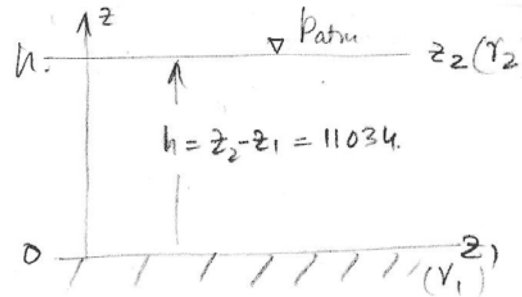
#1.

The deepest known point in the ocean is 11,034 m in the Mariana Trench in the Pacific. At this depth the specific weight of seawater is approximately 10,520 N/m³. At the surface, γ = 10,050 N/m³. Estimate the absolute pressure at this depth, in *atm*.

$$\frac{dp}{dz} = -\gamma(z)$$



$\gamma_1 = 10520$ N/m³
$\gamma_2 = 10050$ N/m²

$$\gamma(z) = 10520 + \frac{d\gamma}{dz}(z)$$

$$= 10520 + \frac{10050 - 10520}{z_2 - z_1} \cdot z$$

$$= 10520 - \frac{470}{11034} \cdot z$$

$$= 10520 - 0.0426\, z$$

so $$\frac{dp}{dz} = (0.0426\, z - 10520)$$

$$\int_{p_1}^{p_2} dp = \int_{z_1}^{z_2} (0.0426 z - 10520)\, dz$$

$$p_2 - p_1 = \left(0.0426 \cdot \frac{z^2}{2} - 10520 z\right)\Bigg|_{z_1 = 0}^{z_2 = h}$$

$$p_{atm} - p_{seabed} = \frac{0.0426}{2}(11034)^2 - 10520\,(11034)$$

$$= 2593257 - 1.16078 \times 10^8$$

$$= -1.135 \times 10^8 \text{ N/m}^2$$

$$p_{seabed} = p_{atm} + 1.135 \times 10^8 \text{ N/m}^2$$

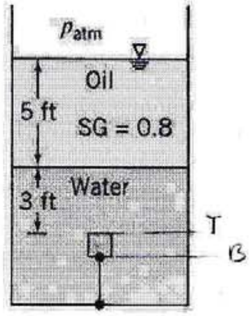
$$= (1 + 1120) \doteq 1121 \text{ atm}.$$

or 1.136×10^8 Pa.

or 113.6 MPa

#2.

A 1 ft cube of solid oak is held submerged by a tether as shown. Calculate the actual force of the water on the bottom surface of the cube and the tension in the tether.



Pressure on the bottom surface :

$$p_B = 0 + \gamma_{oil} \times 5 + \gamma_w (3+1) \qquad \text{(Gage pressure)}$$

$$= 0 + 0.8 \times 62.4 \times 5 + 62.4 \times 4$$

$$= 499.2 \ \text{lbf/ft}^2$$

$$p_B = p_{B,gage} + p_{atm} = 499.2 + 2116.8 = 2616 \ \text{lbf/ft}^2$$

$$F_B = p_B \times A_{bottom} = 2616 \ \frac{\text{lbf}}{\text{ft}^2} \times 1 \ \text{ft}^2 = 2616 \ \text{lbf} \quad \text{Ans}$$

pressure on top surface :

$$p_T = 2116.8 + 0.8 \times 62.4 \times 5 + 62.4 \times 3 = 2553.6 \ \text{lbf/ft}^2$$

$$F_T = 2553.6 \ \text{lbf/ft}^2 \times 1 \ \text{ft}^2 = 2553.6 \ \text{lbf}$$

$$\text{Wt. of block, } W = \gamma_{oak} \forall = 0.77 \times 62.4 \times 1 = 48.1 \ \text{lbf}$$

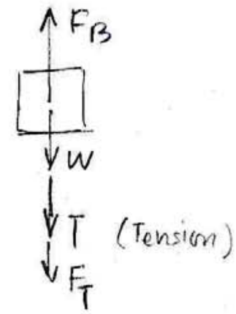
For equilibrium in y direction.

$$\Sigma F_y = 0$$

$$\Rightarrow F_B - W - T - F_T = 0$$

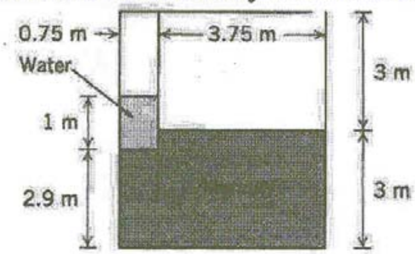
$$\Rightarrow T = F_B - W - F_T = 2616 - 48.1 - 2553.6$$

$$= 14.3 \ \text{lbf} \quad \text{Ans}$$



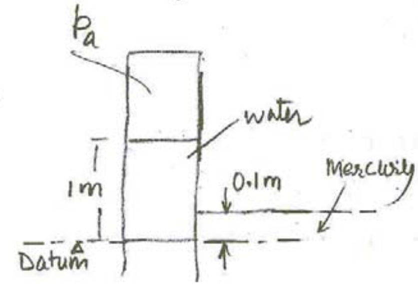
#3.

A partitioned tank as shown contains water and mercury. What is the gage pressure in the air trapped in the left chamber? What pressure would the air on the left need to be pumped to in order to bring the water and the mercury free surfaces level?



Case I

Equate pressures at datum line :



$$p_a + \gamma_w \times 1 = 0 + \gamma_{Hg} \times 0.1$$

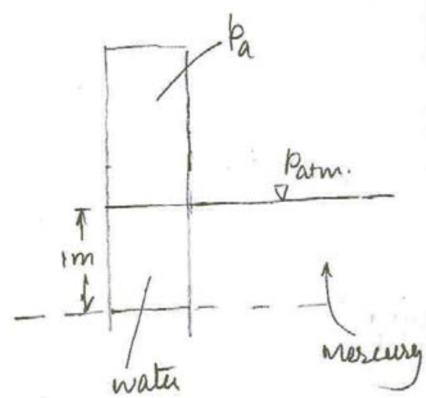
$$p_{a,gage} = \gamma_{Hg} \times 0.1 - \gamma_w \times 1$$

$$= 132790 \times 0.1 - 9800$$

$$= 3479 \text{ N/m}^2 = 3.48 \text{ kPa} \quad \underline{\text{Ans}}$$

Case II : Chamber pressure increased :

Equate pressures at new datum :



$$p_{a,gage} + \gamma_w \times 1 = 0 + \gamma_{Hg} \times 1$$

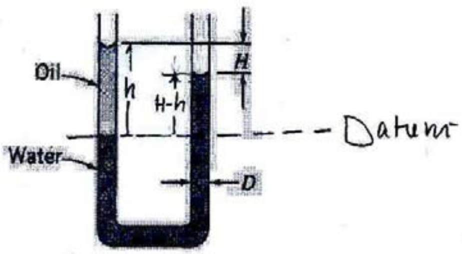
$$p_{a,gage} = 132790 - 9800$$

$$= 122990 \text{ N/m}^2$$

$$\simeq 123 \text{ kPa} \quad \underline{\text{Ans}}$$

#4.

A manometer is formed from glass tubing with uniform inside diameter, D = 6.35 mm, as shown. The U- tube is partially filled with water. Then $\forall$ = 3.25 cm^3 of Meriam red oil *(SG = 0.827)* is added to the left side. Calculate the equilibrium height, H, when both legs of the U-tube are open to the atmosphere.



$D = 6.35 \text{ mm}$

$\quad = 6.35 \times 10^{-3} \text{ m}$

$A = \pi \dfrac{D^4}{4} = \dfrac{\pi}{4} \times (6.35 \times 10^{-3})^2 = 3.17 \times 10^{-5} \text{ m}^2$

Given Volume of oil column, $\forall = 3.25 \times 10^{-6} \text{ m}^3$

$$h = \frac{\forall}{A} = \frac{3.25 \times 10^{-6}}{3.17 \times 10^{-5}} = 0.1025 \text{ m.}$$

$\gamma_{oil} = 0.827 \times 9800 = 8105 \text{ N/m}^3$

Equating pressures at the Datum line :

$$0 + \gamma_{oil} \cdot h = 0 + (H-h)\gamma_{water}$$

$$(\gamma_{oil} + \gamma_{water}) h = \gamma_{water} \cdot H$$

$$H = \frac{(\gamma_{oil} + \gamma_{water}) h}{\gamma_{water}} = \frac{(8105 + 9800) \times 0.1025}{9800}$$

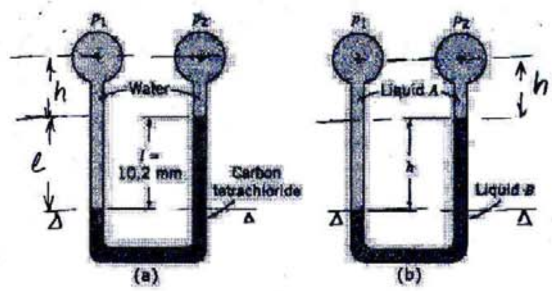
$$= \frac{173.737}{9800} = 0.01773 \text{ m.}$$

So $\quad H = 17.7 \text{ mm} \quad$ Ans

#5.

a). Consider the two fluid manometer shown (Fig a). Calculate the pressure difference?

b). The manometer shown contains two liquids (Fig b). Liquid *A* has $SG = 0.88$ and liquid *B* has $SG = 2.95$. Calculate the deflection, h, when the applied pressure difference is $p_1 - p_2 = 870$ Pa?



a). Equate pressures at datum.

$$p_1 + \gamma_w \times (h + l) = p_2 + \gamma_w h + \gamma_{ccl_4} l$$

$$p_1 - p_2 = \gamma_w h + \gamma_{ccl_4} l - \gamma_w (h + l)$$

$$= \cancel{\gamma_w h} + \gamma_{ccl_4} l - \cancel{\gamma_w h} - \gamma_w l$$

$$= \gamma_{ccl_4} l - \gamma_w l$$

$$= 1.595 \times \gamma_w l - \gamma_w l = (1.595 - 1)\gamma_w l$$

$$= 0.595 \times 9800 \times \frac{10.2}{1000} = 59.47 \text{ Pa} \quad \underline{\text{Ans}}$$

b). Equate pressures :

$$p_1 + (h + \cancel{h_1})\gamma_A = p_2 + \cancel{h_1}\gamma_A + h\gamma_B$$

$$p_1 - p_2 = h\gamma_B - h\gamma_A = h(\gamma_B - \gamma_A)$$

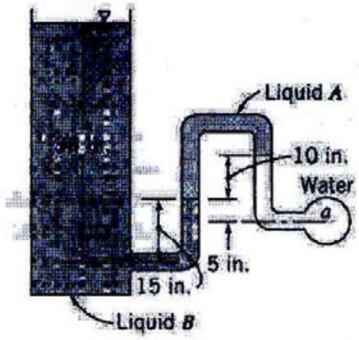
$$p_1 - p_2 = 870 = h(2.95 - 0.88)\,9800$$

$$h = \frac{870}{(2.95 - 0.88)\,9800} = 0.04286 \text{ m}$$

$$\doteq 42.86 \text{ mm} \quad \underline{\text{Ans}}$$

#6.

Determine the gage pressure in psig at point a, if liquid A has $SG = 0.75$ and the liquid B has $SG = 1.20$. The liquid surrounding point a is water and the tank on left is open to the atmosphere.



starting from free surface and going all the way to point a.

$$0 + \gamma_B \cdot 36 - \gamma_B \cdot 15 - \gamma_A \cdot 10 + \gamma_W \cdot 15 = p_{a,gage}.$$

so $p_{a,gage} = (36-15)\gamma_B - 10\gamma_A + 15\gamma_W$

$$= \frac{21}{12} \cdot (1.2 \times \gamma_W) - \frac{10}{12} \cdot (0.75 \times \gamma_W) + \frac{15}{12}\gamma_W$$

$$= (2.1 - 0.625 + 1.25) \times \gamma_W$$

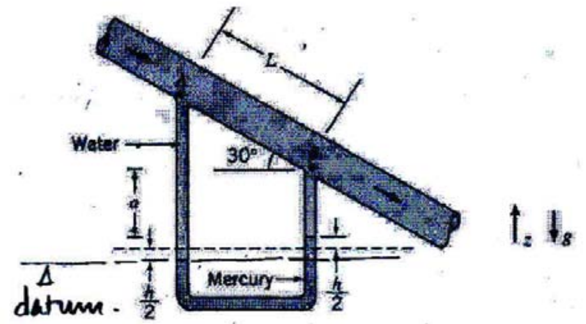
$$= 2.725 \times 62.4$$

$$= 170.04 \ lbf/ft^2$$

$$\simeq \frac{170.04}{144} = 1.18 \ psig.$$

#7.

Water flows downward along a pipe that is inclined at 30° below the horizontal, as shown. Derive an algebraic expression for the pressure difference. Evaluate the pressure difference if $L = 5$ ft and $h = 6$ in.



$L = 5$ ft

$h = 6$ in $= 0.5$ ft.

Equating pressures at the datum:

$$p_A + (L \sin 30^\circ + \cancel{a} + h)\,\gamma_w = p_B + \cancel{a\gamma_w} + h\,\gamma_{Hg}$$

$$p_A + (2.5 + h)\,\gamma_w = p_B + h\,\gamma_{Hg}.$$

$$p_A - p_B = h\,\gamma_{Hg} - (h + 2.5)\,\gamma_w$$

$$= 0.5 \times 13.55\,\gamma_w - (0.5 + 2.5)\,\gamma_w$$

$$= (0.5 \times 13.55 - 3)\,\gamma_w$$

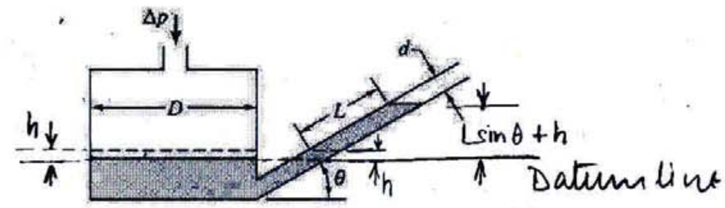
$$= 3.775 \times 62.4 = 235.56\ \frac{lbf}{ft^2}$$

$$= \frac{235.56}{144} = 1.65 \text{ psig.}$$

Ans

#8.

The inclined tube manometer shown has $D = 3$ in. and $d = 0.25$ in., and is filled with Meriam red oil. Compute the angle, θ, that will give a 5 in oil deflection along the inclined tube for an applied pressure of 1 in. of water (gage). Determine the sensitivity of this manometer.



$D = 3\text{ in} = 0.25\text{ ft}$

$d = 0.25\text{ in} = 0.0208\text{ ft}$

$dp = 1\text{ in of water} \Rightarrow dp = \frac{1}{12} \times 62.4 = 5.2\ \text{lbf/ft}^2$

Volume displace on left side = Volume up on right side.

$$\Rightarrow \frac{\pi D^2}{4} h = \frac{\pi d^2}{4} L$$

$$\Rightarrow h = \left(\frac{d}{D}\right)^2 L$$

Equate pressures on datum line

$$dp = 0 + (L\sin\theta + h)\,\gamma_{oil}$$

$$= \left(L\sin\theta + \frac{d^2}{D^2}L\right) \cdot 0.827 \cdot \gamma_W$$

$$= \left(\frac{5}{12}\sin\theta + 2.8935 \times 10^{-3}\right) \cdot 0.827 \cdot 62.4$$

$$\Rightarrow \frac{5}{12}\sin\theta + 0.0028935 = \frac{5.2}{0.827 \times 62.4} = 0.100765$$

$$\frac{5}{12}\sin\theta = 0.100765 - 0.0028935 = 0.09787$$

$$\theta = \sin^{-1}\frac{12 \times 0.09787}{5} \simeq 13.5^\circ \quad \text{Ans}$$

$$\text{Sensitivity, } s = \frac{\Delta L}{(\Delta p)_{head}} = \frac{5}{1} = 5 \quad \text{Ans}$$