

1. Diameter of inlet at $P_1 = 300\text{mm} = 0.3\text{m}$

$$\text{Area of inlet } A_1 = \frac{\pi}{4} \times 0.3^2 = 0.07\text{m}^2$$

Diameter of throat $P_2 = 150\text{mm} = 0.15\text{m}$

$$\therefore \text{Area of throat } A_2 = \frac{\pi}{4} \times 0.15^2 = 0.01767\text{m}^2$$

Specific gravity of heavy liquid (mercury) in U-tube manometer

$$S_{hr} = 13.6$$

Specific gravity of liquid (oil) flowing through pipe

$$S_p = 0.9$$

Reading of differential manometer, $y = 250\text{mm} = 0.25\text{m}$

\Rightarrow The difference 'h' is given by:

$$h = \left[\frac{P_1}{\rho} + z_1 \right] - \left[\frac{P_2}{\rho} + z_2 \right] = y \left(\frac{S_{hr}}{S_p} - 1 \right) = 0.25 \left(\frac{13.6}{0.9} - 1 \right)$$

$$= 3.53\text{m of oil}$$

i) Discharge of oil, Q :

using the relation,

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

$$Q = 0.98 \times \frac{0.07 \times 0.01767}{\sqrt{0.07^2 - 0.01767^2}} \times \sqrt{2 \times 9.81 \times 3.53}$$

$$= \frac{0.001212 \times 8.62}{0.0677}$$

$$= 0.1789\text{m}^3/\text{s}$$

1) Pressure difference between entrance and throat sections $p_1 - p_2$

$$h = \left(\frac{p_1}{\rho} + z_1 \right) - \left(\frac{p_2}{\rho} + z_2 \right) = 3.53$$

But $z_2 - z_1 = 300 \text{ mm}$ or 0.3 m

$$\therefore \left(\frac{p_1}{\rho} - \frac{p_2}{\rho} \right) = 0.3 = 3.53$$

$$\therefore p_1 - p_2 = (9.81) \times 0.3 \times 3.53 \\ = 33.8 \text{ kN/m}^2 //$$

2. Pressure difference ($p_1 - p_2$):

$$A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4} \times 0.15^2 = 0.01767 \text{ m}^2$$

$$A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4} \times (0.075)^2 = 0.00442 \text{ m}^2$$

$$Q_{\text{out}} = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 + A_2^2}} \times \sqrt{2gh}$$

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

$$\therefore h = \left(\frac{0.04}{0.96 \times 0.004565 \times 4.429} \right) = 4.247 \text{ m}$$

$$\Rightarrow \text{Also } h = \left(\frac{p_1}{\rho} + z_1 \right) - \left(\frac{p_2}{\rho} + z_2 \right)$$

$$4.247 = \left(\frac{p_1}{\rho} - \frac{p_2}{\rho} \right) (z_1 - z_2)$$

$$(p_1 - p_2) = \rho g (4.247 + 0.15)$$

$$= (0.8 \times 1000 \times 9.81) (4.247 + 0.15) \text{ N/m}^2$$

$$= 37.51 \text{ kN/m}^2 //$$