College of Engineering & Technology

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

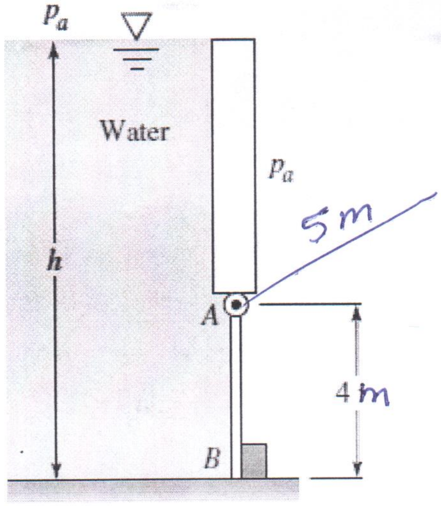
Marks: 20
Time: 10:30 – 12:10
Date: 22/4/2015

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

Answer the following questions:

Question one (10 marks)

A) Gate AB is 5 m wide into the paper, hinged at A, and restrained by a stop at B. The water is at 20°C. Compute (a) the force on stop B and (b) the reactions at A if the water depth h = 9.5 m.



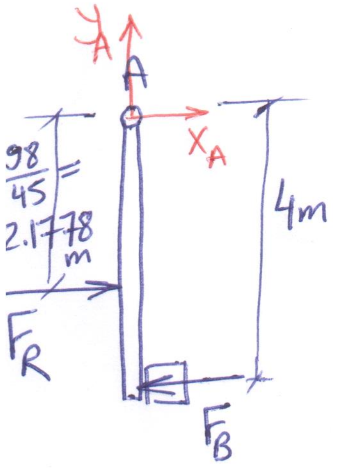
$$F_R = \left[P_o + \rho g\left(S + \frac{b}{2}\right)\right] a\, b$$

$$= \left[0 + 1000 * 9.8 * (5.5 + 2)\right] * 5 * 4$$

$$= 1.47 * 10^6 \text{ Newton}$$

$$y_p = S + \frac{b}{2} + \frac{b^2}{12\left(S + \frac{b}{2} + \frac{P_o}{\rho g}\right)} = 5.5 + 2 + \frac{4^2}{12 * (5.5 + 2 + 0)}$$

$$= 7.6778 \text{ m}$$



$$\Sigma M_A = 0 = 1.477 * 10^6 * 2.1778 - F_B * 4$$

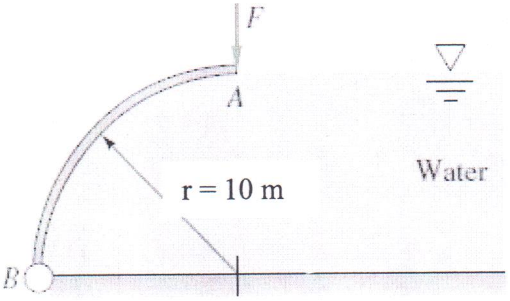
ⓐ $\therefore F_B = 8.00342 * 10^5$ Newton

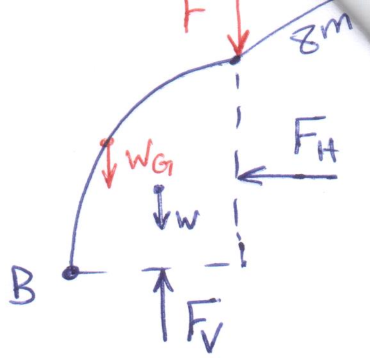
ⓑ $\Sigma F_x = 0$ $X_A + F_R - F_B = 0$

$X_A = -6.697 * 10^5$ Newton

$\Sigma F_y = 0$ $Y_A = 0$

B) Gate AB is a quarter circle 8 m wide into the paper and hinged at B. Find the force F just sufficient to keep the gate from opening. The gate is uniform and weighs 3000N.





$$F_H = (\rho g \frac{b}{2}) a b$$
$$= (1000 * 9.8 * 5) * 8 * 10$$
$$= 3.92 * 10^6$$ Newton

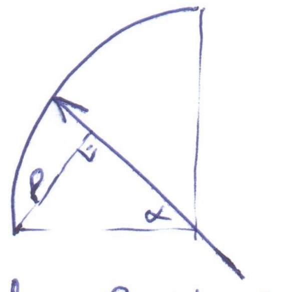
$$F_V = (\rho g h) a b$$
$$= (1000 * 9.8 * 10) * 8 * 10 = 7.84 * 10^6$$ Newton

$$W = \rho g \frac{1}{4} \pi r^2 * a = \frac{9800}{4} * \pi * 10^2 * 8 = 2 * 10^6 \pi$$ Newton

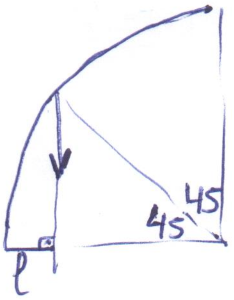
Find F to Keep the gate from opening

$$F = \sqrt{F_x^2 + F_y^2}$$
$$= 4.265 * 10^6 \ N$$
$$\alpha = \tan^{-1} \frac{F_y}{F_x} = 23.22^\circ$$

$$F_x = F_H = 3.92 * 10^6 N$$
$$F_y = F_V - W$$
$$= 7.84 * 10^6 - 2\pi * 10^6$$
$$= 1.682 * 10^6 N$$



$l = R \sin \alpha$

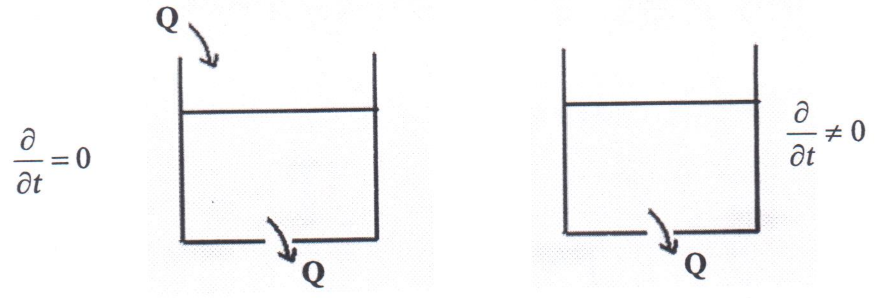


$l = R - R \cos 45^\circ$

$$\Sigma M_B = 0$$
$$F R + W_G (R - R \cos 45) - F_R * R \sin \alpha = 0$$
$$F = F_R \sin \alpha - W_G (1 - \cos 45)$$
$$= 4.265 * 10^6 \sin 23.22 - 3000 (1 - \cos 45)$$
$$= 1.68 * 10^6$$ Newton

Question two (10 marks)

A) Compare between Steady flow and Unsteady flow.



steady flow unsteady flow

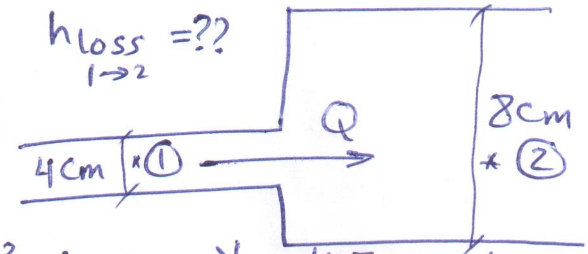
* **Steady flow:** pressure, velocity, flow rate (flow parameters) are constant with respect to time.

* **Unsteady flow:** any of the flow parameters change with time.

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.

$Q = 6 * 10^{-3}\ m^3/sec$ $SG = 0.9$ $h_{loss\ 1\to 2} = ??$

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



sol^n $Q = A_1 V_1 = A_2 V_2$

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

$V_1 = 4.77\ m/s$

$V_2 = 1.19\ m/s$

B.E. $\frac{P_1}{\rho g} + \cancel{z_1} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \cancel{z_2} + \frac{V_2^2}{2g} + h_{loss\ 1\to 2}$

same horizontal level

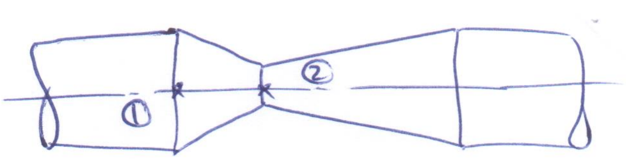
$$h_{loss\ 1\to 2} = \frac{P_1 - P_2}{\rho g} + \frac{V_1^2 - V_2^2}{2g} = \frac{(2-2.04)*10^5}{0.9 * 9800} + \frac{(4.77)^2 - (1.19)^2}{2 * 9.8}$$

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

Horizontal

C) A venturi meter is to be fitted to a 25-cm diameter horizontal pipe, in which the maximum flow is 7200 lit/min. of water and the pressure head at the inlet to the venture is 6-m water. What is the minimum diameter of the throat so that there is no negative pressure in it? Assume ideal flow.

$d_1 = 25 * 10^{-2}$ m   water



$Q = 7200$ lit/min

$= 7200 * \frac{10^{-3}}{60}$ m^3/sec $= \frac{3}{25} = 0.12$ m^3/sec

$h_1 = \frac{P_1}{\rho g} = 6$ m   ideal flow

$d_2 = ??$ $\therefore h_2 = \frac{P_2}{\rho g} = 0$

soln

$$\frac{P_1}{\rho g} + \underbrace{\cancel{z_1} + \frac{V_1^2}{2g} = \overset{=0 \text{ not negative}}{\cancel{\frac{P_2}{\rho g}}} + \cancel{z_2}}_{\text{same horizontal level.}} + \frac{V_2^2}{2g} + \overset{0 \text{ ideal flow}}{\cancel{h_{loss\,1\to 2}}}$$

$$6 + \frac{V_1^2}{2g} = 0 + \frac{V_2^2}{2g}$$

$$V_2^2 = 2g * 6 + V_1^2$$

$$\frac{Q^2}{A_2^2} = 2 * 9.8 * 6 + \frac{(0.12)^2}{\left[\frac{\pi}{4}(0.25)^2\right]^2}$$

$$A_2 = \sqrt{\frac{(0.12)^2}{123.5762}} = 0.01$$

$$\frac{\pi}{4} d_2^2 = 0.01 \qquad \therefore d_2 = 0.117 \text{ m}$$

Another soln

$$Q^2\left[\frac{1}{A_2^2} - \frac{1}{A_1^2}\right] = 2g\left[\frac{P_1 - \overset{=0 \text{ not negative}}{P_2}}{\rho g} - \overset{\text{ideal flow } =0}{\cancel{h_{loss\,1\to 2}}} + \underbrace{\cancel{z_1} - \cancel{z_2}}_{\text{horizontal}}\right]$$

$$\frac{1}{A_2^2} - \frac{1}{A_1^2} = \frac{2gP_1}{\rho g\, Q^2}$$

$$\frac{1}{A_2^2} = \frac{2*9.8*6}{(0.12)^2} + \frac{1}{\left[\frac{\pi}{4}(0.25)^2\right]^2}$$

$$A_2 = \frac{\pi}{4} d_2^2 = \sqrt{\frac{1}{8581.678}} = 0.01079$$

$$d_2 = 0.117 \ m$$