1. Diameter at inlet $D_1 = 300mm = 0.3m$

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

Diameter at throat, $D_2 = 150mm = 0.15m$

Area at throat, $A_2 = \frac{\pi}{4} \times 0.15^2 = 0.01767m^2$

Specific gravity of heavy Liquid (mercury) in U-tube manometer, $S_H = 13.6$

Specific gravity of Liquid (oil) flowing through pipe, $S_f = 0.9$

Reading of differential manometer $y = 250mm = 0.25m$

The differential 'h' is given by:

$$h = \left(\frac{P_1}{\omega} + Z_1\right) - \left(\frac{P_2}{\omega} + Z_2\right)$$

$$= y\left[\frac{S_H}{S_f} - 1\right] = 0.25\left[\frac{13.6}{0.9} - 1\right]$$

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

i) Discharge of oil, Q: using the relation

$$Q = C \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}, \text{ we have:}$$

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

$$= \frac{0.001212}{0.0677} \times 8.52 = 0.1491 m^3/s$$

2) Pressure difference $(P_1 - P_2)$:

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

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

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

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

OR

$$0.04 = 0.96 \times 0.004565 \times 4.429 \sqrt{h}$$

$$\therefore h = \left(\frac{0.04}{0.96 \times 0.004565 \times 4.429} \right)^2 = 4.247 m$$

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

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

$$= \left(\frac{P_1 - P_2}{\rho g} \right) - 0.15$$

or, $(P_1 - P_2) = \rho g (4.247 + 0.15)$

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

$= 34.51 kN/m^2$

ii) Pressure difference between entrance and throat sections, $P_1 - P_2$

$$h = \left(\frac{P_1}{w} + Z_1\right) - \left(\frac{P_2}{w} + Z_2\right) = 3.53$$

$$\left(\frac{P_1}{w} - \frac{P_2}{w}\right) + (Z_1 - Z_2) = 3.53$$

U-tube

$Z_2 - Z_1 = 300mm$ or $0.3m$

$S_f = 0.9$

$0.26m$

$$\therefore \left(\frac{P_1}{w} - \frac{P_2}{w}\right) - 0.3 = 3.53 \quad \text{or} \quad \frac{P_1 - P_2}{w} = 3.83$$

$$P_1 - P_2 = (9.81 \times 0.9) \times 3.83 = 33.8 \, kN/m^2$$