - Tape the bottles symmetrically to the wood (2 on each side of equal volume.)
 - Leave at least 2 to 3 inches of wood exposed at the base.
 - Tape everything very firmly. These bottles will be filled with water.
 - You may want to add a handle made of tape at the top of the device. This will make transporting and holding your device easier when laden with water.
2. Weigh your device without water (weight should be measured or converted to pounds).
3. Add water to your device to make the total weight of your device 14.7 pounds.
 - a. Pour water into the bottles so that the weight of the device is symmetric. Remember to include the mass of the empty device when adding water.
 - b. Remember that water weighs about 2.2 pounds (1 kilogram) per liter. So a full 2-liter bottle will weigh about 4.4 pounds.
 - c. Estimating the amount of water is ok, but using a graduated cylinder is better.



Example of filling the device shown on the previous page:

- The device weighs .9 pounds.
- Both the upper 2-liter bottles are filled to the top with water each (4.4 lbs+4.4 lbs. = 8.8 lbs.)
- Both the lower 1.5-liter bottles are filled with 1.1 liters of water each (2.5 lbs. +2.5 lbs. = 5.0 lbs.)
- So, the total weight is .9 lbs. +8.8 lbs. +5.0 lbs. = 14.7 lbs.

To do and notice:

This is a device for tactile demonstrations of an atmosphere of pressure. If you rest the one-inch square base of your device on a body part, such as the your palm or your toe*, you will feel the pressure of an additional atmosphere on that location.

*(note: your shoe may spread the force so that you feel less than 14.7 psi on your toe)



What going on?

An additional one-square inch of atmospheric pressure resting on your body is almost uncomfortably unpleasant. Fortunately, the atmosphere pushes evenly all over your body. Our bodies are adapted to this 14.7 pounds of push on every square inch of surface area including our skin, lungs, eyes, ears etc. To keep your shape as a human being, our body parts responds by pushing outward at a pressure of 14.7 psi.

The device above is resting on my toe. My toe now has the equivalent of 2 atmospheres of pressure resting on top of it.

Option 1:

If you want to do this activity in metric:

Here are some useful conversions:

Area conversion:

$$1 \text{ square inch} = 6.45 \text{ square centimeter}$$

Weight/mass conversion:

$$14.7 \text{ pound} = 6.67 \text{ kilogram}$$

Air pressure conversion:

$$\begin{aligned} 1 \text{ atmosphere} &= 14.7 \text{ pounds/1 square inch} \\ &= 6.67 \text{ kilograms/6.45 square centimeters or} \\ &= 1.03 \text{ kilogram/1 square centimeter} * \end{aligned}$$

Option 2:

This device uses the units of pound per square inch. Students can calculate and build atmosphere bars that use different units.

Using the conversions above, you can make a smaller pressure bar.

1.03 kilograms is about the weight of a filled 1-liter bottle of water. Resting the bottle, cap side down, on your index finger covers an area of about 1 square centimeter. So, this is another way to feel one atmosphere on your body.



Option 3:

Make the atmosphere of other worlds.

Venus:

Do not put this device on any body part!

Venus has 90 atmospheres of pressure or 1323 pounds per square inch.

This is the same as standing your portable potable atmosphere bar on the head of a 12 or 11 gauge finishing nail.



The Underwater world - The deep ocean:

Do not put this device on any body part!

In water, every thirty-three feet (ten meters) of depth is equivalent of one atmosphere of pressure. The average depth of the ocean is 13,200 feet (4000 meters) and the pressure there is 400 atmospheres or 5,880 pounds per square inch. At sufficient depths, water can crush the hulls of submarines.



This is the same as standing your portable potable atmosphere bar on the on an unbent paper clip.

Mars

Mars has an atmosphere that is about 1% that of earth. This is roughly .15 pounds per square inch.

This is much lighter than an empty atmosphere bar. You can cut a piece of 1 inch square wood that is a few inches long (pine would be about 6 to 7 inches long, oak would be about 4.5 inches long, etc...)