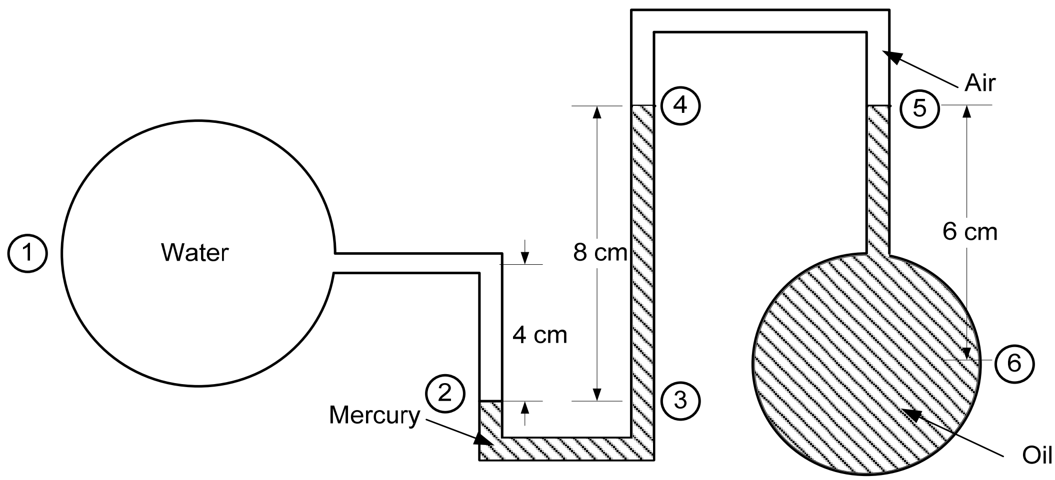
ENSC 283 Week # 3, Tutorial # 2– Pressure Distribution in a Fluid

Problem 1: A manometer connects an oil pipeline and a water pipeline as shown in the figure. Determine the difference in pressure between the two pipelines using the readings on the manometer. Use $SG_{oil} = 0.86$ and $SG_{Hg} = 13.6$.



<u>Solution</u>

Step 1: Write out what you are required to solve for (this is so you don't forget to answer everything the question is asking for)

Find:

– Pressure difference between water and oil pipelines

Step 2: Prepare a data table

Data	Value	Unit
SG_{oil}	0.86	–
SG_{Hg}	13.6	–

Also, required heights for computations are shown in the figure.

Step 3: State your assumptions (you may have to add to your list of assumptions as you proceed in the problem)

Assumptions:

1) The specific weight of water is assumed to be $9800\ N/m^3$.

Step 4: Calculations

The points of interest have been positioned on the manometer in the figure. The pressure at point 2 is equal to the pressure at point 3:

$$p_2 = p_3 \qquad \text{(Eq1)}$$

$$p_{water} + \gamma_{water} \times 0.04(m) = p_4 + \gamma_{Hg} \times 0.08(m) \qquad \text{(Eq2)}$$

Note that the heights must be in meters. The pressure at point 4 is essentially the same as that at point 5, since the specific weight of air is negligible compared with that of the oil. So,

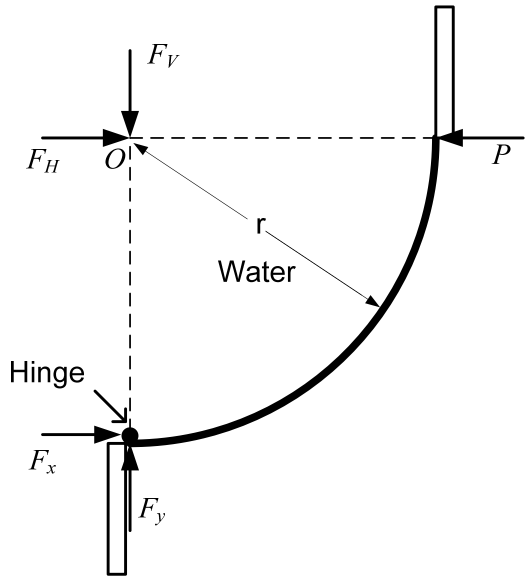
$$p_4 = p_5 = p_{oil} - \gamma_{oil} \times 0.06(m) \qquad \text{(Eq3)}$$

Finally,

$$\begin{aligned} p_{water} - p_{oil} &= -\gamma_{water} \times 0.04(m) + \gamma_{Hg} \times 0.08 - \gamma_{oil} \times 0.06(m) \qquad \text{(Eq4)} \\ &= -9800\ \left(\frac{N}{m^3}\right) \times 0.04(m) \\ &+ (13.6 \times 9800)\left(\frac{N}{m^3}\right) 0.08(m) \\ &- (0.86 \times 9800)\left(\frac{N}{m^3}\right) 0.06(m) = 9764.72\ Pa(N/m^2) \end{aligned}$$

Note that $\gamma_{oil} = SG_{oil}.\gamma_{water}$ and $\gamma_{Hg} = SG_{Hg}.\gamma_{water}$.

Problem 2: Consider the gate in the following figure to be a quarter circle of radius $80\ cm$ with the hinge $8\ m$ below the water surface. If the gate is $1\ m$ wide, what force P is needed to hold the gate in the position shown?



<u>Solution</u>

Step 1: Write out what you are required to solve for (this is so you don't forget to answer everything the question is asking for)

Find:

– The force P needed to hold the gate

Step 2: Prepare a data table

Data	Value	Unit
w	1	m
r	80	cm
h	8	m

Step 3: Calculations

We put the forces F_H and F_V on the center of the circular arc, as shown in the figure. This is allowed since all the force components that make up the resultant vector force pass through the center of the arc. In other words, we can move a force to any point by adding the moment of the force with respect to the new point. In the present case, the force *F* passes through the center of the circular arc *O*, therefore, its moment is zero, see the following figure. The free-boundary diagram of the gate would appear as in the first figure. If moments are taken about the hinge, F_x, F_y, and F_V produces no moments. So,

$$P.r = F_H.r \Longrightarrow P = F_H \qquad \text{(Eq1)}$$

The force P is

$$\begin{aligned} P = \gamma\bar{h}A = \gamma\left(h-\frac{r}{2}\right)A = \gamma\left(h-\frac{r}{2}\right)w.r \qquad \text{(Eq2)} \\ = 9810\left(\frac{N}{m^3}\right)\times(8-0.4)(m)\times(0.8\times 1)(m^2) \\ = 93200\ N \end{aligned}$$