Biomedical Engineering Program

Midterm exam. In Fluid mechanics (MPE171) 2016-2017

Time Allowed 75 minutes (20 total marks)

Name : ....

Section : .... model answer ....

Question (1) : A square metal plate 1.8 m side and 1.8mm thick weighting 80 N is to be lifted through a vertical gap of 40 mm of infinite extent. The oil in the gap has a specific gravity of 0.95 and viscosity of 4 Pa.s. If the metal plate is to be lifted at a constant speed of 0.2 m/s. Determine the force and power required.

$A = l^2 = 1.8 \times 1.8 = 3.24\,m^2$, $U = 0.2\,m/s$.

$y = \frac{40 - 1.8}{2} = 19.1\,mm$

$\mu = 4\,Pa.s$, $\rho_o = sg \times \rho_w = 0.95 \times 1000 = 950\,kg/m^3$

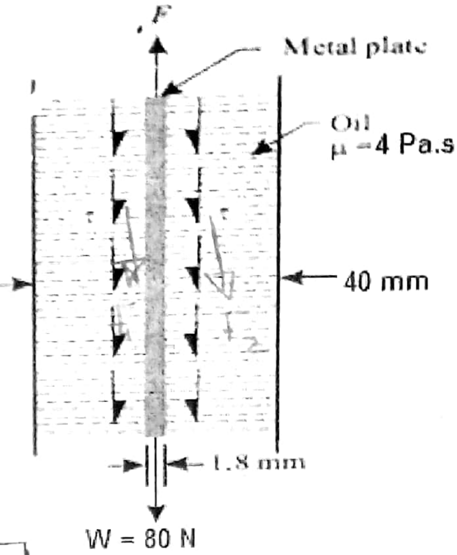

Fig. 1

$F = F_1 + F_2 + W$

$F = 2\mu A \frac{U}{y} + W$

$= 2 \times 4 \times 3.24 \times \frac{0.2}{19.1 \times 10^{-3}} + 80$

$\therefore \boxed{F = 351.414\,N}$

$P = F.V = 351.414(0.2) = \boxed{70.2828\,Watt}$

Question (2) : For the configuration shown in Fig 2, calculate the pressure P_B and the weight of the piston if the gage reading P_A is 100 kPa. $P_A = 100 \times 10^3\,Pa$. $P_B = ??$ $W = ??$

$P_x = \boxed{P_y = P_z}$

$P_B = \gamma_w(1 - 0.4) + P_A$

$\therefore P_B = 9810\,(0.6) + 100 \times 10^3$

$\therefore \boxed{P_B = 105.886 \times 10^3\,Pa}$

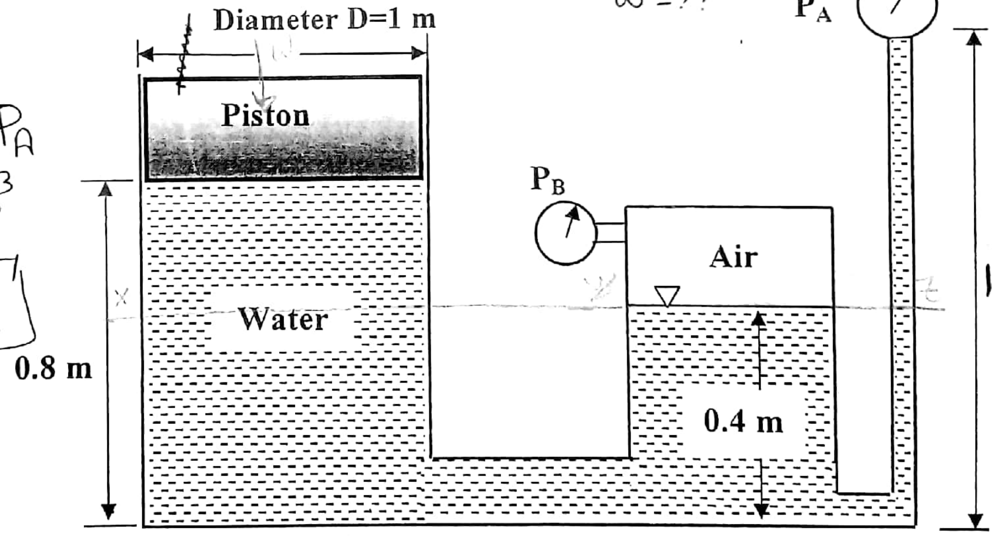

Fig. 2

$P_x = P_y$

$\gamma_w(0.8 - 0.4) + P_p = P_B$

$9810(0.4) + P_p = 105.886 \times 10^3$

$\therefore P_p = 101.962 \times 10^3\,Pa$

$\therefore P_p = \frac{W_p}{A_p} = \frac{W}{\frac{\pi}{4} D^2}$

$101.962 \times 10^3 = \frac{W}{\frac{\pi}{4}(1)^2} \Rightarrow \boxed{W = 80.081 \times 10^3\,N}$

Question (3) : The flow of water from a reservoir is controlled by a 2 m wide L-shaped gate hinged at point A, as shown in Fig. 3. If it is desired that the gate open when the water height is 4 m, determine the mass of the required weight W.

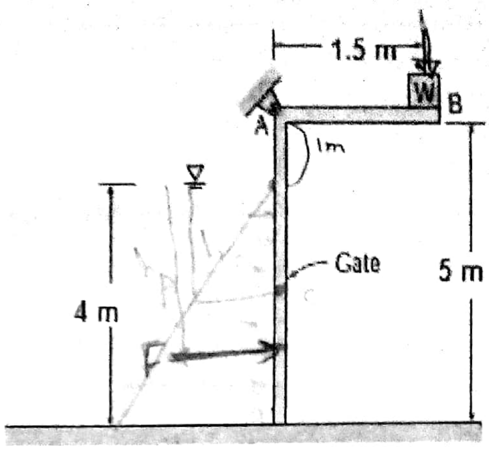

Fig. 3

$h_c = 2m$

$F = \gamma_w h_c A$

$= 9810 \times 2 \times 8$

$\therefore \boxed{F = 156.96 \times 10^3 \ N}$

$h_p = h_c + \frac{I_{cc} \sin^2\theta}{A h_c}$

$h_p = 2 + \frac{\frac{1}{12} 2 (4)^3}{2 \times 4 \times 2} = \frac{8}{3} \ m$

for check

$h_p = \frac{2}{3}(4)$

$= \frac{8}{3} m$

For equilibrium

$\sum M_A = 0$

$W(1.5) - F(1 + h_p) = 0 \Rightarrow W(1.5) = 156.96 \times 10^3 \left(1 + \frac{8}{3}\right)$

$\therefore \boxed{W = 383.68 \times 10^3 \ N} \Rightarrow \boxed{\therefore m = 39.11 \ kg}$

$W = mg$

$383,680 = 9.81 \ m$

Question (4) : The weight of a certain crown in air was found to be 14 N and its weight in water 13 N. Assuming the crown is an alloy of gold (s.g=19.3) and silver (s.g=10.5). Compute the fraction of silver and gold in the crown.

$W = 14 \ N$

$T = 13 \ N$

∵ The body is totally immersed.

$\therefore T = W - F_B$

$13 = 14 - F_B$

$\therefore F_B = 1 N = \gamma_f V_b$

$1 = 9810 \ V_b \Rightarrow \boxed{V_b = 1.0194 \times 10^{-4} \ m^3}$

$\rho_b = \frac{m_b}{V_b} = \frac{W}{g V_b} = \frac{14}{9.81(1.0194 \times 10^{-4})}$

$= 13999.56 \ kg/m^3$

$\rho_b = X_s \rho_s + (1 - X_s) \rho_g$

$13999.56 = X_s (10500) + (1 - X_s)(19300)$

$5300.444 = 8800 X_s \Rightarrow \boxed{X_s = 0.6}$

$\rho_g = s.g_g \rho_w$

$= 19.3(1000)$

$= 19300 \ kg/m^3$

$\rho_s = s.g_s \rho_w$

$= 10.5(1000)$

$= 10500 \ kg/m^3$

Fraction of silver $= X_s$

$= \boxed{0.6} = 60\%$

Fraction of gold $=$

$1 - X_s = \boxed{0.4} = 40\%$

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