College of Engineering & Technology

Department: Mechanical Engineering
Lecturer: Dr. Rola Afify
Course Code: ME362

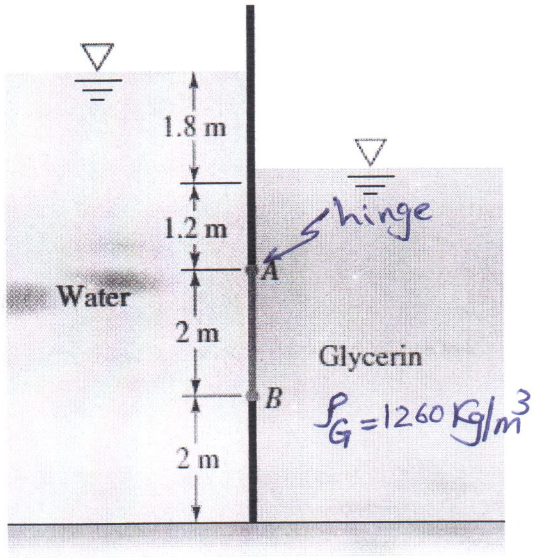
Marks: 20
Time: 8:30 – 10:10
Date: 22/4/2015

Name: Model Answer **R. N.:**

Answer the following questions:

Question one (10 marks)

A) Find the net hydrostatic force per unit width on the rectangular gate AB and its line of action. and its line of action



$$F_{Rw} = \left[P_o + \rho g\left(s + \frac{b}{2}\right)\right] ab$$

$$= [0 + 9800(3+1)]\ 2*1$$

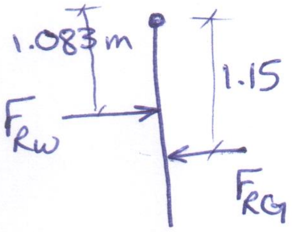
$$= 78400 \text{ Newton}$$

$$y_{P_w} = s + \frac{b}{2} + \frac{b^2}{12\left(s + \frac{b}{2} + \frac{P_o}{\rho g}\right)}$$

$$= 3 + 1 + \frac{2^2}{12(3+1+0)} = \frac{49}{12} = 4.0833 \ m$$

$$F_{RG} = [0 + 1260*9.8(1.2+1)]*2*1 = 54331 \text{ Newton}$$

$$y_{P_G} = 1.2 + 1 + \frac{2^2}{12(1.2+1+0)} = \frac{388}{165} = 2.35 \ m$$



$$\Sigma M_A = F_R * L$$

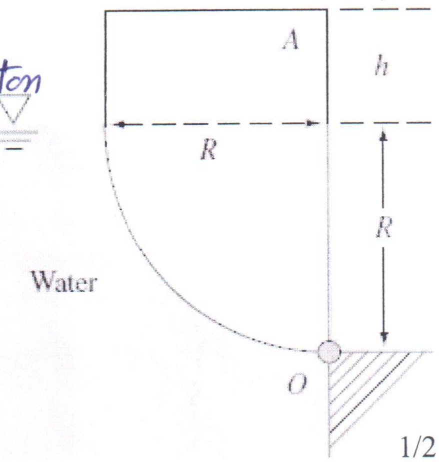
$$F_{Rw} * 1.083 - F_{RG} * 1.15 = (F_{Rw} - F_{RG}) L$$

$$78400*1.083 - 54331*1.15 = 24069 * L$$

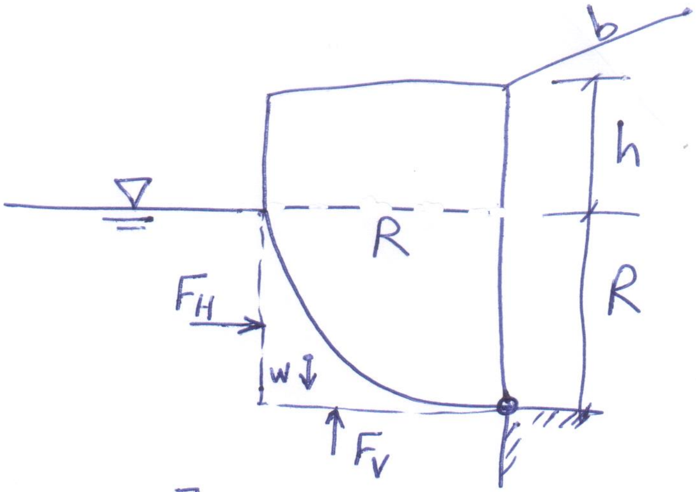
$$\therefore L = 0.932 \ m$$

the net hydrostatic force 24069 Newton $= F_{Rw} - F_{RG}$

B) The uniform body A ~~in Fig. P2.95~~ has width b into the paper and is in static equilibrium when pivoted about hinge O. What is the specific gravity of this body if (a) h = 0 and (b) h = R?



static equilibrium



$$F_x = F_H = F_R = (\rho g \frac{b}{2})\, ab$$

$$= 1000 * 9.8 * \frac{R}{2} * bR$$

$$= 4900\, bR^2$$

$$F_V = (\rho g h)\, ab = 9800 * bR^2$$

$$W = mg = \rho V g = \rho_w g \left[R^2 - \frac{1}{4}\pi R^2\right] b$$

$$= 9800 * 0.215 R^2 b$$

$$= 2103 R^2 b$$

$$F_y = F_V - W = 2450 \pi b R^2$$

$$F_R = \sqrt{F_x^2 + F_y^2} = 9124\, bR^2$$

static equilibrium $\quad \Sigma F_y = 0$

$$mg = F_y$$

if $h = 0$

$$\rho A b g = 2450 \pi b R^2$$

$$\rho \frac{1}{4} \pi R^2 b * 9.8 = 2450 \pi b R^2$$

$$\rho = \frac{4}{9.8} * 2450 = 100\ Kg/m^3$$

$$SG = \frac{\rho}{\rho_w} = 1$$

if $h = R$

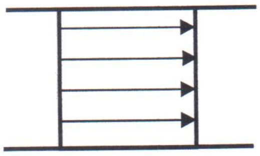
$$\rho g \left[\frac{1}{4} \pi R^2 b + R^2 b\right] = 2450 \pi b R^2$$

$$\rho = \frac{2450 \pi b R^2}{R^2 b \left[\frac{\pi}{4} + 1\right] * 9.8} = 439.9\ Kg/m^3$$

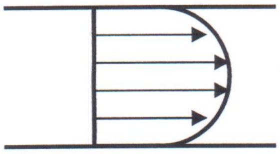
$$SG = \frac{\rho}{\rho_w} = 0.4399$$

Question two (10 marks)

A) Compare between Ideal flow and Real flow.



Ideal flow



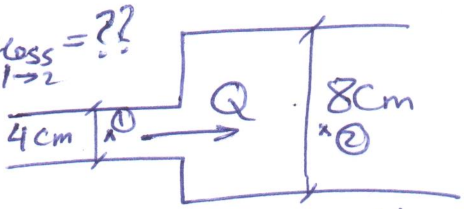
Real flow

* **Ideal flow:** means frictionless flow, no energy is lost, viscosity is considered zero.
* **Real flow:** viscosity can't be neglected, there is friction. Friction causes some of the mechanical energy to be converted into heat energy and can't be restored .

B) A pipe 4 cm diameter is connected in series to a pipe 8-cm diameter. For a discharge of 6 lit/s, of a liquid of sp. gr. 0.9, the pressure before & after the sudden enlargement was 2 bar & 2.04 bar. Calculate the head lost in the enlargement.

$Q = 6 * 10^{-3}\ m^3/sec \qquad SG = 0.9 \qquad h_{loss\ 1\to2} = ??$

$P_1 = 2 * 10^5\ Pa\ \&\ P_2 = 2.04 * 10^5\ Pa$



soln

C.E. $Q = A_1 V_1 = A_2 V_2$

$6 * 10^{-3} = \frac{\pi}{4}(0.04)^2 V_1 = \frac{\pi}{4}(0.08)^2 * V_2$

$\therefore V_1 = 4.77\ \frac{m}{sec}$

$V_2 = 1.19\ \frac{m}{sec}$

B.E. $\frac{P_1}{\rho g} + Z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + Z_2 + \frac{V_2^2}{2g} + h_{loss\ 1\to2}$

same horizontal level

$h_{loss\ 1\to2} = \frac{P_1 - P_2}{\rho g} + \frac{V_1^2 - V_2^2}{2g} = \frac{(2 - 2.04) * 10^5}{0.9 * 9800} + \frac{(4.77)^2 - (1.19)^2}{2 * 9.8}$

$= -\frac{200}{441} + 1.0886 = 0.635$ m of liquid.

C) A Horizontal venturi-meter is used to measure the discharge in 100-mm water pipe line. The venturi throat is 60-mm diameter and it's discharge coefficient C_d = 0.96. Calculate the water discharge and the energy loss in the convergent part when a U-tube manometer containing carbon-tetra-chloride (sp.gr = 1.64) is connected between the venturi inlet and throat sections reads 80 cm.

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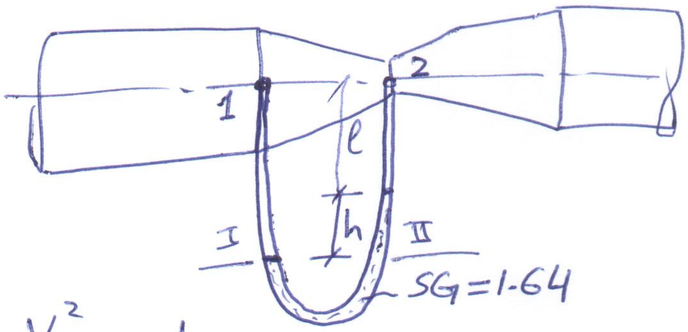
water

$d_1 = d = 100 * 10^{-3}$ m $C_d = 0.96$

$d_2 = d_{th} = 60 * 10^{-3}$ m $Q = ??$ $h_{loss} = ??$

U-tube $SG = 1.64$ & $h = 80 * 10^{-2}$ m

Soln



$$Q = A_1 V_1 = A_2 V_2$$

$$\frac{\pi}{4}(0.1)^2 V_1 = \frac{\pi}{4}(0.06)^2 V_2$$

$$V_1 = \frac{9}{25} V_2 \longrightarrow (*)$$

$$\frac{P_1}{\rho g} + Z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + Z_2 + \frac{V_2^2}{2g} + h_{loss_{1\to2}}$$

same horizontal level

$$\frac{V_1^2 - V_2^2}{2g} = \frac{P_2 - P_1}{\rho g} + h_{loss_{1\to2}}$$

from (*)

$$\left(\frac{9}{25}\right)^2 V_2^2 - V_2^2 = 2g\left[\frac{P_2 - P_1}{\rho g} + h_{loss_{1\to2}}\right] \longrightarrow (1)$$

$$P_I = P_{II}$$

$$P_1 + \rho_w g l + \rho_w g h = P_2 + \rho_w g l + \rho g h$$

$$P_1 - P_2 = (\rho - \rho_w) g h = (SG - 1)\rho_w g h \longrightarrow (2)$$

sub. in (1)

$$V_2^2\left[1 - \left(\frac{9}{25}\right)^2\right] = 2g\left[(SG-1)h - h_{loss_{1\to2}}\right]$$

$$\frac{Q^2}{A_2^2} = 22.5184\left[(1.64-1) * 80 * 10^{-2} - h_{loss_{1\to2}}\right]$$

$$Q = \frac{\pi}{4}(0.06)^2 * 4.745\sqrt{\left[0.512 - h_{loss_{1\to2}}\right]} \longrightarrow (3)$$

if Cd is given

$$Q = C_d * \frac{\pi}{4}(0.06)^2 * 4.745\sqrt{0.512} = 9.22 \text{ lit/sec}$$

(C_d = 0.96)

sub. in (3)

$$9.22 * 10^{-3} = 0.0134\sqrt{(0.512 - h_{loss_{1\to2}})}$$

$$h_{loss} = 0.0386 \text{ m}$$

Another solution

$$Q = C_d \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2g\left[\frac{P_1 - P_2}{\rho g} + z_1 - z_2\right]}$$

$$H = \frac{P_1 - P_2}{\rho g} + z_1 - z_2 = \left(\frac{SG_m}{SG_w} - 1\right) h$$

$$\therefore Q = 0.96 \frac{\frac{\pi}{4}(0.1)^2 * \frac{\pi}{4}(0.06)^2}{\sqrt{\left[\frac{\pi}{4}(0.1)^2\right]^2 - \left[\frac{\pi}{4}(0.06)^2\right]^2}} \sqrt{2 * 9.8 * \left(\frac{1.64}{1} - 1\right) * 0.8}$$

$$= 9.22 * 10^{-3} \ m^3/sec$$

$$Q = \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2g(H - h_{loss\ 1\to2})}$$

$$\frac{Q^2 \left[A_1^2 - A_2^2\right]}{2g A_1^2 A_2^2} = \left(\frac{SG_m}{SG_w} - 1\right) h - h_{loss\ 1\to2}$$

$$h_{loss\ 1\to2} = \left(\frac{1.64}{1} - 1\right) * 0.8 - \frac{(9.22 * 10^{-3})^2 \left[\left(\frac{\pi}{4}(0.1)^2\right)^2 - \left(\frac{\pi}{4}(0.06)^2\right)^2\right]}{2 * 9.8 * \left(\frac{\pi}{4}(0.1)^2\right)^2 * \left(\frac{\pi}{4}(0.06)^2\right)^2}$$

$$= 0.03978 \ m$$