1) Given Sp.gr of gravity 0.8, $D_1 = 150mm = 0.15m$, $D_2 = 75mm$
$= 0.075m$ $Z_2 - Z_1 = 150mm = 0.15m$, $Q = 44.645 L/s$
$= 0.044 m^3/s$, $Cd = 0.96$ pressure difference $(P_1 - P_2)$

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

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

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

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

$0.04 = 0.96 \times 0.00456 \times 4.429 \sqrt{h}$

$h = \left(\frac{0.04}{(0.96 \times 0.00456 \times 4.429)} \right)^2 = 4.247m$

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

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

$4.247 = \left(\frac{P_1 - P_2}{\rho g} \right) - 0.15$

OR $4.247 = \left(\frac{P_1 - P_2}{\rho g} \right)$ $\Rightarrow$ $4.247 + 0.15 = \left(\frac{P_1 - P_2}{\rho g} \right)$

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

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

$P_1 - P_2 = 34.51 kN/m^2$

$$\frac{P_1 - P_2}{\omega} = 3.53 + 0.3$$

$$\frac{P_1 - P_2}{\omega} = 3.83$$

$$P_1 - P_2 = 3.83\omega$$

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

$$P_1 - P_2 = 33.8 \text{ kN M}^{-2}$$

2. Diameter of inlet $D_1 = 300\,mm = 0.3\,m$

Area of inlet $D_1 = \frac{\pi D_1^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.07\,m^2$

Diameter of throat $D_2 = 150\,mm = 0.15\,m$

Area of inlet $A_2 = \frac{\pi D_2^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.0176\,m^2$

S_g of heavy liquid (mercury) in the manometer

$S_H = 13.6$

S_g of oil flowing through PPE $S_P = 0.9$

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

The differential "h" is given by;

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

$$= y\left[\frac{S_H}{S_P} - 1\right] = 0.25\left[\frac{13.6}{0.9} - 1\right) = 3.53\,m\ of\ oil$$

a) Discharge of oil q

Using the relation

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

$$Q = \frac{0.98 \times 0.07 \times 0.07787 \times \sqrt{2 \times 9.81 \times 3.53}}{(0.07^2 - 0.07787^2)^{1/2}}$$

$$Q = 0.145\,m^3 s^{-1}$$

b) Pressure difference between entrance and throat section $P_1 - P_2$. We know;

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

$$Z_2 - Z_1 = 300\,mm = 0.3\,m$$

$$\left(\frac{P_1 - P_2}{w}\right) - 0.3 = 3.53$$