College of Engineering & Technology

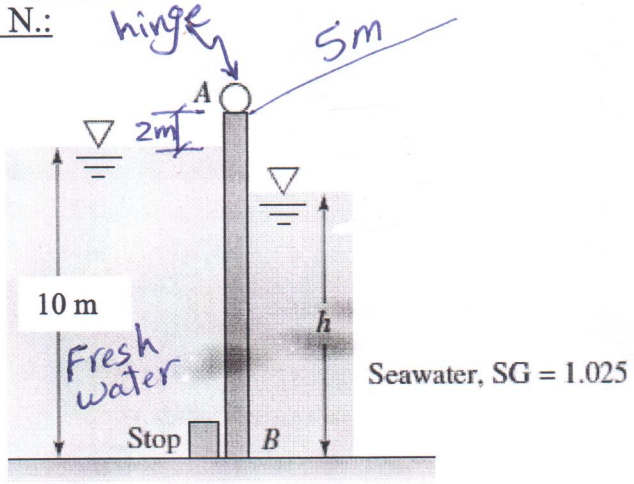
Department: Mechanical Engineering — Marks: 20
Lecturer: Dr. Rola Afify — Time: 2:30 – 4:10
Course Code: ME362 — Date: 22/4/2015

Name: Model Answer — R. N.:

Answer the following questions:

Question one (10 marks)

A) Gate AB is 5 m wide into the paper and opens to let fresh water out when the ocean tide is dropping. The hinge at A is 2 m above the freshwater level. At what ocean level h will the gate first open? Neglect the gate weight.



$$F_{Fw} = [P_o + \rho g(5 + \tfrac{b}{2})]ab$$
$$= [0 + 1000 * 9.8\,(0+5)]\,5*10 = 2.45*10^6 \text{ Newton}$$

$$y_{P_{Fw}} = 5 + \frac{b}{2} + \frac{b^2}{12(5 + \frac{b}{2} + \frac{P_o}{\rho g})} = 0 + 5 + \frac{10^2}{12(0+5+0)} = \frac{20}{3}$$
$$= 6.667 \text{ m}$$

$$F_{Sw} = [0 + 1025 * 9.8 * (0 + \tfrac{h}{2})] * h * 5 = 25112\,h^2$$

$$y_{P_{Sw}} = 0 + \frac{h}{2} + \frac{h^2}{12(0 + \frac{h}{2} + 0)} = \frac{h}{2} + \frac{h}{6} = \frac{2h}{3} = 0.667\,h$$

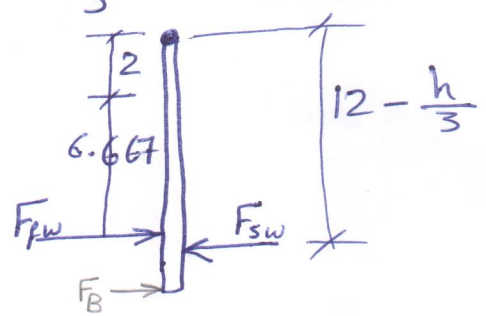
h at the first open of gate

Hint $\quad \Sigma M_A = F\,L$

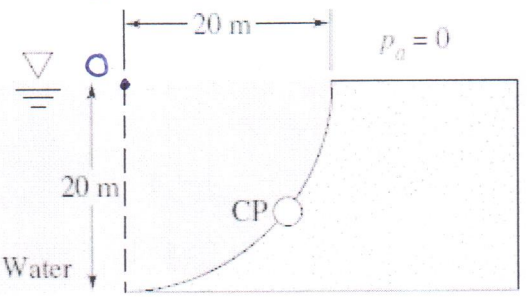
$$F_{Fw} * 8.667 - F_{Sw} * (12 - \tfrac{h}{3}) = F_B * 12$$

F_B → 0 about to open

$$2.45 * 10^6 * 8.667 = 25112\,h^2\,(12 - \tfrac{h}{3})$$



B) The dam is a quarter circle 50 m wide into the paper. Determine the ~~horizontal and vertical components of the~~ hydrostatic force against the dam and ~~the point CP where the resultant strikes the dam. if it passes through point O,~~ its angle about horizontal.



Q1) A) Cont.

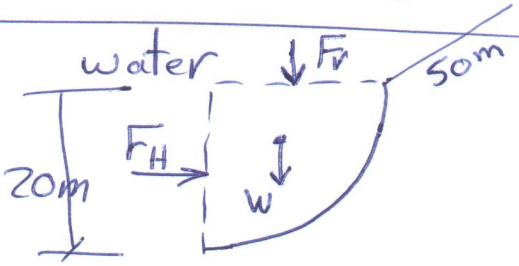
$$845.56 = 12h^2 - \frac{h^3}{3}$$

$$h^3 - 36h^2 + 25368 = 0 \qquad \therefore h = 9.848 \text{ m}$$

B) $F_H = (\rho g \frac{b}{2})ab$

$= (1000 * 9.8 * 10) 50 * 20$

$= 9.8 * 10^7$ Newton



$F_v = (\rho g h)ab = 1000 * 9.8 * 0 * 50 * 10 = 0$

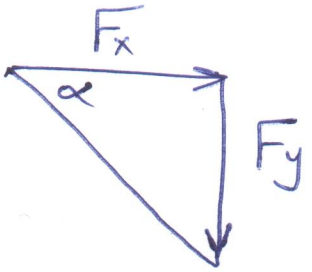
$w = \rho g \frac{1}{4} * \pi r^2 a = 9800 * \frac{1}{4} * \pi * 20^2 * 50$

$= 49\pi * 10^6$ Newton

$F_R = \sqrt{F_{H^2} + W^2} = \sqrt{F_x^2 + F_y^2}$ $\quad F_x = F_H$ & $F_y = -W$

$= \sqrt{(9.8 * 10^7)^2 + (49\pi * 10^6)^2}$

$= 18.24 * 10^7$ Newton

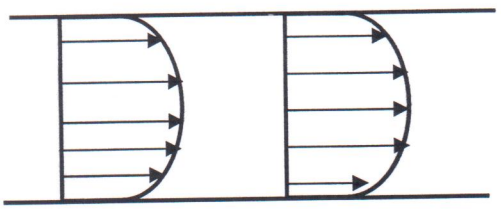


$\tan\alpha = \frac{F_y}{F_x} = \frac{-49\pi * 10^6}{9.8 * 10^7} = \frac{-\pi}{2}$

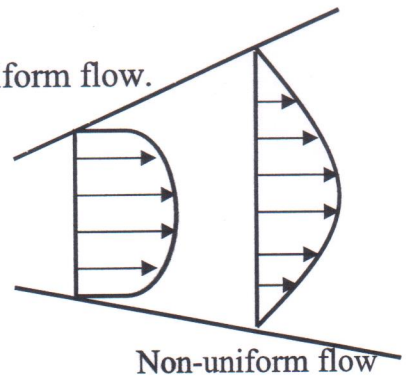
$\therefore \alpha = -57.5^\circ$

Question two (10 marks)

A) Compare between Uniform flow and Non-uniform flow.



Uniform flow



Non-uniform flow

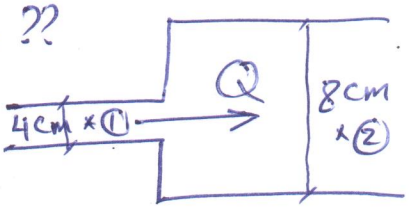
*** Uniform flow:** the velocity at a given instant is the same in magnitude and direction at every point in the flow.

*** Non-uniform flow:** the velocity at a given instant changes from point to point.

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.

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

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



soln $\quad Q = A_1 V_1 = A_2 V_2$

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

$\therefore V_1 = 4.77\ m/s$

$V_2 = 1.19\ m/s$

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

same horizontal level

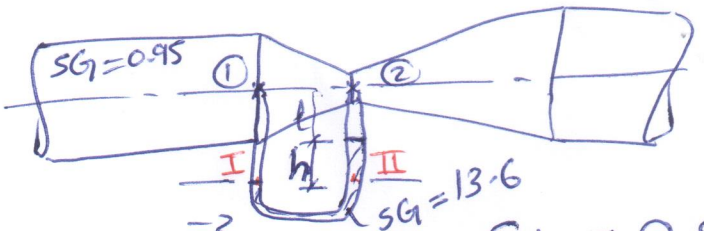
$$h_{loss}_{1\to2} = \frac{P_1 - P_2}{\rho g} + \frac{V_1^2 - V_2^2}{2g} = \frac{(2 - 2.04) * 10^5}{0.9 * 9.8} + \frac{(4.77)^2 - (1.19)^2}{2 * 9.8}$$

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

C) 4 lit/s of a liquid of sp. gr. 0.95 flows through a 6-cm pipe. A venturi meter with 3-cm throat diameter and $C_d = 0.94$ is used to measure the discharge through the pipe. What would be the reading of a mercury U-tube connected to the meter if the venturi is Horizontal.

Dr. Rola Afify

$Q = 4 * 10^{-3}\ m^3/sec$



$SG = 0.95$

$d_1 = 6 * 10^{-2}\ m$ $\quad d_2 = 3 * 10^{-2}\ m$ $\quad C_d = 0.94$

$h = ??$ $\quad if \quad SG_m = 13.6$

Soln

$$Q = C_d \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2g\left(\frac{SG_m}{SG} - 1\right)h}$$

$$4 * 10^{-3} = 0.94 \frac{\frac{\pi}{4}(0.06)^2 \frac{\pi}{4}(0.03)^2}{\frac{\pi}{4}\sqrt{(0.06)^4 - (0.03)^4}} \sqrt{2 * 9.8\left(\frac{13.6}{0.95} - 1\right)h}$$

$h = 0.1302m = 13\ cm$

Another soln

$$E_1 = E_2 + h_{loss}\ {}_{1\to2}$$

$$\frac{P_1}{\omega} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\omega} + z_2 + \frac{V_2^2}{2g} + h_{loss}\ {}_{1\to2}$$

same horizontal level

$$\frac{V_2^2 - V_1^2}{2g} = \frac{P_1 - P_2}{\omega} - h_{loss}\ {}_{1\to2}$$

$$Q^2\left[\frac{1}{A_2^2} - \frac{1}{A_1^2}\right] = 2g\left[\frac{P_1 - P_2}{\rho g} - h_{loss}\ {}_{1\to2}\right] \longrightarrow (1)$$

$$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(0.06)^2 = 2.827 * 10^{-3}\ m^2$$

$$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(0.03)^2 = 7.069 * 10^{-4}\ m^2$$

$$P_I = P_{II}$$

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

$$P_1 - P_2 = \rho_m g h - \rho g h$$

$$\frac{P_1 - P_2}{\rho g} = \left(\frac{\rho_m}{\rho} - 1\right) h$$

$$= \left(\frac{13.6}{0.95} - 1\right) h = 13.316\, h \longrightarrow (2)$$

in (1)

$$Q^2 = C_d \frac{1}{\left[\frac{1}{A_2^2} - \frac{1}{A_1^2}\right]} * 2g\,[13.316\, h]$$

$$(4 * 10^{-3})^2 = \frac{(0.94)^2}{\left[\frac{1}{(7.069 * 10^{-4})^2} - \frac{1}{(2.827 * 10^{-3})^2}\right]} * 2 * 9.8 * 13.316h$$

$$h = 0.1302 \text{ m}$$

$$= 13.02 \text{ cm}$$