PHYS 102-Concepts of Physics II-Spring 2007
Solutions to Homework #2   100 points possible

1. (20 pts) Air pressure does work on the ball as it moves down the tube, giving the ball kinetic energy. So use (Force)(distance) = ½ mv^2. The force is the air pressure in the room, about 101,000 N/m^2, multiplied by the cross-sectional area of the ball, which is πr^2, where in this case r = 0.05 meters. The distance is the length of the tube, 3 meters. The mass of the ball is stated as 0.33 kg. Therefore:

   [(Force)](distance) = ½ mv^2 becomes (all in metric units):

   $[(101{,}000)(\pi)(0.05)^2](3) = \frac{1}{2}(0.33)\, v^2$

   Solving for v gives about 120 m/s, which is about 270 mph. (fast! No wonder we couldn't see it in class.)

2. (10 pts) You should have made a reasonably good sketch of your chosen cam and surrounding components, and explained it fairly well.

3. (20 pts)(a) Both balloons have weight, and both balloons experience an upward force due to greater air pressure at the bottom of the balloon than at the top of the balloon (this upward force is often called "buoyancy"). In the case of the helium balloon, the buoyancy force is greater than its weight, so it rises.

(b) On the surface of the Moon, there is no air, so no buoyancy force, so the balloon will fall. There is also less gravity, so the weight of the helium balloon is less. To calculate the time to fall, use $H = 1/2\ gt^2$, but use the value of "g" on the Moon. Note that there is also no air drag to slow the balloon down as it falls, so this equation will give a very accurate prediction of the time. Also, we're assuming the balloon is strong enough that it doesn't expand and burst. That's a real possibility, but if that doesn't happen, then the above explanation is true.

(c) There IS air inside the ship, so there IS air pressure inside the ship, but with no gravity there is no <u>difference</u> in air pressure with height, so no buoyancy force. There is also no weight to the balloon, so it will just hover. Another way to look at this problem is that, without gravity, "up" and "down" can't be defined, so all directions are equivalent, and therefore the balloon will just hover because it has no idea which way to go.

4. (12 points) The surrounding pressure increases rapidly with depth, so there are a couple of problems with trying to breathe through a tube while deep underwater. The tube may collapse if it's too thin, thus preventing air from reaching the diver. Even if the tube is stiff enough, the diver may not be able to expand his lungs and thus would not be able to breathe. I don't know at what depth this becomes a

significant problem for the average person. It's certainly possible to breathe this way at shallow depths—this is called snorkeling. "Snuba" is marketed as a way to do this at depths up to 20 feet, BUT they use pressurized air tanks to force the air into the diver's lungs, just like in Scuba diving.

5. (13 points) If the force of gravity on Earth increased, it's true that the weight of ships would increase. But, the weight of the water would also increase. And remember from class that the buoyancy force on an object equals the "weight of the displaced fluid"—in this case the water. So the (upward) buoyancy force increases by the same amount that the (downward) weight of the ship increases, and thus the ship will still float fine.

   (In a really extreme case, a gigantic increase in gravity could cause changes to the shape of the ship, or changes to the water—crushing it into neutrons or something like that—but we'll assume that Vonnegut isn't implying that.)

6. (25 points)(a) Neatly drawn diagrams.

(b) We see 4 visible lines in the spectrum for hydrogen. According to the web site, the orange-red line is somewhere between ABOUT
 6550 and 6570 x 10^{-10} meters in wavelength.

(c) Since we are considering only the three smallest orbits, the only possible transitions during which a photon is emitted are (3 to 2), (3 to 1) and (2 to 1)

(d) Using E =hf, and (frequency)(wavelength) = c, gives the following:

 (3 to 2) gives wavelength of about 6540 x 10^{-10} meters
 (3 to 1) gives wavelength of about 1030 x 10^{-10} meters
 (2 to 1) gives wavelength of about 1220 x 10^{-10} meters

 These numbers may not be exact because of rounding off of the energy levels in hydrogen! But your numbers should be somewhere close to these.

 The (3 to 2) transition is by far the closest to the wavelength for the orange-red line, so this is the transition that causes that line.

(e) Your eye can only see from around 4000 x 10^{-10} meters to 7000 x 10^{-10} meters (some sources state a slightly larger range), so the other two transitions are NOT visible to the human eye.