HW CH (1)

①

mass density $(\rho) = 14.2 * 10^3 = 14200\ kg/m^3$

specific weight $(\varpi) = \frac{w}{v} = \rho g = 14200 * 9.81 = 139160\ kN/m^3$

specific volume $(V) = \frac{1}{\rho} = \frac{1}{14200} = 0.00007\ m^3/kg$

②

$V = 5y^2 - 2y$

$\frac{du}{dy} = 10y - 2$

at $y = 1.5\,m$

$\frac{du}{dy} = 13$

$\tau = \mu \frac{du}{dy} = 1.2 * 13 = 15.6\ N/m^2$

③

ⓐ specific weight $(\varpi) = \frac{w}{v} = \frac{80}{9} = 8888.88\ kN/m^3$

ⓑ Density $(\rho) = \frac{\varpi}{g} = \frac{8888.88}{9.81} = 907.03\ kg/m^3$

④

$F = \tau A$

$F = F_1 + F_2 = A[\tau_1 + \tau_2]$

$= A\left[\mu_1 \frac{du}{dy} + \mu_2 \frac{du}{dy}\right] = 0.5 * 4\left[0.02 * \frac{1}{6(10^{-3})} + 0.01\ \frac{1}{3(10^{-3})}\right]$

$= 13.33\ N$

⑤ $T = F * r$

$1 = F * \left(\frac{0.1}{2}\right) \Rightarrow F = 20\ N$

$F = \tau . A = \mu \frac{du}{dy} * A$

$20 = 0.125 * \frac{v}{(0.105 - 0.1)/2} * \pi(0.1)(0.3)$

$v = 4.244\ m/s$

(6)

$$\nu = \frac{\mu}{\rho} \Rightarrow \mu = 8*10^{-4} * 0.91 * 1000 = 0.728 \ kg/m^3$$

$$\tau = \mu \frac{du}{dy} = 0.728 * \frac{3}{0.3*10^{-3}} = 7282.93 \ N/m^3$$

$$P = \tau . A$$

$$= 7282.93 * \left[\pi (25*10^{-3}) * 0.5\right]$$

$$= 286 \ N$$

(7)

$$\tau = \frac{F}{A} = \frac{w \sin\theta}{A}$$

$$\tau = \mu \frac{v}{y} \Rightarrow \mu = \tau \frac{y}{v}$$

$$\mu = \frac{y w \sin\theta}{vA}$$

(8)

$$\Delta P = \frac{4\sigma}{d}$$

$$\sigma = \frac{\Delta P d}{4} = \frac{1.5 * 30 * 10^{-3}}{4} = 0.001125 \ N/m$$

(9)

$$\Delta P = \frac{4\sigma}{d}$$

$$d = \frac{4\sigma}{\Delta P} = \frac{4 * 7.36 * 10^{-2}}{125} = 0.0023552 \ m = 2.3 mm$$

(10)

$$k = \rho \frac{\Delta P}{\Delta \rho} = \frac{100 * 44.54 * 10^3}{0.002} = 2.227*10^9 \ kN/m^2$$

(11)

$$k = -\frac{\Delta P}{\Delta V/V} \Rightarrow \Delta P = -k * \frac{\Delta V}{V}$$

$$= 2.2 * \frac{3}{100} = 0.066 \ MPa$$

(12)

$$\Delta P = P - P_{atm}^{\nearrow 0} = P = \frac{F}{A} = \frac{2000}{\frac{\pi}{4}(0.015)^2} = 11323425.34 \ N$$

$$k = -\frac{\Delta P}{\Delta V/V} \Rightarrow -\frac{\Delta P}{k} = \frac{\Delta V}{V}$$

$$\frac{\Delta V}{V} = \frac{V_f - V_i}{V_i} = \frac{V_f}{V_i} - 1 = \frac{\frac{\pi}{4}(0.015)^2 L_2}{\frac{\pi}{4}(0.015)^2 * 0.5} - 1 = \frac{L_2}{0.5} - 1$$

$$-\frac{\Delta P}{k} = \frac{L_2}{0.5} - 1 \Rightarrow L_2 = 0.5\left[-\frac{\Delta P}{k} + 1\right]$$

$$= 0.5\left[-\frac{11323425.34}{2*10^9} + 1\right]$$

$$\boxed{L_2 = 0.497 \ m}$$

HW. CH (2)

①

ⓐ $P = \rho g h = 1002 * 9.81 * 2000 = 19659240 \ Pa$

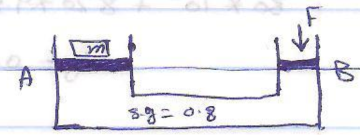
②

diameter ratio 8 : 1

600mm : d_2

$d_2 = \frac{600}{8} = 0.075m$

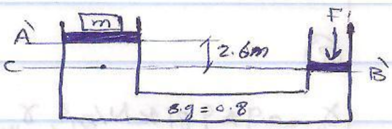
F on smaller piston = ??



ⓐ $P_A = P_B$

$\frac{9.81 * 3500}{\frac{\pi}{4}(0.6)^2} = \frac{F}{\frac{\pi}{4}(0.075)^2} \Rightarrow F = 536.48 \ N$

ⓑ



$P_C = P_{B'}$

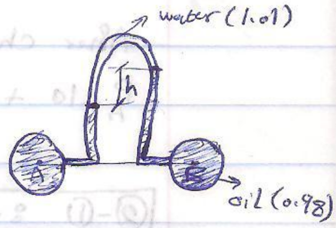
$\frac{9.81 * 3500}{\frac{\pi}{4}(0.6)^2} + 800 * 9.81 * 2.6 = \frac{F'}{\frac{\pi}{4}(0.075)^2}$

$F = 626.58 \ N$

③ $P_B - P_A = (\rho - \rho_{man}) g h$

$= (1010 - 980) * 9.81 * 75 * 10^{-3}$

$= 22.0725 \ N/m^2$



④

$P_{atm}^{\nearrow 0} + 1000 * 9.81 * 0.7 = P_A = 6867 \ Pa$

$P_A - 1000 * 9.81 * 0.9 = P_B = -1962 \ Pa$

$P_B + 1.23 * 9.81 * 0.4 = P_C = -1957.1785 \ Pa$

$P_C - 1000 * 9.81 * 0.9 = P_D = -10786.1735 \ Pa$

⑤

ⓐ $P_A = 0 + 720 * 9.81 * h_A = 0 + 720 * 9.81 * 1.7$

$h_A = 1.7 \ m$

elevation = $1.7 + 0.3 = 2m$

(b)

$0 + 720 * 9.81 * 1.7 + 2360 * 9.81 * 0.3 = 2360 * 9.81 * h_B$

$h_B = 0.819\ m$ = elevation

(c) $P_{Bottom} = 0 + 720 * 9.81 * 1.7 + 2360 * 9.81 * 0.3 = 18127.64\ Pa$

(6)

$30 * 10^3 + 820 * 9.81 * 3 + 1000 * 9.81 * 3 - 13600 * 9.81 * y = 0$

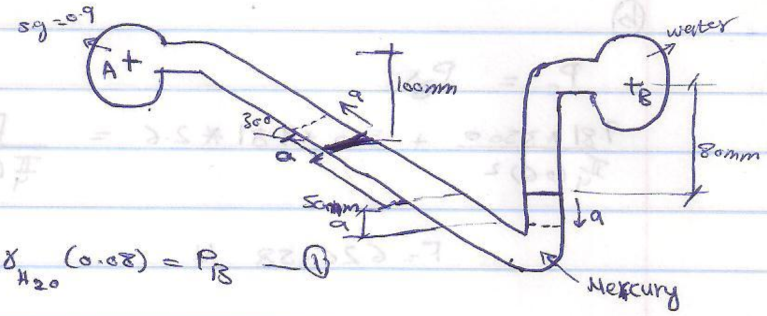
$y = 0.626\ m$

(7)

$P_A - \rho_{oil} g y - \rho_{Hg} g * 1.2 + \rho_{oil}\ g\ (1.2 + y) = P_B$

$P_A - P_B = -13600 * 9.81 * 1.2 + 910 * 9.81 * 1.2 = -149386.68\ Pa$

(8)



$\gamma_A = 0.9 * 9.81\ kN/m^3$, $\gamma_{Hg} = 133\ kN/m^3$

$\gamma_{H_2O} = 9.80\ kN/m^3$

– Before change pressure :

$P_A + \gamma_A (0.1) + \gamma_{Hg} (0.05 \sin 30) - \gamma_{H_2O} (0.08) = P_B$ — (1)

– After change pressure :

$P_A - 10 + \gamma_A (0.1 - a \sin 30) + \gamma_{Hg} (a \sin 30 + 0.05 \sin 30 + a) - \gamma_{H_2O} (0.08 + a) = P_B$ — (2)

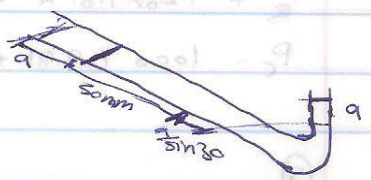
(2)–(1) : $-10 + \gamma_A (a \sin 30) - \gamma_{Hg} (a \sin 30 + a) + \gamma_{H_2O} (a) = 0$

$10 + a\ \gamma_A (\sin 30) - a\ \gamma_{Hg} (\sin 30 + 1) + a\ \gamma_{H_2O} = 0$

$10 + a \left[\gamma_A \sin 30 - \gamma_{Hg} (\sin 30 + 1) + \gamma_{H_2O} \right] = 0$

$a = \dfrac{-10}{\gamma_A \sin 30 - \gamma_{Hg} (\sin 30 + 1) + \gamma_{H_2O}} = 0.0540\ m$

New differential reading $= \dfrac{a}{\sin 30} + 0.05 + a$



$= 0.212\ m$

⑨

$\cancel{P_{atm}}^{0} + \gamma_{oil} * 1 + \gamma_{water} * 2 + \gamma_x * 3 + \gamma_{Hg} * 0.5 = 242 * 10^3$

$\gamma_x = 49050 \ N/m^3$

⑩ $\frac{P_{new}}{P_{old}} = \frac{V_{old}}{V_{new}} = \frac{110}{80} = \frac{A(8)}{A(H_{new})}$

$H_{new} = 5.818 \ cm$

$H_{Hg} = 10 + 8 - 5.818 = 12.182 \ cm$

$11300 + 133100 * h = 133100 * (0.12182 + 0.02) + 9790 (0.09) + 110 * 10^3$

$h = 0.213 m \rightarrow h = 21.3 cm$

⑪

$P_m = P_{Head}$

$\frac{w}{\frac{\pi}{4}(8*10^{-2})^2} = 827 * 9.81 * 0.1 * \sin(15)$

$w = 1.0549 \ N$

⑫

$180 * 10^3 + 1000 * 9.81 * h + 13600 * 9.81 * 80 = 350 * 10^3$

$h = 6.449 m$

$180 + 1000 * 9.81 * (h + 80) = P_B = 251.113 \ kPa$

⑬

$P_A + 608 * 0.2 * 9.81 - 13550 * 9.81 * 0.08 - 804 * 9.81 (0.4 - 0.08) + 1000 * 9.81 (.4 - .14)$
$- 1.23 * 9.81 * 0.09$
$= P_B$

$P_A - P_B = 9415.54 \ Pa$

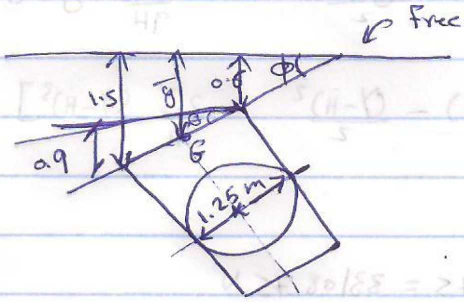
1)

$R = \rho g A \bar{y} = 1000 * 9.81 * \frac{\pi}{4}(1.25)^2 * 1.05 = 12641 N$

$D = \sin^2\phi \left(\frac{I_G}{A\bar{y}}\right) + \bar{y}$

$I_G = \frac{\pi}{4}\left(\frac{125}{2}\right)^4 = 0.12 m^4$

$= \frac{\sin^2(46.1) * 0.12 + 1.05}{\frac{\pi}{2}(1.25)^2 * 1.05} = 1.1 m$



$\sin(\phi) = \frac{.9}{1.25}$

$\phi = 46.1°$

$\sin(46.1) = \frac{X}{0.625}$

$X = 0.45$

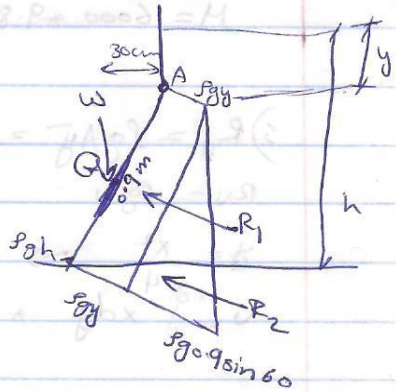
$\bar{y} = 0.6 + 0.45 = 1.05 m$

2) $R_1 = V_{\square}$

$= \rho g y * .9 * 1.2 = 10594.8y N$

$R_2 = V_{\Delta}$

$= \frac{1}{2}\rho g\, 0.9\sin 60 * .9 * 1.2 = 4128.91 N$



$\circlearrowleft + \sum M_A = 0$

$-R_1 * 0.45 - R_2 * \frac{2}{3} * .9 + 9810 * 0.3 = 0$

$R_1 = \frac{-R_2 * \frac{2}{3} * .9 + 9810 * 0.3}{0.45}$

$y = \frac{-R_2 * \frac{2}{3} * .9 + 9810 * 0.3}{0.45 * 10594.8}$

$y = 0.0977 m \Rightarrow h = 0.0977 + .9\sin 60 = 0.877 m$

3) $R_1 = \frac{1}{2} \rho g (Y+y) * \frac{2Y}{\sqrt{3}} * b$

$R_2 = \rho g (Y+y) * \frac{2y}{\sqrt{3}} * b$

$R_3 = \frac{1}{2} \rho g (Y-H) * \frac{2(Y-H)}{\sqrt{3}} * b$

$\circlearrowleft + \Sigma M_A = 0$

$w * \frac{2H}{\sqrt{3}} + \rho g b \frac{(Y-H)^2}{\sqrt{3}} * \left[H + \frac{4\sqrt{3}}{9}(Y-H)\right] - \rho g (Y+y) * \frac{2Y}{\sqrt{3}} * b * \frac{Y}{\sqrt{3}} - \frac{\rho g b Y (Y+y)}{8} * \frac{4\sqrt{3}}{9} Y = 0$

$w = \frac{5\sqrt{3}}{9H} \rho g b Y^2 (Y+y) - \frac{\rho g b}{2} (Y-H)^2 - \frac{2\sqrt{3}}{9H} \rho g b (Y-H)^3$

$w = \rho g b \left[\frac{5\sqrt{3}}{9H} Y^2 (Y+y) - \frac{(Y-H)^2}{2} - \frac{2\sqrt{3}}{9H} (Y-H)^3 \right]$

4) $R_H = \rho g A \bar{y}$

$= 1000 * 9.81 * 1.5 * 3 * 0.75 = 33108.75 \, N$

$R_V = \rho g V$

$= 1000 * 9.81 * \frac{\pi}{4} (1.5)^2 * 3 = 51980.7375 \, N$

$R = \sqrt{R_H^2 + R_V^2} = 61.6 \, N$

$\theta = \tan^{-1}\left(\frac{R_V}{R_H}\right) = 57^\circ \, 30'$

$\Sigma M_o = 0$

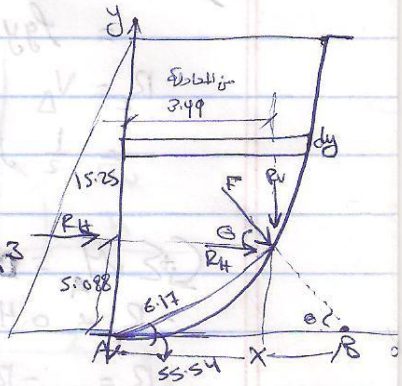
$M = 6000 * 9.81 * 0.6 = 35316 \, N \cdot m$

5) $R_H = \rho g A \bar{y} = 1000 * 9.81 * 15.25 * 1 * \frac{15.25}{2} = 1140719.663 \, N$

$R_V = \rho g V$

$y = \frac{x^2}{2.4} \Rightarrow x = \sqrt{2.4 y}$

$V = \int_0^{15.25} x \, dy * 1 = \int_0^{15.25} \sqrt{2.4}\sqrt{y} = \sqrt{2.4} * \frac{2}{3} y^{\frac{3}{2}} \Big]_0^{15.25} = 61.51 \, m^3$



$R_V = 1000 * 9.81 * 61.51 = 603413.1 \, N$

$R = \sqrt{R_V^2 + R_H^2} = 1290.48 \, KN$

$\theta = \tan^{-1}\left(\frac{R_V}{R_H}\right) = 27.88^\circ$

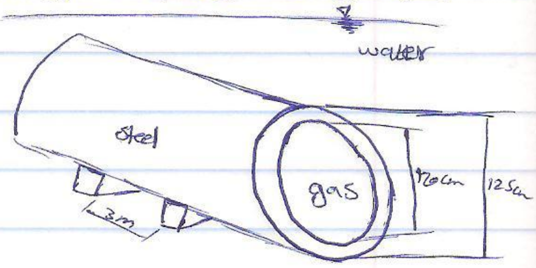
$\frac{X}{\sin(180 - (27.88 + 55.54))} = \frac{6.17}{\sin(27.88)} \Rightarrow X = 13.11 \, m$

(6)

(a) Buoyancy Force (N/m) = weight of water displaced by body

$= \rho_w g V_p$

$= 1000 * 9.81 * \frac{\pi}{4} * (1.25)^2 =$ ~~[crossed out]~~ 12037 N/m



(b)

upword Force (N)

$\Sigma F_y = 0$

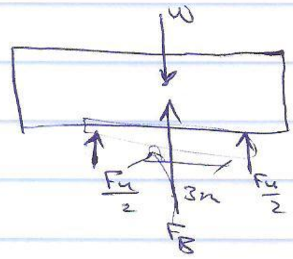
$+\frac{F_u}{2} + \frac{F_u}{2} + F_B = W$

$F_u = W - F_B$

$F_B = 12037 \text{ N/m} * 3 \text{ m} = 36111 \text{ N}$

$W = 9.81 * 7900 * \frac{\pi}{4}(1.25^2 - 1.2^2) * 3 = 22368 \text{ N}$

$F_u = 22368 - 36111 = -13743 \text{ N}$



(7)

$R = \rho g A \bar{y}$

$= 1000 * 9.81 * \left(\frac{\pi}{4}(0.01)^2\right) * \left[\frac{0.01}{2} + 7\right]$

$= 5.4 N$

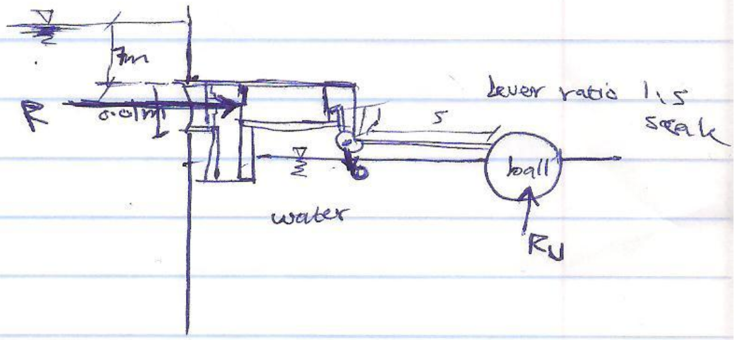
$R_u = w = \rho g V = 1000 * 9.81 * V$

$\Sigma M_o = 0$

$M_R = M_{Ru}$

$5.4 * 1 = 9810 V * 5$

$V = 1.10 * 10^{-4} m^3 = 110 m^3$



8)

$w_1 + w = \rho g V$

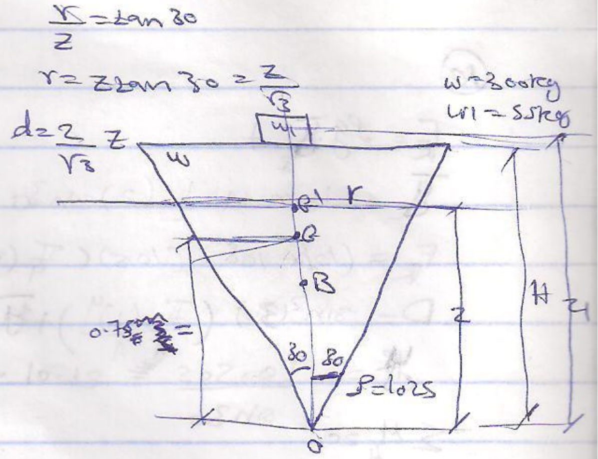
$(55+300)\,9.81 = 1025 \times 9.81 \times \left[\frac{\pi}{4} d^2 (z)\left(\frac{1}{3}\right)\right]$

$355 = 1025\left[\frac{\pi}{4}\left(\frac{2}{\sqrt{3}} z\right)^2 \times z \times \frac{1}{3}\right]$

$z = 0.997 \Rightarrow d = 1.152$

$OB = \frac{3}{4} z = 0.747\, m$

$\frac{0.6}{H} = \tan 30 \Rightarrow H = 1.04\, m$



$OG = \frac{3}{4}(1.04) = 0.78\, m$

$BG' = BM = \frac{I}{V} = \frac{\frac{\pi}{64}(d)^4 d^2}{\frac{\pi}{3}\frac{d^2}{4} z} = \frac{(1.152)^2 \times 12}{64 \times 0.997} = 0.249\, m$

$\Sigma M_o = 0$

$55(z_1) + 300(0.75) = 355(OB + BG')$

$z_1 = 2.33\, m$

Max. h. of CG above the top of buoy $= z_1 - H = 2.33 - 1.04 = 1.29\, m$

9)

(10)

$F_R = \rho g \bar{y} A$

$\bar{y} = 10m + \frac{1}{2}(2)\sin 30 = 10.5\,m$

$F_R = (10 \times 10^3)(10.5)(\frac{\pi}{4}(2m)^2 = 3.33 \times 10^5 N$

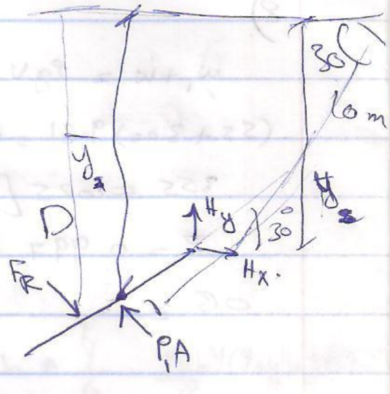
$D = \sin^2(30)\left(\frac{\frac{\pi}{4}(1)^4}{\bar{y} A}\right) + \bar{y} = 10.505\,m$

$y = \frac{10.505}{\sin 30} = 21.01\,m$

$\Sigma M_H = 0$

$F_R(21.012 - 20) = P_1 \pi (1)^2 (1)$

$P_1 = 107\,kPa$



$y_2 = \frac{10}{\sin 30} + 1 = 21$

(11)

$F_{w_1} = \frac{1}{2}\rho g h \times h \times 2 = \rho g h^2$

$\Sigma M_A = 0$

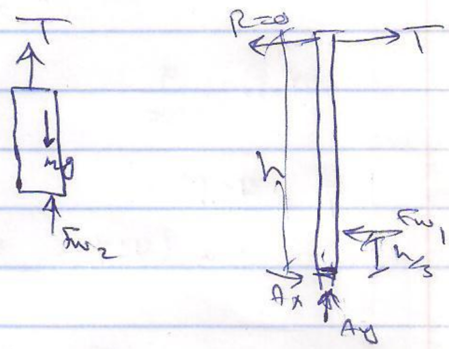
$4T = \frac{\rho g h^3}{3} \rightarrow T = \frac{\rho g h^3}{12}$

$\Sigma F_y = 0$

$T + F_{w_2} - mg = 0$

$\frac{\rho g h^3}{12} + \rho g \frac{\pi}{4}(1)^2 \times (h-1) - mg = 0$

where $h = 2.5 \Rightarrow m = 2479.58\,kg$



(12)

$F_w = \frac{1}{2}\rho g h \times h \times 4 = 2\rho g h^2$

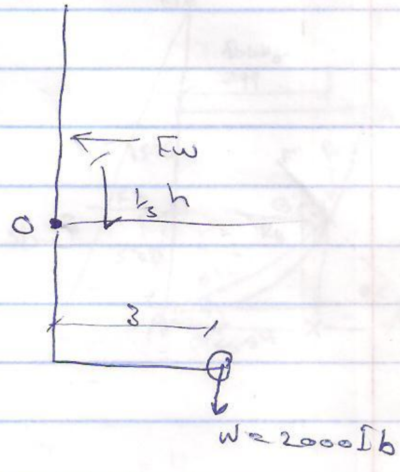
$\Sigma M_o = 0$

$F_w \times \frac{h}{3} = 200 \times 3$

$\frac{h}{3} = \frac{200 \times 3}{2\rho g h^2}$

$\sqrt[3]{h^3} = \sqrt[3]{\frac{3 \times 200 \times 3}{2 \times 62.4}}$

$= 5.244\,ft$



(13)

$\Sigma M_s = 0$

$w \cdot 2.5 \sin\theta = R \cdot 2 \sin\theta$

$w = 0.8 R$

$R = w$

$= \rho g v$

$= \rho g \frac{\pi}{4}(0.08)^2 * 4 = 197.1\ N$

$W = 0.8 R = 0.8 * 197.1 = 157.7 N$

$\frac{s.g}{1000} = \rho = \frac{w}{v} = \frac{157.7}{\frac{\pi}{4}(0.08)^2 * 5} = 6277.866 \times 1000 = 62.778$

$\Sigma F_y = 0$

$T = R - w = 39.4 N$

(14)

$RH_1 = \frac{1}{2} \rho g * 4 \times 4 * 8$

$= 64.2 * 4^3 = 3993.6\ lb$

$R_{V_1} = \rho g v = 64.2 * \frac{1}{2}\frac{\pi}{4}(4)^2 * 8 = 322.540\ lb$

$RH_2 = \frac{1}{2} \rho g * 2 * 2 * 8 = 998.4\ lb$

$R_{V_2} = \rho g V = 64.2 * \frac{1}{4} * \frac{\pi}{4}(4)^2 * 8) = 1612.704\ lb$

$w = \rho g * v = 0.8 * 64.2 * \pi (2)^2 * 8 = 5160.6528\ lb$

$\Sigma F_x = 0$

$3993.6 - 998.4 = \boxed{C_x = 2995.2\ lb}$

$\Sigma F_z = 0$

$w - R_{V_1} - R_{V_2} - C_z = 0$

$\boxed{C_z = 322.5398\ lb}$

HW CH.(4

4.6

$$Re = \frac{\rho U D}{\mu} = \frac{10^3 * 6 * 25 * 10^{-3}}{1.3 * 10^{-3}}$$

$$= 115384.6 > 4000 \text{ Turb.}$$

$$Re = \frac{\rho U D}{\mu} = \frac{0.9 * 10^3 * 6 * 25 * 10^{-3}}{9.6 * 10^{-2}}$$

$$= 1406.25 < 2000 \quad \text{laminar.}$$

4.7

$$U = \frac{Q}{A} = \frac{0.42}{300 * 450 * 10^{-6}} = 3.11 \text{ m/s}$$

$$U = \frac{Q}{A} = \frac{0.42}{150 * 400 * 10^{-6}} = 7 \text{ m/s}$$

4.11

$$\dot{m}_c = \dot{m}_A + \dot{m}_B$$

$$= Q_A \rho_A + Q_B \rho_B = 56 * 10^{-3} * 930 + 30 * 10^{-3} * 870 = 78.18 \text{ kg/s}$$

$$U = \frac{Q_c}{A_c} = \frac{56 * 10^{-3} + 30 * 10^{-3}}{\frac{\pi}{4}(0.175)^2} = 3.58 \text{ m/s}$$

$$s.g = \frac{\rho_c}{1000} \Rightarrow \rho_c = \frac{\dot{m}_c}{Q_c} = \frac{78.18}{86 * 10^{-3}} = 909 \text{ kg/m}^3$$

$$\Rightarrow s.g_c = 0.909$$

4.12

$$Q = 2\pi \int_0^{0.3} (-5r^2 + 0.45) r \, dr$$

$$= -2\pi \int_0^{0.3} 5r^3 - 0.45r \cdot dr$$

$$= -2\pi \left[\frac{5r^4}{4} - \frac{0.45 r^2}{2} \right]_0^{0.3} = 0.06358 \text{ m}^3/\text{s}$$

$$\bar{u} = \frac{Q}{A} = \frac{0.0636}{\frac{\pi}{4}(0.6)^2} = 0.225 \text{ m/s}$$

other questions :

1

a) $Q_1 = Q_2 + Q_3$

$100 = \frac{\pi}{4} (0.05)^2 * 8 * 3600 + Q_3$

$Q_3 = 43.48 \ m^3/hr.$

b) $u_3 = \frac{Q_3}{A_3} = \frac{43.48}{\frac{\pi}{4}(0.04)^2 * 3600} = 9.616 \ m/s$

2

h → constant → steady

incompressible → ρ constant

$Q_2 = Q_1 + Q_3$

$\frac{\pi}{4}(0.07)^2 u_2 = \frac{\pi}{4}(0.05)^2 (3) + 0.01$

$u_2 = 4.1304 \ m/s$

3

Oil ⇒ $\rho_1 = \rho_2$, steady

a) $Q_1 = Q_2 = \frac{\dot{m}}{\rho}$

$\dot{m} = \frac{\dot{w}}{g} = \frac{250}{9.81 * 3600} = \dot{m}$

$Q_1 = Q_2 = \frac{\dot{m}}{0.89 * 1000} = 7.95 \times 10^{-6} \ m^3/s = 7.95 \ mL/s$

b) $u_2 = \frac{Q_2}{A_2}$

$= \frac{7.95 \times 10^{-6}}{\pi * (0.002) * (0.1)} = 0.01265 \ m/s$

$= 1.265 \ cm/s$

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