You step onto your bathroom scale one morning and are somewhat pleased to find that last night's pizza binge didn't do as much harm as you'd feared. But how is it that the scale measured "zero" before you stepped on it, despite the weight of the atmosphere pushing down on it? With its settings adjusted as they are currently, what numerical value would the scale read if it were placed in a vacuum chamber (still on Earth) with nothing on it? Explain.

If you remove the atmospheric force, how does the scale respond?

The **scale would read negative numerical values due to the fact force due to the atmosphere is removed** since the scale is in a vacuum chamber while the chamber sucks the air out.

Is this like taring a scale in the lab?

Clearly, **the scale has been calibrated such that when the force exerted onto it is equal to just that which results from air pressure, it reads zero**. Any additional force exerted on it leads to an increase in the reading. It then follows that any decrease in the force due to air pressure (caused by, for example, a vacuum chamber) would lead to decreases in the reading. Assume that the scale is set such that it reads 0 N when experiencing force due to air pressure at sea level (P = 10^5 Pa). **The typical scale surface is approximately a square with side length 1/4 meters. Thus, the area over which this pressure will act on the scale is (1/4 m)^2 = 1/16 m^2.** Now as P=F/A, it must be true that 10^5 Pa = F/(1/16 m^2). Then the force exerted on the scale at sea level F = (10^5 Pa)(1/16 m^2). **Thus, the force is approximately F = 6250 N**. Then the scale must subtract 6250 N from the total force exerted on it. So, if it is in a vacuum (no air pressure and thus no force due to air pressure), the scale must read 0N - 6250 N = -6250 N.

Resolution: the atmosphere pushes up from below as well.

The scale would measure a small positive weight in a vacuum chamber; because, **the pressure from the atmosphere is not just pushing down on just the top of the scale, it is pushing from all sides which will counteract each other**. Putting the scale in a vacuum would however remove the tiny buoyant force caused by the air the scale itself was displacing and therefore make the scale display a small positive weight.

The density of water is 1 g/cm^3, by definition of the gram. With careful attention to units, show that descending 10 meters under water increases pressure by approximately one atmosphere, 10^5 Pa. Show your work.

Step one: use convenient units

to show the change in pressure, delta P= (rho)g(delta h). so delta P= 1gm/cm^3 (9.8 m/s^2)(10m)= **100 gm^2/cm^3s**

which is the worst unit ever. 1 Pa = 1N/m^2 so I should convert before I solve...

Step 2: write out all conversion factors clearly!

1 g/cm^3 = 1*10^-3/1*10^-6 = 10^3 kg/m^3

(That's kind of opaque, so I augmented those to make it clear)

1 g/cm^3 =(1 g/cm^3)(1*10^-3 kg/g)*(1*10^2 cm/m)^3 = 10^3 kg/m^3

Change in pressure = p*g*change in height = 10^3 kg/m^3 * 10 N/kg * 10 m = 10^5 N/m^2 = 10^5 Pa

Step 3: put it all together to get the change in pressure

Density of Water = 1g/cm^3 = 0.001kg/ (0.01meter)^3 (cm^3) = cm * cm * cm = 0.01 (meter * meter * meter))
= 0.001 / 0.01^3 = 1000 = **1000 kg/meter^3**

Gravity = 10 Newtons/kilogram

Delta Height = 10 meters

The total force exerted on an object is equal to the weight of the fluid, in this case the weight of water. **Knowing this delta pressure is equal to the density of water times the height change in the object times gravity**. Using this **1000 kg/m^3 times 10 meters times 10 Newtons/kilogram**. This gets shows a weight of water equal to **1000 times 10^2 or 100000 Newton / meter^2** (cancel out like wise units). 100000 = **10^5 Pa** or one atmosphere.

How is it that ships made of metal float?

a. The metal used is a special alloy that is lighter than water
b. Most of their volume is air
c. Their motion gives an upward thrust, just like an airplane's wings
d. Trick question: metal ships can't float, they're actually made of fiberglass and only look metallic