SMS 204: Integrative marine sciences.

**Assignment #2.**

Knowledge base: hydrostatic pressure, ideal gas law, ability to apply the continuity principle, computation of volume, mass and momentum flux. Nature of forces in fluids. Skills: algebra, unit conversion, significant digits.

Assignment can be done in a group, but has to be emailed individually and be distinct.

1. (15 pts) Assume that you have a U-shaped, hollow tube (we call it a 'manometer') with Karo syrup (density 1250 kg m^{-3}) in it such that both arms are half filled. What would happen if you added a given mass of water (density ~1g ml^{-3}) into one of the arms of the manometer? (The mass added has less volume than half the arm of the monometer.) Feel free to add a drawing describing initial and final states.

The fluid in both arms will rise. The fluid in the arm where water was added will be higher than in the other arm.

karo   water
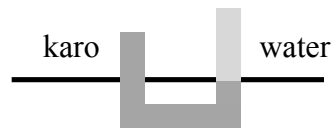
Extra credit (10 pts): If the cross-sectional area of the manometer is 10 cm^2 and the amount of water added is 40 ml, what will be the height difference between the two arms of the manometer?

The height of the added water is 40ml=40cm^3/10cm^2=4cm. Since at the position of the black line (and below) the same pressure should be in the fluid (otherwise the fluid will flow in the manometer) :

4.0cm*1000kg/m^3=y*1250kg/m^3 → y=3.2cm. Where y denotes the height of the karo above the line.
→ The difference in height will be 4.0-3.2=0.8cm.

2. (20 pts) An ingenious inventor decides to use a large chamber with a bottom that is open as a submarine. He fills it with air so its volume at the ocean's surface is 30m^3. The inventor and the submarine starts descending down to depth. Assuming no exchange of gas with the surrounding fluid, what will be the chamber's air volume at 5, 10, and 20 and 100 m?

We use the fact that PV is conserved (assuming no change in temperature, just as with the 15pd weight on the syringe in Lab 2). Every 10m of water adds (nearly) the same pressure as that of the atmosphere (that is another 10^{5}Pa).

Depth (m)	Pressure (Pa)	Volume (L)	Pressure x volume
0	10^5Pa	30m^3	$3 \cdot 10^6$Pa m^3
5	$1.5 \cdot 10^5$Pa	20m^3	$3 \cdot 10^6$Pa m^3
10	$2 \cdot 10^5$Pa	15m^3	$3 \cdot 10^6$Pa m^3
20	$3 \cdot 10^5$Pa	10m^3	$3 \cdot 10^6$Pa m^3
100	$11 \cdot 10^5$Pa	2.73m^3	$3 \cdot 10^6$Pa m^3

3. (20 pts) At Old Town, near Indian Island, you measure the average width of the Penobscot river to be 40m, its average depth to be 4m, and the average velocity of the water to be on average 10 cm s^{-1}. Downstream, near Veazie, you measure the averaged width to be 50m, the average depth to be 5m and the average velocity to be 20 cm s^{-1} at the same time. The Stillwater is a tributary that joins the Penobscot river at Orono, between Old Town and Veazie.

a. What are the mass and volume fluxes of the Stillwater into the Penobscot in SI units?

Old Town (In)=40m*4m*0.1m/s*1000kg/m^3 =16,000Kg/s
Veazie (Out)=50m*5m*0.2m/s*1000kg/m^3=50,000Kg/s
Stilllwater=out-in=34,000Kg/s

Volume flux:
Old Town (In)= 40m*4m*0.1m/s =16m^3/s
Veazie (Out)= 50m*5m*0.2m/s =50m^3/s
Stilllwater=out-in =34m^3/s

b. If the Stillwater's average width is 10m and its average depth 1m where it joins the Penobscot, what is the average water velocity where it joins the Penobscot in cm s^{-1}?

$<v> = 34m^3/s /(10 \times 1 m^2) = 3.4m/s = 340cm/s$

Assume no other sources or sinks of water between Old Town and Veazie and use, if needed, a typical density of fresh water for your calculations.

4. A. (5 pts) How can water flow up a straw and into a mouth in a direction opposing gravity?

B. (10 pts) Many marine organisms have tubes or siphons. Choose one such organism and discuss how the tube/siphon generates flow into/out off that organism (use and cite at least one reference from the WWW or a paper you found).

5. (20pts) Report the following values with the appropriate significant digits (see http://misclab.umeoce.maine.edu/boss/classes/SMS_204/Error.pdf or other resources of your choice, such as https://en.wikipedia.org/wiki/Significant_figures):

   a. 1.3862m when the uncertainty is +/-10cm

b. 3,546ml when the uncertainty is +/-10%
c. 0.004892g when the uncertainty in the value is +/-5%
d. 3,350,698 fish when the uncertainty is +/-1000fish

Answer:
   a. 1.4 +/-0.1m
   b. 3,550 +/-350ml
   c. (4.9 +/-0.25)10^{-3}g
   d. 3,351,000 +/-1000 fish

6. (5 pts) Watch the movie: 'The science of water pressure | History' (https://www.youtube.com/watch?v=0B0EhuxJsts). Convert all the magnitudes that are given in non-SI units to SI units (e.g. atmospheric pressure etc').

By order of appearance 170ft=51.81m, 14.8psi=10204Pa, 60,000ft=18,288m, 1Atm=101325Pa, 2Atm=202650Pa, 110ft=33.42m.

7. (5pts) Watch the movie: 'The science of diving – Understanding pressure' (https://www.youtube.com/watch?v=6IPFLixjqVg). How will the density of air in your lungs change if you dove to 40m (e.g. when taking the PADI deep diver course)?
The lung volume will change due to pressure. If the lung volume is V at the surface and the air mass M, the density of the air in the surface is M/V. Diving to 50m the volume will change as the pressure is multiplied by 5. At 40m the volume is $V/5$. Assuming the mass of air to stay constant, the density of air at 40m will be $M/(V/5)$ =5 M/V. *The density is five time larger.*