SMS 204: Integrative marine sciences.

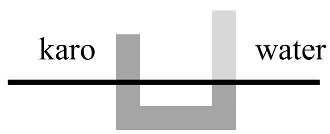
Assignment #2.

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 1400 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.



Extra credit (10 pts): If the cross-sectional area of the manometer is 1 cm^2 and the amount of water added is 5 ml, what will be the height difference between the two arms of the manometer?

The height of the added water is $5cm^3/1cm^2=5cm$. 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) :

$5.0cm*1000kg/m^3=y*1400kg/m^3$ → $y=3.57cm$. Where 'y' denotes the height of the karo above the line.
→ *The difference in height will be 5.0-3.57=1.43cm.*

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 $40m^3$. 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 40m and 80 m?

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

Depth (m)	Pressure (Pa)	Volume (L)	Pressure x volume
0	10^5Pa	40m^3	$4{\cdot}10^6$Pa m^3
5	$1.5{\cdot}10^5$Pa	26.66m^3	$4{\cdot}10^6$Pa m^3
10	$2{\cdot}10^5$Pa	20m^3	$4{\cdot}10^6$Pa m^3
20	$3{\cdot}10^5$Pa	13.33m^3	$4{\cdot}10^6$Pa m^3
80	$9{\cdot}10^5$Pa	4.44m^3	$4{\cdot}10^6$Pa m^3

3. (20 pts) At Old Town, near Indian Island, you measure the average width of the Penobscot river to be 100m, its average depth to be 3m, and the average velocity of the water to be on average 20 cm s^{-1}. Downstream, near Veazie, you measure the averaged width to be 50m, the average depth to be 6m and the average velocity to be 25 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)=100m*3m*0.2m/s*1000kg/m^3 =60,000Kg/s*
*Veazie (Out)=50m*6m*0.25m/s*1000kg/m^3=75,000Kg/s*
Stilllwater=out-in=15,000Kg/s

Volume flux:
*Old Town (In)= 100m*3m*0.2m/s =60m^3/s*
*Veazie (Out)= 50m*6m*0.25m/s =75m^3/s*
Stilllwater=out-in =15m^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}?

$\langle v \rangle = 15m^3/s /(10 \times 1\ m^2) = 1.5m/s = 150cm/s$

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?

By lowering the pressure in the mouth relative to the atmospheric pressure, water will flow as water flows from high to low pressure (the pressure time the cross-sectional area is the force that pushes it).

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 (2.5pts each,

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, and https://www.khanacademy.org/math/arithmetic-home/arith-review-decimals/arithmetic-significant-figures-tutorial/v/more-on-significant-figures):

a. 61.3699m when the uncertainty is +/-1cm
b. 4,544ml when the uncertainty is +/-5%
c. 0.003951g when the uncertainty in the value is +/-10%
d. 5,321,652 fish when the uncertainty is +/-1,000fish

Answer:

a. *61.37 +/-0.01m*
b. *4,500+/-225ml*
c. *(4.0 +/-0.4)*10^{-3}*g*
d. *5,322,000 +/-1,000 fish*

Convert the following units (see https://www.khanacademy.org/tag/unit-conversionalgebra to learn more about this critical skill).

1. (2pt). How many ml are there in $5m^3$?
2. (2pt). A tuna swims at 50cm s^{-1}. How many km does he swims in an hour?
3. (6pt). A seal weighing 120lb needs to be administered drug X at 33mg per kg of bodyweight twice a day. The drug comes in a solution of density 1.2g/ml. How many ml should we administer twice a day?

Answer:

1. $1\ ml = 1\ cm^3 = 10^{-6}\ m^3 \rightarrow 5\ m^3/10^{-6}\ m^3 = 5 \times 10^6$ *ml in* $5m^3$
2. $50cm\ s^{-1} = 0.5\ m\ s^{-1} = 5\times10^{-4}\ km\ s^{-1} \times 3600s\ hr^{-1} = 1.8\ km\ hr^{-1}$
3. *120lb=54.43 kg , total # of mg=54.43 x 33 mg =1796.2mg = 1.796g.*
   Need to administer: 1.796g/(1.2 g/ml) = 1.5 ml twice daily.

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=102040Pa, 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 20m (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 20m the volume will change as the pressure is multiplied by 3. At 20m the volume is V/3. Assuming the mass *of air to stay constant, the density of air at 20m will be M/(V/3) =3 M/V. The density is three time larger.*
