Homework 2

Answer each of these problems carefully and with plenty of explanation of your reasoning and/or how you found your answer. Homework is due to me in class on **Friday, 27 Sept** at the **start** of class. No late homework will be accepted.

You may get help from each other, from the Learning and Writing Center (good for math help), or especially from John. You may *not* use **solutions** from elsewhere, such as the internet. Acknowledge any help you received at the end of each problem. (Something like, "I worked with Blast Hardcheese on this problem," or "I am indebted to Mrs. Peacock for her help with this problem.") Also, remember to cite any sources you use for values or equations. (*eg*, "The mass of the Earth came from Appendix Q in the Hewitt.")

You must use your own words to write up your solution to prove that you understand. This means your solutions should be distinct from your classmates', even if you work together to solve the problem.

1. Calculate the pressure at the base of the Hoover dam where the water depth is 220 m. **(10 pts)**

As explained by Hewitt on page 230 and as we derived in class, the pressure at depth d in water of density ρ is given by

$$p = dg\rho$$

where g is the acceleration due to gravity on the Earth's surface. We're given that d is 220 m and we know that the density of water is 1000 kg/m^3 and that g=9.8m/s^2. (You can get those from either the in-class activity of from Hewitt.) Putting in these numbers, we get $2.2\times10^6 N/m^2 = 2.2\times10^6 Pa$ as the pressure at that depth. Since atmospheric pressure is about 100,000 Pa, this means that the pressure at the bottom of the Hoover Dam is around 20 times that at the surface of the water. Ouch.

2. If the pressure in the ocean were the same at all depths, would there be a buoyant force? Explain clearly why or why not. **(6 pts)**

No, if liquid pressures were the same at all depths, there would be no buoyant force. Pressure itself results in no net force on an object and a *difference* in pressures is requires to exert such a net force, including the buoyant force.

3. A boat floats in the ocean. The water level comes up to a marking on the side of the boat. If a load of Styrofoam is added to the boat, will the new water level be above the previous mark, below it, or will it remain the same? Explain. **(6 pts)**

The ship loaded with Styrofoam would sink deeper. The depth to which the ship sinks depends *only* on the dry weight of the ship, not on the contents. So putting 10 tons of Styrofoam on board is the same as putting 10 tons of lead on board, although our intuition probably says otherwise.

Put another way: the volume on the ship that ends up occupied by the Styrofoam was previously occupied by air. The Styrofoam is less dense than air (we know this, otherwise it would float away), so it increases the overall density of the ship and contents.

4. While I was watching a barge enter a lock and dam in Minnesota, I saw it accidentally dump its load of iron ore into the water. The lock was closed, so it was as if the barge was in a small, self-contained lake of its own. If the water level was at that "9 feet" mark before the barge dumped the iron, was it higher, lower, or the same after? Explain clearly. **(6 pts)**

The level would drop, surprisingly enough. The reason is this: when the iron was floating, it displaced a volume of water equal to its weight in order to float. It takes a larger volume of water to equal the same weight as it does of iron. (This is another way of saying "iron is denser", just kind of backwards.) So when the iron went into the water and it then displaced only its own volume, that volume was decreased. And so the water level dropped.

Another way to think about this: when the iron is in the boat, it displaces an amount of water equal to its weight. When it's in the water, it displaces less; we know this because it sinks. (If displaces as much or more, it would float.)

5. How would Aristotle explain each of the following? **(9 pts)**
    a. A helium balloon rising.
    The helium balloon is made up of air. In particular, the helium must be more "air-like" than actual air, so the helium wants to rise up more than the normal air does.
    b. A balloon filled with warm air rising, but cold air sinking.
    The warm air contains considerable contributions of the element "fire". Since fire wants to rise more than air does, the balloon rises as a whole.
    c. A ball keeps moving upward even after it leaves your hand.
    Aristotle explained this by suggesting that the air itself serves as the continuous mover, rushing in behind the ball to continue propelling it upwards.