AP Physics - Fluids - Density and Pressure

Note Title 11/18/2007

Density (ρ) = Mass per unit volume

Greek letter "Rho" - Not English letter "p"!!!

$$\rho = \frac{m}{V}$$

Density can describe any matter, including solids, liquids, or gas. Gases tend to be less than $\frac{1}{1000}$ as dense as the same substance in liquid form, but this depends on the temperature and pressure of the gas.

Specific Gravity (S.G.) - Ratio of a substance's density to the density of water at 4°C, which is

$$\rho_{water@4°C} = 1000\ kg/m^3 \text{ or } 1.0\ g/cm^3 \text{ or } 1.0\ g/mL$$

Substance	Density kg/m³	Density g/cm³	S.G. (unitless)
Ice	917	0.917	0.917
Aluminum	2700	2.700	2.700
Lead	11,300	11.300	11.300

Pressure (P) = Ratio of force per unit area

$$P = \frac{F}{A}$$

$$P \doteq \left[\frac{N}{m}\right] = [\text{Pascal}] = [\text{Pa}]$$

In chemistry, you saw how varying pressure affected ideal gases. Though you won't need to know it for the AP exam, pressure is also of critical importance to solids:

Solids don't break because of excessive force. They break because of excessive <u>pressure</u>.

Consider two nylon ropes, one of a small diameter, and another of a large diameter.

The smaller diameter rope will break under a smaller force, even though it is made of the same material. Why?

$$P = \frac{F}{A}$$ ← Force applied (F); ← Cross-sectional area of rope (A)

For the small dia. rope: $P = \frac{F}{A}$

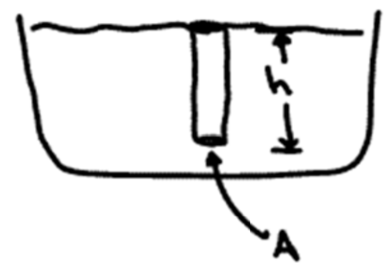
→ P exceeds breaking pressure!

For the large dia. rope: $P = \frac{F}{A}$

→ P does not exceed breaking pressure

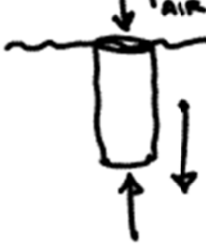
Pressure Change with Depth

Consider a cylindrical "piece" of water in a tank. The cylinder extends from the surface of the water to a depth of h, and has a cross-sectional area of A.



FBD

$\downarrow F_{\text{AIR PRESSURE}} = P_0 A$



$F_g = mg = (\rho V)g = (\rho A h)g = \rho A h g$

$F_{\text{pressure at depth}} = PA$

$\Sigma F_y = ma = 0$

$PA - P_0 A - \rho A h g = 0$

$P - P_0 - \rho g h = 0$

$P = P_0 + \rho g h$

∴ Hydrostatic (nonmoving) pressure at any depth h is given by the equation

$$\boxed{P = P_0 + \rho g h}$$

P_0 = Atmospheric Pressure (Normally $1.01 \cdot 10^5$ Pa or $14.7 \frac{\text{lbF}}{\text{in}^2} = 14.7$ psi)