LAW-ADUE EMMANUEL
19/ENG05/069
MECHATRONICS

QUESTION ONE

(i) Inlet diameter, $d_1 = 300mm = 0.3m$

Throat diameter, $d_2 = 150mm = 0.15m$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.071m^2$$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.0177m^2$$

$$h = y\left(\frac{\text{C.G of mercury}}{\text{C.G of oil}} - 1\right);$$

$$= 0.04\left(\frac{13.6}{0.9} - 1\right) = 3.5m$$

$$Q = \frac{Cd \times A_1 \times A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

$$Q = \frac{0.98 \times 0.071 \times 0.0177 \times \sqrt{2 \times 9.81 \times 3.5}}{\sqrt{0.071^2 - 0.0177^2}}$$

$$Q = 0.149\ m^3/s$$ ///

(ii) Recall that, $h = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$

From bernoulli's equation;

$$\left(\frac{P_1}{w} - \frac{P_2}{w}\right) + (-h) + (z_1 - z_2) = 0$$

$$\left(\frac{P_1}{w} - \frac{P_2}{w}\right) + (z_1 - z_2) = h$$

Not forgetting that $z_2 - z_1 = 0.3m$, and $h = 3.5m$

$[w = \rho g]$

$$\frac{P_1 - P_2}{w} - 0.3 = 3.5$$

$$\frac{P_1 - P_2}{w} = 3.53 + 0.3 \quad ; \quad \frac{P_1 - P_2}{w} = 3.83$$

~~$\frac{P_1 - P_2}{\rho g} = 3.23$~~

$P_1 - P_2 = 0.9 \times 9.81 \times 3.83$

$P_1 - P_2 = 33.8\ KN/m^2$ ///

~~$P_1 - P_2 = \rho g \times 3.23 = 0.9 \times 9.81 \times 3.23$~~

~~$P_1 - P_2 = 28.52\ KN/m^2$~~

~~Pressure difference $= 28.52 KN/m^2$~~ ///

NUMBER TWO

Specific gravity = 0.8, $D_1 = 150\,mm = 0.15m$, $D_2 = 75mm = 0.075m$; $Z_2 - Z_1 = 0.15$

$Q_{act} = 40\,l/s = 0.04\,m^3/s$

$C_d = 0.96$

Finding pressure difference $(P_1 - P_2)$;

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.01767\,m^2$$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times 0.075^2}{4} = 0.00442\,m^2$$

$$Q_{act} = \frac{C_d \times A_1 \times A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

$$0.04 = \frac{0.96 \times 0.01767 \times 0.00442 \times \sqrt{2 \times 9.81 \times h}}{\sqrt{0.01767^2 - 0.00442^2}}$$

$$\rightarrow h = (0.04 / (0.96 \times 0.004565 \times 4.429))^2$$

$$= h = 4.247m$$

$$4.247 = \left(\frac{P_1}{w} - \frac{P_2}{w}\right) + (z_1 - z_2)$$

$$4.247 = \frac{P_1 - P_2}{w} + (-0.15)$$

$$\frac{P_1 - P_2}{w} = 4.247 + 0.15$$

$$P_1 - P_2 = w \times (4.247 + 0.15) \quad ; \quad w = \rho g$$

$$P_1 - P_2 = 0.8 \times 1000 \times 9.81 \times (4.247 + 0.15)$$

$\therefore$ Pressure difference, $P_1 - P_2 = 34.51 \text{ kN/m}^2$ ///