TEACHERS GUIDE

PASCALS PRINCIPLE DEMONSTRATOR

ITEM # 3544-00

CHEMISTRY - PROPERTIES OF MATTER

Memorable and dramatic demonstration of Pascal’s Law that liquid pressure is transmitted equally in all directions. Fill with water, push the piston, and watch the water squirt out every hole equally! Consists of a borosilicate glass bulb, of 2” (50mm) diameter with holes, fitted with a piston for compressing liquids. Total height about 10” (250mm).

Materials

- force plate
- ruler
- plastic rod
- rabbit fur
- balloons
- bottle
- packing tape
- rubber mallet
- wooden matches
- 3 large syringes
- aluminum cylinder

Goals & Objectives

See page 7 for National Next Generation Science Standards

History

1795 was the first patent of a hydraulic press by Joseph Bramah, a British mechanic – first patented use of Pascal's law.

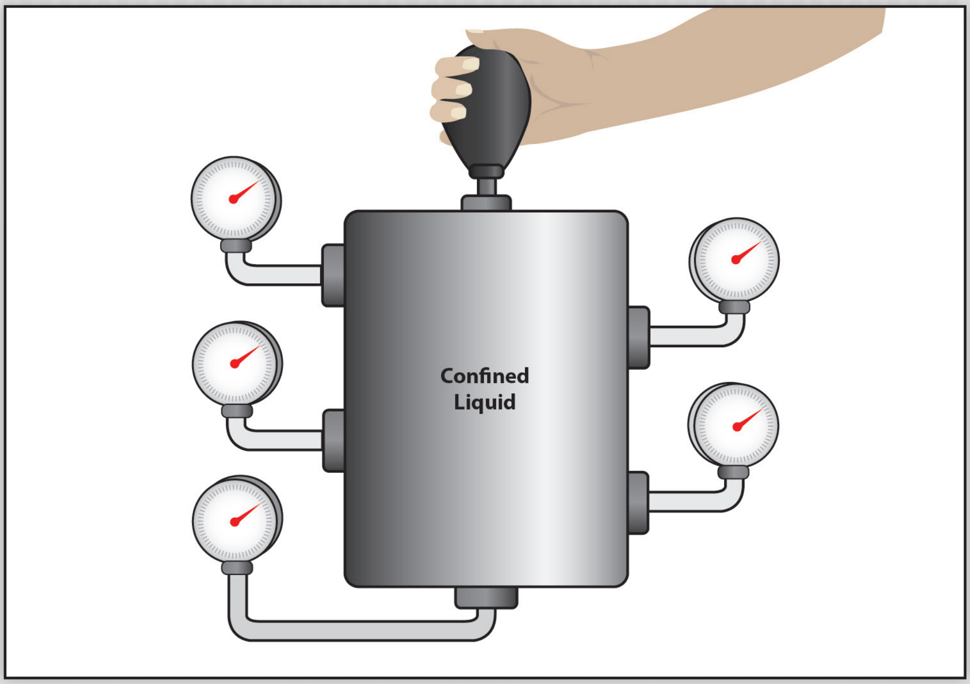
Mechanical systems designed to use compressed fluids to work can be classified into two types:

Hydraulic systems use an incompressible fluid, such as oil or water, to transmit the force applied within the fluid from one location to another. Most aircrafts use hydraulics in the braking systems as well as landing gear.

Pneumatic systems use compressible fluids such as air for their operation. Some aircrafts also utilize pneumatic systems for their brakes, landing gear as well as the movement of wing flaps.

How it works

Fluids transmit an applied pressure equally in all directions. Recall that work is force x distance. So if you apply a force into the system a certain distance the force will be the same in a fluid in all directions, but it will move smaller distance depending on how many openings are on the container. If pipes or tubes are attached to the container with pressure gauges, the gauges will confirm the principle by having the same pressure.



Glossary

- Pascals law
- hydraulic
- pneumatic
- pressure
- work
- force

ACTIVITIES

1 Fill the Pascal's device with water by submerging it in a beaker of water and pulling on the syringe. Depress the syringe and the water will squirt out of all the openings the same distance because the force you are applying and the force that the water is exiting is the same, but the distance you have to depress the syringe is greater than the distance the water flows.

Ask your students to predict what would happen if you covered half the openings with tape. (It will flow a longer distance)

Practice using a force plate to apply the force and measure the distance the plunger depresses. (Ask for a volunteer to help)

Measure the distance the water flows out of one of the holes and calculate the force of the water using:

work in = work out

(F(in)d = F(out)d).

Ask students to predict what would happen if the holes were bigger.
Pressure = F x V or P=F/ surface area (for constant force). If more volume can escape or the surface area of the hole is increased the pressure decreases.

2 Fill one balloon with air and another with water to approximately the same diameter. Place on demonstration table and ask students to describe how the two balloons are similar and how they are different.
Prompt a discussion about one is filled with a gas and the other a liquid.
Discuss how both are fluids and you can observe some similar properties.

Press down on each with your hand. Do they bulge in only one direction or all directions? (All) Does one bulge more than the other? Which?

3 Use tape to wrap a glass bottle around the bottom and sides and fill almost to the rim.
Use the rubber mallet to hit the top of the bottle. With enough sudden force, the bottom of the bottle will drop out, as well as all the liquid inside.
The circular seam, where the bottom is joined to the rest of the bottle during manufacturing is where the break occurs.
The reason this demonstration works is because the sudden increase in pressure is transferred throughout the bottle, by Pascal's Principle.

***Note**
It is always best to DO an experiment ahead of time to be able to best present it to the class.

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ACTIVITIES

3 An even distribution of force presses on the bottom of the bottle. The seam just above the bottom just happens to be the weakest "joint" in the bottle, so that's where the bottle gives way.
Note that because the bottle mouth is much smaller than the bottom of the bottle, the liquid inside exerted more force on the bottom than the hand exerted on the fluid. Furthermore, the bottom needes to be moved outward only on a molecular scale—the width of a few atoms—to break the seam around the bottom, while the mallet hits the mouth inward over a far greater distance. Therefore, the bottom drops out by being subjected to a greater force, although it is a shorter distance.

4 Use a syringe to compress a sample of air, a sample of water, and a solid aluminum cylinder. The gas is compressible, and the liquid and solid are not.

5 Prepare the matchsticks by cutting off the heads of the matches and discarding the tail ends (portions without the combustible head).
Fill a bottle to the brim with water.
Drop the matchstick-heads into the bottle.
Cover the mouth of a balloon tightly over the bottle's opening.
Press your finger on the balloon 'diaphragm' covering the mouth of the bottle.
Ensure that the balloon you choose will fit tightly around the mouth of the bottle you choose for the experiment.

The match heads will float on top of the water initially but as soon as the finger is pressed on the balloon diaphragm, they will begin to sink slowly to the bottom.
However, when the finger is lifted, the matchstick-heads float up again.

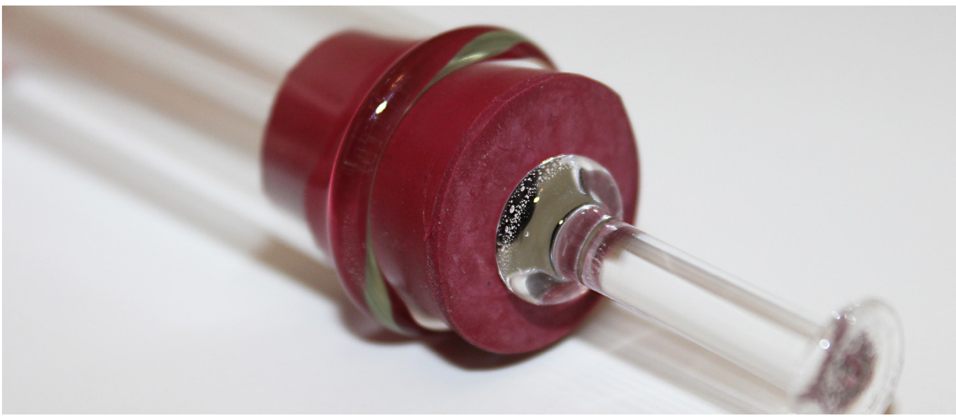
The match heads move down because of the pressure that is transmitted through the water. When the finger is pressed down on the balloon diaphragm, a small quantity of water penetrates into

ACTIVITIES

Student Activities *continued*

2 each match head, which adds enough weight to it, causing it to sink. When the finger is removed, the air pressure inside the match heads force out the water and make the match heads rise again.

The compression and expansion of the gas (air) in the match heads changes the density of the match head.



DISCUSSION

Additional Discussion and Real Life Applications

Discuss common items that use Pascal's principle to operate.

What components are common to all the devices?
- a pump
(sometimes including cylinders and pistons) that forces fluids through a system

- conductors
(tubing, hoses, or pipes) that provide a pathway to carry a fluid

- valves
to keep the fluid moving in the desired direction at the desired time

-a pressure gauge
monitors pressure within the system

National Next Generation Science Standards

Students who demonstrate understanding can:

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

G3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.oals and Objectives:

MS-PS2-2. 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.

HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Standards Key

K = Kindergarten
3 = 3rd Grade
(numbered by grade)
MS = Middle School
HS = High School
PS = Physical Science
LS = Life Science
ES = Earth Science

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