PHYS 102- Concepts of Physics II- Spring 2007
Homework #2
Due in class Wednesday February 28th

You <u>must</u> mostly type the text part of your work. But hand-write equations and drawings as needed; just please be neat. [Late work will not be carefully graded, but will be given a moderate amount of credit if it's generally satisfactory. If submitting late work, you must keep a back-up copy for yourself.]

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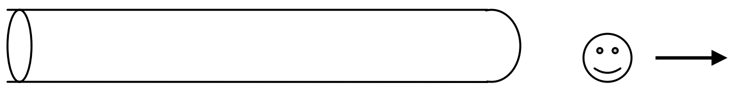
1. In this problem you will estimate the speed of a ball emerging from a "vacuum cannon."



Assume the tube is 3 meters long, has an inner radius of 5 cm, and that the ball, of mass 1/3 kg, fits this radius but without significant friction when moving through the tube. Your goal is to find the speed of the ball, first in meters per second and then convert to mph, when it emerges from the tube. Here are some hints: What force does work on the ball as it travels the tube? Calculate this work. Recall that work converts energy from one form to another. What type of energy has been added to the ball?

2. Find a "cam" in use around grounds (probably in one of the weight rooms, but somewhere else is fine as long as it's clearly visible). Sketch it and the important surrounding components, and briefly describe the cam's function.

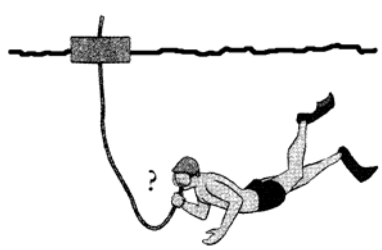
3. (a) When released near the surface of the Earth, an ordinary rubber balloon filled with air will fall. But the same balloon filled with enough helium will rise. Explain why this is, and also explain the force that is pushing the balloon upward.

   (b) You take the helium-filled balloon to the surface of the Moon and release it. Will it rise, fall, or just hover? Explain. If it rises, will it rise at the same rate as on Earth? If it falls, explain how you could calculate the time it takes to fall.

   (c) You take the helium-filled balloon inside a spaceship far out in space (i.e. no gravity). The ship does have air inside, though, so the astronauts can breathe normally. Will the balloon rise, fall, or just hover? Explain.

4. Scuba divers take their own supply of air with them when they go underwater. Why couldn't they just take a long hose with them from the surface and breathe through it (as shown below)?

5. At one point in the novel *Slapstick* by Kurt Vonnegut, the force of gravity on Earth suddenly



"increased tremendously." The result:

> *…elevator cables were snapping, airplanes were crashing, ships were sinking, motor vehicles were breaking their axles, bridges were collapsing, and on and on.*

Would a ship really sink if the force of gravity were increased? Explain your answer. Something to consider: The weight of a ship really would increase.

6. For this problem you will need to refer to the web site below. Click on "emission", then click on hydrogen to see its spectrum. You can then drag the cursor along the spectrum and read the wavelength. Multiply the number shown by 10^{-10} to convert the number to meters. For example, the middle of the scale is about 5500 x 10^{-10} meters.

   http://jersey.uoregon.edu/vlab/elements/Elements.html

   (a) For reference, draw a hydrogen atom, with a dot for the nucleus, and the three smallest possible electron orbits. These are called n=1, n=2, and n=3 (or E1, E2 and E3). Also draw an energy level diagram for hydrogen, like figure 14.26 in Hobson (4^{th} edition), but only for the first three levels. Label the energy <u>differences</u> as follows: between n=2 and n=1 is 1.632 x 10^{-18} Joules, and between n=3 and n=2 is 0.3024 x 10^{-18} Joules.
   (b) How many different lines do you see in the hydrogen emission spectrum? These are only the <u>visible</u> lines. There are many more lines that are invisible to our eyes. Approximately what is the wavelength, in meters, of the line the furthest to the right? (It appears orange-red. Your number may not be exact, but it will be close enough to answer the questions below.)
   (c) It turns out that the orange-red line is due to one of the 3 possible transitions among the orbits that you have drawn. What are these 3 possible transitions?
   (d) Using your energy-level diagram for hydrogen, calculate the wavelength in meters for <u>each</u> of those 3 transitions, and determine which one accounts for the orange-red line.
   (e) For the other 2 transitions from part (c) (the ones that don't cause the orange-red line), determine if they are visible or invisible to the human eye. (Refer to the chart on page 196 of Hobson. Violet light has a wavelength of about 4 x 10^{-7} meters, and red light about 7 x 10^{-7} meters.)