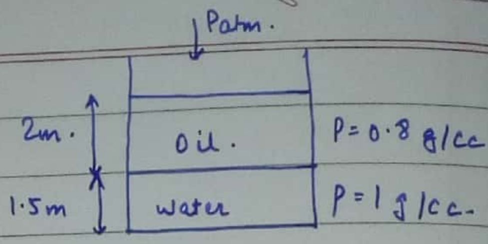
Problem Sheet - Fluid Statics

1. Gauge pressure = pressure at the req.d point. − Patm.




∴ (i) Gauge pressure at Interface

$= (P_{atm} + \text{Pressure due to oil column}) - P_{atm}.$

$= P_{oil} \cdot g\,(h).$

$= 800 (kg/m^3) \times 9.81 (m/s^2) \times 2 (m).$

$= 15696\ N/m^2 = 1.57\ N/cm^2$

(ii) Gauge pressure at bottom of tank.

$= 1.57\ N/cm^2 + (1000 \times 9.81 \times 1.5 \times 10^{-4})$

$= (1.57 + 1.47)\ N/cm^2 = 3.04\ N/cm^2.$

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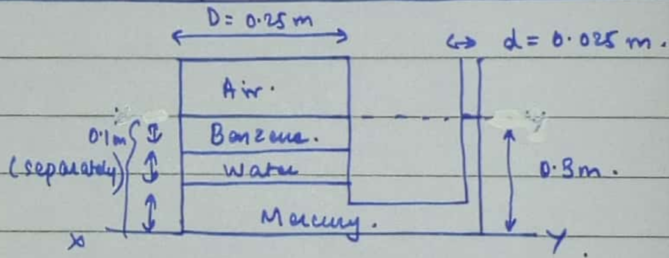
2. $P_{Benzene} = 879\ kg/m^3$

$P_{Mercury} = 13550\ kg/m^3$




$P_x = P_{air} + (879 \times 9.81 \times 0.1) + (1000 \times 9.81 \times 0.1) + (13550 \times 9.81 \times 0.1)$

$P_x = P_{air} + \quad . \ 15.136\ kPa$

$P_y = P_{atm} + (13550 \times 9.81 \times 0.3)$ [∵ we're considering gauge pressure only].

$= 39.878\ kPa.$

∴ $P_x = P_y. \Rightarrow P_{air} = (39.878 - \overset{15.136}{\quad})$

$= \boxed{24.791\ kPa.\ (gauge)} \rightarrow$

Let after opening hole, at top of left limb, mercury in right limb falls h Cont. (Right to left).

Now, volume of mercury transfer $= \frac{\pi d^2}{4} \cdot h$

area of left limb $= \frac{\pi D^2}{4}.$

$\therefore$ Wt. ~~increased~~ in left limb $= \dfrac{\pi d^2 h/4}{\pi D^2/4} = \left(\dfrac{d}{D}\right)^2 . h. =$

Now, $P_x = P_{atm} + (879 \times 9.81 \times 0.1) + (1000 \times 9.81 \times 0.1) + (13550 \times 9.81 \times (0.1 + 0.01h))$

$P_y = P_{atm} + (13500 \times 9.81 \times (0.3 - h))$

$\therefore P_x = P_y .$

$\Rightarrow 15.136 + (13500 \times 9.81 \times 0.01h) = (13500 \times 9.81 \times 0.3) - (13500 \times 9.81 \times h)$

$\Rightarrow (13500 \times 9.81 \times 1.01h) = 39.878 \text{ KPa} - 15.136 \text{ KPa}.$

$\Rightarrow$

$\Rightarrow h = 0.185 \text{ m}.$

$\therefore$ level of mercury in right limb $= 0.3 - 0.185$

$= 0.115 \text{ m}.$

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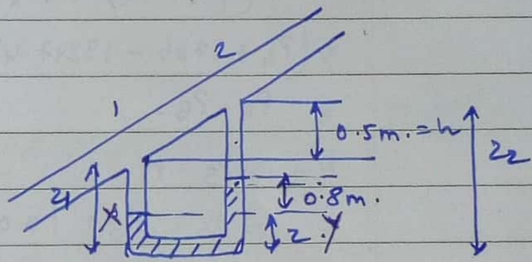
3.

$P_x = P_1 + (z_1 - z).\rho_w.g$

$P_y = P_2 + 0.8\rho_m.g + (z_2 - z - 0.8)\rho_w.g.$




$P_x = P_y$ 2

$P_1 - P_2 = 0.8\rho_m.g - 0.8\rho_w g + \rho_w g (z_2 - z - z_1 + z)$

$: 0.8g(\rho_m - \rho_w) + \rho_w.g(z_2 - z_1)$

$= 0.8 \times 9.81 \times (13600 - 1000) + 1000 \times 9.81 \times (0.5).$

$= 103.79 \text{ KPa}.$

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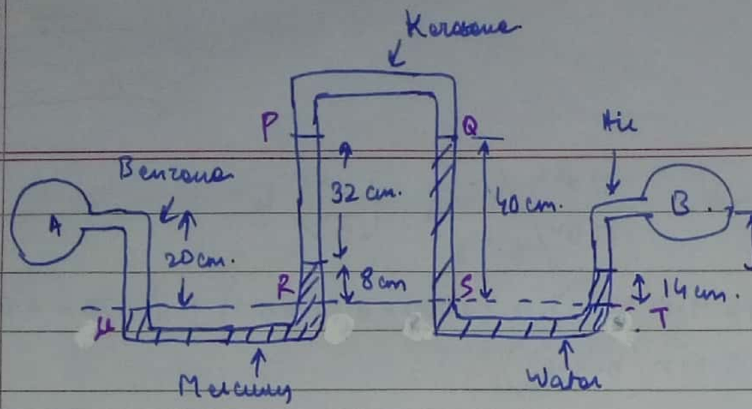
4.




$\rho$(Benzene) = 880
$\rho$(Kerosene) = 820
$\rho$ (air) = 1.2
$\rho$ (mercury) = 13600

kg/m³.

$P_P = P_Q$

$$P_R - (0.08 \times 13600 \times 9.81) - (0.32 \times 820 \times 9.81) = P_S - (0.4 \times 1000 \times 9.81)$$

$$\Rightarrow P_R - P_S = 9323.424 \text{ Pa} \longrightarrow (1)$$

Now, $P_R = P_U$

$$\Rightarrow P_R = P_A + (0.2 \times 880 \times 9.81)$$

$$\Rightarrow P_R = P_A + 1726.56$$

And, $P_S = P_T$.

$$\Rightarrow P_S = P_B + (0.09 \times 1.2 \times 9.81) + (0.14 \times 1000 \times 9.81)$$

Putting $P_R, P_S$ in (1):

$$P_A - P_B + 352.1 = 9323.424.$$

$$\Rightarrow P_A - P_B = 8971.324$$

$$= 8.971 \text{ kPa}.$$

5. Let vacumm pressure = P

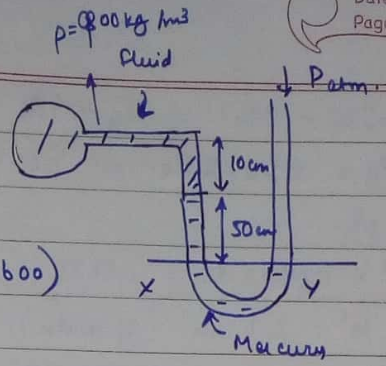
~~$\therefore P + (0.10 \times 9.81) + ($~~

$P_x = P_y$

$\therefore P + (0.1 \times 9.81 \times 900) + (0.5 \times 9.81 \times 13600) = 0$

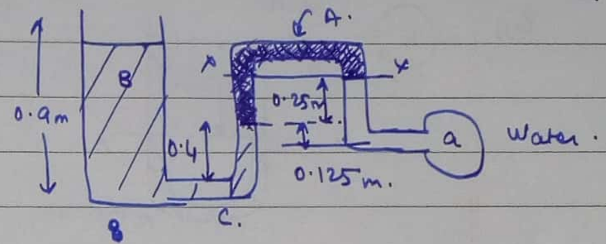
$\Rightarrow P = -67.6\ kPa$

$\therefore$ Vacumm pressure $= 67.6\ kPa$.




6. $P_x = P_y$.

$P_y = P_a - (0.375 \times 9.81 \times 1000)$




$P_x = P_c - (0.4 \times 9.81 \times 750) - (0.25 \times 9.81 \times 1200)$

$= (0.9 \times 9.81 \times 750) - (5886)$

$= 735.75\ Pa$

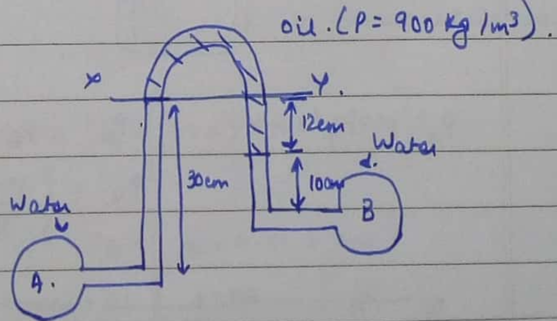
$P_c = (0.9 \times 9.81 \times \cancel{1200}\ 750)$

$\therefore P_a - 3678.75 = 735.75$

$\Rightarrow P_a = 4414.5\ Pa$

$= 4.414\ kPa$

7. $P_a = 2.5\,m$ of water $= (2.5 \times 1000 \times 9.81) = 24525\ Pa$.




$P_x = P_y$

$P_x = P_A - (0.3 \times 1000 \times 9.81)$

$P_y = P_B - (0.1 \times 1000 \times 9.81) - (0.12 \times 900 \times 9.81)$.

$\Rightarrow 24525 - 2943 = P_B - 981 - 1059.48$

$\Rightarrow P_B = 23622\ Pa$ or $23.622\ kPa$.

OR.

$h' \times 1000 \times 9.81 = 23622$.

$\Rightarrow h' = 2.41\ m$. (of water).

$\therefore$ Pressure $= 23.622\ kPa$ or $2.41\ m$ of water.

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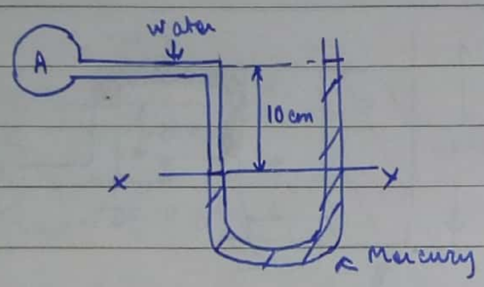
8(i)




$P_x = P_A + (0.1 \times 1000 \times 9.81)$

$P_y = (0.1 \times 13600 \times 9.81)$

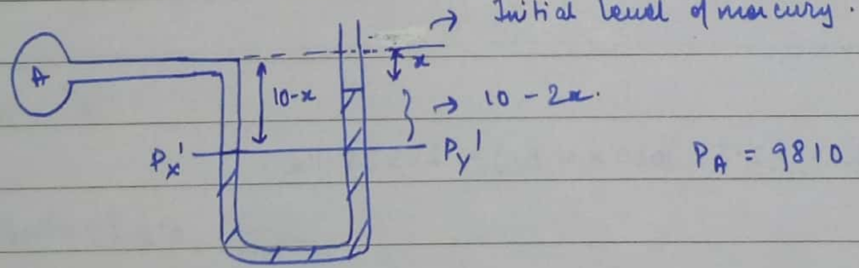
Now, $P_x = P_y$.

$\Rightarrow P_A = (0.1 \times 13600 \times 9.81) - (0.1 \times 1000 \times 9.81)$.

$= 12{,}360.6\ Pa$.

$= 12.361\ kPa$ (Gauge).

(ii)




$P_A = 9810\ Pa$

$P_x' = P_y'$

$P_x' = P_A + \left(\frac{10-x}{100} \times 9.81 \times 1000\right)$

$P_y' = \left(\frac{10-2x}{100} \times 9.81 \times 13600\right)$

$\cancel{\Rightarrow P_A = \frac{9810}{100}(10-2x-10+x)}$.

$\cancel{\Rightarrow P_A = 98.1(-x)}$

$\Rightarrow P_A = 9.81[136(10-2x) - 10(10-x)]$

$\Rightarrow 9810 = 9.81[1360 - 272x - 100 + 10x]$

$\Rightarrow 1000 = [1260 - 262x]$.

$\Rightarrow x = 0.99236$

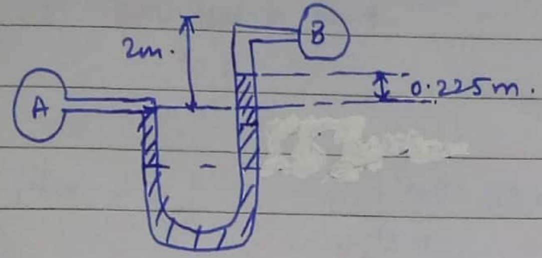
Scanned by CamScanner

$\therefore$ Diff. in mercury levels

$= (10 - 2x)$ cm.

$= \boxed{8.0152 \text{ cm.}}$

9.




$\therefore \quad P_A = P_B + (0.225 \times 13560 \times 9.81) + (1.775 \times 820 \times 9.81).$

$\Rightarrow P_A - P_B = 44208 \text{ Pa}$

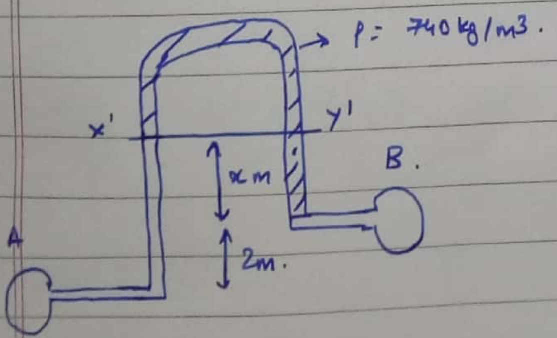
$= 44.2 \text{ KPa}$

respective piezometric heads: $\dfrac{P_A}{\rho_{oi} g} + z_1$ and $\dfrac{P_B}{\rho_{oi} g} + z_2$

$\therefore$ Difference $= \dfrac{P_A - P_B}{\rho_{oil} \times g} + (z_1 - z_2)$

$= \dfrac{44208}{820 \times 9.81} + (-2).$

$= 3.496 \text{ m}.$




$x \rightarrow$ diff. in limbs (manometric reading).

$P_{x}' = P_A - [(2 + x) \times 9.81 \times 820].$

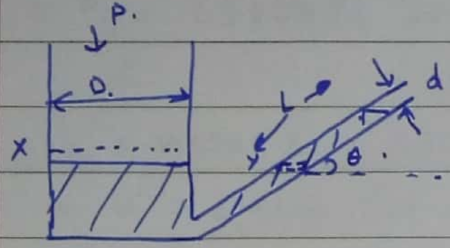
$P_{y}' = P_B - [x \times 9.81 \times 740].$

$\therefore \quad P_A - P_B = 9.81[820(2+x) - 740x].$

$\Rightarrow 44208 = 9.81[80x + 1640].$

$\Rightarrow x = 35.83 \text{ m}.$

10. Applied pressure = 25 mm of water = 245.25 Pa.




D = 76 mm, d = 8 mm. ; L = 15 cm.

Vol. of fluid transferred (L → R)

$= \frac{\pi . d^2}{4} L$

Area of left limb.

$= \frac{\pi D^2}{4}$.

$\therefore$ height reduced in left limb $= \frac{\pi d^2 L/4}{\pi D^2/4} = \left(\frac{d}{D}\right)^2 . L = h_1 . =$ $1.662 \times 10^{-3}$ m

Equating pressure at datum [w/o considering Patm; since we want gauge pressure]:

~~$P_x - (h_1 . \rho g) = P_y + (L \sin\theta . \rho . g)$~~

$\Rightarrow P_x = P = 245.25$

$P_y = (L \sin\theta . \rho . g) + (h_1 . \rho . g) = [\underset{}{0.15 \sin\theta} \times 827 \times 9.81] + [1.662 \times 10^{-3} \times 827 \times 9.81]$.

$\therefore P_x = P_y$.

$\Rightarrow 245.25 = 1216.93 \sin\theta + 13.484$

$\Rightarrow \boxed{\theta = 10.979^{\circ}}$

— x —.