Day 1: pressure, density, buoyant force, Archimedes principle

Pressure:

P = F/A

Measured in N/m^2, aka Pascal. 1 N/m^2 = 1 Pa

Other units: Torr, mmHg, atm. 1 atm = 1.013×10^5 Pa = 101.3kPa

Pressure is a scalar, it has no direction. This is particularly understandable with regard to fluids. If we're talking about a static fluid, one that is not moving, the pressure the fluid exerts on its surroundings must be perpendicular to the surface everywhere. If there were a parallel component to the force, the fluid would start moving. Since we already said it's static, we know that's not the case, thus the force is being applied perpendicularly everywhere. Since "everywhere" can be any part of the surface, there is no particular direction associated with this pressure.

Example: nail in board, high heel on foot, sharp vs. dull knife

> Important Aside: When it comes to the movement of objects, we are still primarily concerned with forces, but when we're dealing with volumes of squishy fluid, it's not the easiest thing to know the forces directly, so we incorporate knowledge about pressure to help us find the forces. Pressure is a way to understand the forces acting on objects due to fluids. It's still about the forces, just in a roundabout way.

Density, ρ = m/v, kg/m^3

Specific gravity. Ratio of an object's density to that of water, how many times more or less dense than water. Water's ρ = 1000kg/m^3

Pressure at depth:

P = F/A, where F=weight of water above.

F=mg, where m (according to density), m=ρ V. V = volume of water above.

V = Ah, so m = ρAh

Thus, F = ρAhg

F/A becomes ρAhg/A, so in the end the pressure at depth:

P = ρgh where ρ = density of fluid

Buoyant force: if something is experiencing a buoyant force, that means there is an upward force on the object due to the surrounding fluid. If you tried to life a rock while underwater, it's easier! Why? There's a greater buoyant force from the water than there is from the air, so you've got some help in lifting the rock.

Let's evaluate this buoyant force: F = PA

$F_b = F_{bottom} - F_{top}$

$F_b =$ P(at depth h_{bottom}) A - P(at depth h_{top}) A

$F_b = \rho g h_{bottom} A - \rho g h_{top} A$,

$F_b = \rho g A (h_{bot} - h_{top})$

$F_b = \rho g A h$ hA = V…

$F_b = \rho g V$ where ρ = density of *fluid,* and V = volume of *object*

Archimedes Principle. An object immersed in a fluid experiences a buoyant force equal to the weight of the volume it displaces. This says that the weight of the water, mg, equals the buoyant force, ρgV

$mg = \rho g V$ where m = mass of fluid, ρ = density of fluid, and V = volume displaced (volume of object)

Day 2: Pascal's Principle, Gauge pressure

Gauge pressure: $P = P_g + P_{atm}$

P = absolute pressure, P_g = Gauge pressure, P_{atm} = atmospheric pressure

In other words, $P_g = P - P_{atm}$ which is to say that the pressure a gauge measures is the *difference* between the absolute pressure and the atmospheric pressure. A Pressure gauge on a scuba tank that reads zero doesn't mean there's no pressure whatsoever in the tank. There's still the usual atmospheric air pressure pushing on both the inside and outside of the tank. If there's "no pressure" it just means that the outside equals the inside. Once you begin pumping air into the tank, the gauge will begin to rise, indicating that the inside of the tank is at some pressure *above* the outside environment. A tire feels "flat" when pressure inside = pressure outside… $P_g = 0$

Absolute pressure can only go down to 0. There is no such thing as "negative pressure". This is when absolutely no fluid molecules are pushing on a surface. Typically, in our lives, we experience an absolute pressure of 1Atm. In an un-sealed scuba tank, a gauge would measure 0Pa. No difference between inside and outside. If you sealed the tank and then sucked out all the gas, the gauge would read -1Atm. The lowest reading of a gauge is -1Atm.

Demo air pressure cannon. Sweet.

Pascal's principle: pressure applied to a confined fluid increases the pressure throughout by the same amount.
Ex: squeeze balloon. Added pressure at one end transmits to all parts of balloon.
Draw Hydraulic lift. Assuming pressure everywhere at a given height is equal, $F1/A1 = F2/A2$.
So, $F2/F1 = A2/A1$. You can multiply the force by increasing the area! Cons. Of Energy is in agreement, because you exert a small force and move it far, and on the other end a large force causes small movement.
$W = Fd = fD$

Followup questions for class discussions:

Where would you experience greater buoyant force, in water or oil? Why?

Does Fb affect your weight?

You will float if $F_b >$ your weight
$\rho(\text{surrounding fluid})Vg > \rho(\text{you})\,Vg$
Since V and g are equal for both, you will float if $\rho\ (\text{fluid}) > \rho\ (\text{you})$