Flipping Physics Lecture Notes:
Fluid Pressure - Billy's Still Dreaming about Physics
http://www.flippingphysics.com/fluid-pressure.html

Example: We can determine the pressure exerted by water in a rectangular fish tank on the bottom of the tank. For this tadpole tank, our numbers are:

The area of the bottom of the tank in square meters:

$$A_{\text{bottom}} = 50.2cm \times 25.4cm = 1275cm^2 \times \frac{1^2 m^2}{100^2 cm^2} = 0.1275cm^2$$

The height (or depth) of the water in meters:

$$h_{\text{water}} = 18.5cm \times \frac{1m}{100cm} = 0.185m$$

And we can solve for the pressure on the bottom of the tadpole tank caused by the weight of the water pushing down on the bottom of the tank:

$$P_{\text{bottom}} = \frac{F_g}{A_{\text{bottom}}} \ \& \ F_g = mg$$

We need to determine the weight, or force of gravity, of the water.
For that we need to use the density equation:

$$\rho = \frac{m}{V} \Rightarrow m = \rho V = \rho A h \Rightarrow F_g = mg = \rho A_{\text{bottom}} hg$$

And we can substitute that back into our pressure equation:

$$P_{\text{bottom}} = \frac{F_g}{A_{\text{bottom}}} = \frac{\rho A_{\text{bottom}} hg}{A_{\text{bottom}}} \Rightarrow P_{\text{bottom}} = \rho g h$$

Which means we need the density of water at room temperature:

$$\rho_{\text{water}} = 998\frac{kg}{m^3}$$

We can solve for the pressure caused by the water on the bottom of the tadpole tank:

$$\Rightarrow P_{\text{bottom}} = \rho g h = (998)(9.81)(0.185) = 1793Pa \times \frac{1kPa}{1000Pa} \approx 1.79kPa$$

Notice the area of the tank cancelled out of the equation. In other words, the pressure caused by a fluid, $P_{\text{fluid}} = \rho g h$, depends on:

- ρ, the density of the fluid.
- g, the gravitational field of the planet.
- h, the depth of the fluid.
    - *It does **not** depend on the area of the fluid*

In other words, the deeper you dive into water, the larger the pressure from the water. The weight of all the water above you pushes down on you causing this pressure.

The same is true for all the air in the atmosphere above you. This is why there is pressure all around you when you are standing on the surface of the Earth. The miles and miles of air above you is pushing down and causing the pressure you currently experience.♥ This is called atmospheric pressure and is a typical unit.

- $1.00atm = 1.01 \times 10^5 Pa$.
    - In other words, 1 atmospheres of pressure is 1.01 x 10^5 Pa.
- This is the pressure referred to in Standard Temperature and Pressure or STP.
    - Standard Pressure is 1.00 atm.
    - Standard Temperature is 0°C or 32°F or 273.15 Kelvins.

This atmospheric pressure is pushing down on the tank of water. That means the total pressure at the bottom of the tank is the addition of the atmospheric pressure and the pressure caused by the water.

- $P_{\text{total}} = P_{\text{atm}} + \rho g h$
- The pressure caused by a vertical column of fluid is called *gauge* pressure.
    - $P_{\text{gauge}} = \rho g h$
- The total pressure is called the *absolute* pressure.
    - $P_{\text{absolute}} = P_{\text{atm}} + P_{\text{gauge}}$
- The absolute pressure at the bottom of the tank is:
    - $P_{\text{absolute}} = P_{\text{atm}} + P_{\text{gauge}} = 1.01 \times 10^5 + 1793 = 102793Pa \times \frac{1kPa}{1000Pa} \approx 103kPa$

A few extra tidbits:

- What we've been talking about here is called Fluid Pressure. The pressure from the water and the air on objects is fluid pressure.
- The particles in fluids are constantly moving around, colliding with one another, and colliding with the surface bordering the fluid. The pressure exerted by a fluid is caused by the particles in the fluid colliding with the surfaces next to the fluid.
- Often liquids are considered to be incompressible. The volumes and densities of incompressible fluids do not change regardless of the pressure applied to them.

♥ Yes, I am assuming you are reading this while on the surface of planet Earth and not underwater.