

# Static Pressure

## Using PhET – Fluid Pressure and Flow

Before you do this lab, find the basic physics formula for pressure:  $P = \text{force}/\text{area}$  The standard units are:  $\text{N}/\text{m}^2$  or Pa

Open the simulation. Grab the pressure gauge and see what happens to the readings as you lower it from the top of the screen down to just above the water (about 3 meters). Explain why this happens: **The pressure increases as you lower the gauge because of the increasing amount of air above.**

Click on the Grid box in the upper-right. Fill the tank. Now lower the pressure gauge from the top of the water to the bottom of the screen (about 3 meters). Explain why this result differs from your previous answer: **Again, the pressure increases as you lower the gauge because of the increasing amount of water above. But the rate of increase is greater under the water due to water's greater density.**

Leaving the pressure gauge at the bottom of the screen, discover how the pressure is related to the density ( $\rho$ ):

**The pressure increases as the density increases. They are directly proportional.**

Leaving the pressure gauge at the bottom of the screen, discover how the pressure is related to the gravity:

**The pressure increases as the gravity increases. They are directly proportional.**

The formula for pressure at depth at sea level is  $P = 101325\text{Pa} + \rho g d$ , where  $d$  is depth. Use this formula to calculate the pressure in Pa under 3 meters of water (show your work):  **$P = 101325\text{Pa} + \rho g d$**

$$P = 101325 + (1000\text{Kg}/\text{m}^3)(9.81 \text{ m}/\text{s}^2)(3 \text{ m})$$

$$P = 131000 \text{ Pa}$$

Now switch to the triangular tank using the 2<sup>nd</sup> window at the upper-left. Slide the pressure gauge sideways along the bottom of the tank. What happens as the gauge goes under the slants? Explain: **The pressure doesn't change, regardless of the slants. Only the depth matters. The fluid flows under the slants and transmits the pressure equally, according to Pascal's principle.**

Now go to the 3<sup>rd</sup> window at the upper-left. Put a pressure gauge at the bottom of each tank. What happens to the pressures as the weights are added on the left tank? What is your conclusion? **The weights add to the pressures of each gauge equally. The more weight there is, the more pressure. Again, the pressure is transmitted equally at equal depths.**

Remove the weights. This is a hydraulic system like the brake system on your car. The left piston is small like your brake pedal piston and the right piston is large like the piston at your brake pads. Get a ruler and measure the heights of the fluid in each tank. Now add 1000kg to the left and re-measure the heights. Describe and explain: Before adding the weights, both heights were at 0.75m. After the 100 kg is added, the left piston is at 1.6m, while the right piston is at 0.6m. The left piston went down and that forced the water to rise in the right tank. The right tank didn't rise very much.

Work is  $F \cdot d$ , where  $d$  = (change in height). How much work is done on the left piston?  $W = F \cdot d = m \cdot g \cdot d = (1000\text{kg})(9.81\text{m/s}^2)(0.85\text{m}) = 8340 \text{ joules}$

Ideally, all this work is transmitted to the right piston. What force does this piston have?  $F = W/d = (8340 \text{ joules})/0.15\text{m} = 55600 \text{ Newtons!}$

(Note to teachers: This is only about 5 times the force applied on the smaller piston. But the simulation shows that the right piston is about 5 times the diameter of the smaller piston, and so should have 25 times the area, and so should have 25 times the force. I think the 1.00 simulation needs to be adjusted so we can get better results.)

Use this to explain how you apply a small force on your brake pedal and yet you are able to bring a fast 1000kg car to a stop using the hydraulic principle (even without power brakes!):

$W=W$ , so  $f \cdot D = F \cdot d$ . A small force acting for a large distance equals a large force acting for a small distance. But the pressures are also equal, so  $f/a = F/A$ . A small force acting on a small area piston equals the large force acting on a large area piston.

Now turn off the atmosphere (upper-right box) and describe how the pressure changes as you raise one of the gauges up to the top of the screen Underwater, the pressure decreases as the gauge is raised. But the pressure becomes zero as it is raised above the water and doesn't change as it is raised higher.

This is called gauge pressure and is how most pressure gauges work. Before now, all the gauges you used were set to tell you the absolute pressure. Write a formula that converts absolute pressure to gauge pressure:

$$P_{\text{abs}} = P_{\text{gauge}} + 101325\text{Pa}$$

Which is bigger, gauge pressure or absolute pressure? Absolute pressure is bigger.

This is just an introduction. You need to *practice* to get *better*. Cue the next assignment.