HOMEWORK MODULE 1 SOLUTIONS

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1.45 $$p=\frac{F}{A}=\frac{12.0\,\text{kN}}{\pi(75\,\text{mm})^2/4}\times\frac{10^3\,\text{N}}{\text{kN}}\times\frac{(10^3\,\text{mm})^2}{\text{m}^2}=2.72\times10^6\,\frac{\text{N}}{\text{m}^2}\ =\mathbf{2.72\ MPa}$$

1.48 $$p=\frac{F}{A}=\frac{18000\,\text{lb}}{\pi(2.50\,\text{in})^2/4}\ =\mathbf{3667\ psi}$$

1.58 $\Delta p = -E(\Delta V/V) = -3.59\times10^6\ \text{psi}(-0.01) = \mathbf{35900\ psi}$
$\Delta p = -24750\ \text{MPa}(-0.01) = \mathbf{247.5\ MPa}$

1.63 Stiffness = Force/Change in Length = $F/\Delta L$

Bulk Modulus = $E = \dfrac{-p}{\Delta V/V}=\dfrac{-pV}{\Delta V}$

But $p = F/A$; $V = AL$; $\Delta V = -A(\Delta L)$

$$E=\frac{-F}{A}\times\frac{AL}{-A(\Delta L)}=\frac{FL}{A(\Delta L)}$$

$$\frac{F}{(\Delta L)}=\frac{EA}{L}=\frac{189000\,\text{lb}\,\pi(0.5\,\text{in})^2}{\text{in}^2(42\ \text{in})4}=\mathbf{884\ lb/in}$$

1.76 $$m=\frac{w}{g}=\frac{1.00\,\text{lb}}{32.2\,\text{ft/s}^2}\ =\mathbf{0.0311\ slugs}$$

$m = 0.0311\ \text{slugs}\times14.59\ \text{kg/slug} = \mathbf{0.453\ kg}$
$w = 1.00\ \text{lb}\times4.448\ \text{N/lb} = \mathbf{4.448\ N}$

1.92 $w_o = 35.4\ \text{N} - 2.25\ \text{N} = 33.15\ \text{N}$
$V_o = Ad = (\pi D^2/4)(d) = \pi(.150\ \text{m})^2(.20\ \text{m})/4 = 3.53\times10^{-3}\ \text{m}^3$

$$\gamma_o=\frac{w}{V}=\frac{33.15\,\text{N}}{3.53\times10^{-3}\ \text{m}^3}=9.38\times10^3\ \text{N/m}^3\ =\mathbf{9.38\ kN/m^3}$$

$$\text{sg}=\frac{\gamma_o}{\gamma_w}=\frac{9.38\ \text{kN/m}^3}{9.81\ \text{kN/m}^3}\ =\mathbf{0.956}$$

1.107 $\rho = (0.79)(1.94\ \text{slugs/ft}^3) = \mathbf{1.53\ slugs/ft^3}$; $\boldsymbol{\rho} = \mathbf{0.79\ g/cm^3}$

2.17 Blood plasma, molten plastics, catsup, paint, and others.

2.18 6.5×10^{-4} Pa·s

2.19 1.5×10^{-3} Pa·s

2.20 2.0×10^{-5} Pa·s

2.21 1.1×10^{-5} Pa·s

2.22 3.0×10^{-1} Pa·s

2.23 1.90 Pa·s

2.24 3.2×10^{-5} lb·s/ft^2

2.25 8.9×10^{-6} lb·s/ft^2

2.26 3.6×10^{-7} lb·s/ft^2

2.27 1.9×10^{-7} lb·s/ft^2

2.28 5.0×10^{-2} lb·s/ft^2

2.29 4.1×10^{-3} lb·s/ft^2

2.30 3.3×10^{-5} lb·s/ft^2

2.31 2.8×10^{-5} lb·s/ft^2

2.32 2.1×10^{-3} lb·s/ft^2

2.33 9.5×10^{-5} lb·s/ft^2

2.34 1.3×10^{-2} lb·s/ft^2

2.35 2.2×10^{-4} lb·s/ft^2

2.61

$$\eta = \frac{(\gamma_s - \gamma_f)D^2}{18\upsilon} \text{ (Eq. 2-10)}$$

| $\gamma_f = 0.94(9.81 \text{ kN/m}^3) = 9.22 \text{ kN/m}^3$
| $D = 1.6 \text{ mm} = 1.6 \times 10^{-3} \text{ m}$

$v = s/t = .250 \text{ m}/10.4 \text{ s} = 2.40 \times 10^{-2} \text{ m/s}$

$$\mu = \frac{(77.0 - 9.22)\text{kN}(1.6\times10^{-3}\text{m})^2}{18 \text{ m}^3(2.40\times10^{-2} \text{ m/s})} \times \frac{10^3 \text{ N}}{\text{kN}} = 0.402\frac{\text{N}\cdot\text{s}}{\text{m}^2} = \mathbf{0.402 \text{ Pa}\cdot\text{s}}$$

3.6 True.

3.7 False. Atmospheric pressure varies with altitude and with weather conditions.

3.8 False. Absolute pressure cannot be negative because a perfect vacuum is the reference for absolute pressure and a perfect vacuum is the lowest possible pressure.

3.9 True.

3.10 False. A gage pressure can be no lower than one atmosphere below the prevailing atmospheric pressure. On earth, the atmospheric pressure would never be as high as 150 kPa.

3.11 At 4000 ft, $p_{atm} = 12.7$ psia; from App. E by interpolation.

3.13 Zero gage pressure.

3.41 $p_{air} = p_A - \gamma_o(64\text{ in}) = 180\text{ psig} - (0.9)(62.4\text{ lb/ft}^3)(64\text{ in})(1\text{ ft}^3/1728\text{ in}^3)$

$p_{air} = 180\text{ psig} - 2.08\text{ psi} = \mathbf{177.9\ psig}$

3.44 $p = \gamma h = (0.95)(62.4\text{ lb/ft}^3)(28.5\text{ ft})(1\text{ ft}^2/144\text{ in}^2) = \mathbf{11.73\ psig}$

3.62 $\overset{0}{\cancel{p_{atm}}} - \gamma_m(.075\text{ m}) - \gamma_w(0.10\text{ m}) = p_A$

$p_A = -(13.54)(9.81\text{ kN/m}^3)(0.075\text{ m}) - (9.81)(0.10) = \mathbf{-10.94\ kPa(gage)}$

3.67 $\overset{0}{\cancel{p_{atm}}} + \gamma_m(.475\text{ m}) - \gamma_w(.30\text{ m}) + \gamma_m(.25\text{ m}) - \gamma_o(.375\text{ m}) = p_A$

$p_A = \gamma_m(.725\text{ m}) - \gamma_w(.30\text{ m}) - \gamma_o(.375\text{ m})$

$p_A = (13.54)(9.81\text{ kN/m}^3)(.725\text{ m}) - (9.81)(.30) - (.90)(9.81)(.375)$

$p_A = (96.30 - 2.94 - 3.31)\text{kPa} = \mathbf{90.05\ kPa(gage)}$

3.83 $$p_{atm} = \gamma_m h = \frac{848.7\text{ lb}}{\text{ft}^3} \times 30.65\text{ in} \times \frac{1\text{ ft}^3}{1728\text{ in}^3} = \mathbf{15.05\ psia}$$

3.90 $p = -68.2\text{ kPa }(1000\text{ Pa/kPa})(1.0\text{ mmHg}/133.3\text{ Pa}) = \mathbf{-512\ mmHg}$

3.94 $\Delta P = \gamma_w \times h$

$$\blacklozenge P = 9.810\frac{\text{kN}}{\text{m}^3} \times 16\text{ m} = 157\frac{\text{kN}}{\text{m}^2} = \underline{157\text{ kPa}}$$

4.2 $F = pA = (14.4\ \text{lb/in}^2)(\pi(30\ \text{in}^2)/4) = 10180\ \text{lb}$

4.10 Force on valve $= pA$; $A = \pi(0.095\ \text{m})^2/4 = 7.088 \times 10^{-3}\ \text{m}^2$

$$p = \gamma_w h = \frac{9.81\ \text{kN}}{\text{m}^3} \times 1.80\ \text{m} = 17.66\ \text{kN/m}^2$$

$F = (17.66 \times 10^3\ \text{N/m}^2)(7.088 \times 10^{-3}\ \text{m}^2) = 125\ \text{N}$ Acts at center

$\Sigma M_{hinge} = 0 = (125\ \text{N})(47.5\ \text{mm}) - F_O(65\ \text{mm})$

$F_O = 5946\ \text{N}\cdot\text{mm}/65\ \text{mm} = \mathbf{91.5\ N}$ = Opening force

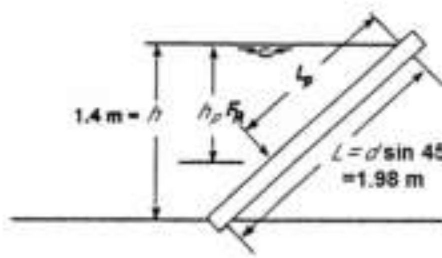
4.17 $F_R = \gamma_o(h/2)A$

$$= (0.86)\frac{9.81\ \text{kN}}{\text{m}^3} \times 0.7\ \text{m} \times (1.98)(4.0)\ \text{m}^2$$

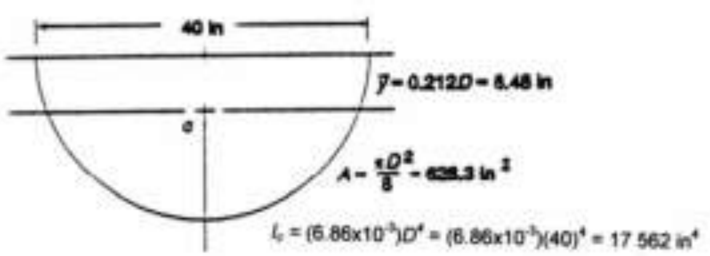
$\mathbf{F_R = 46.8\ kN}$

$h_p = 2/3\ h = (2/3)(1.4\ \text{m}) = \mathbf{0.933\ m}$

$L_p = 2/3\ L = (2/3)(1.98\ \text{m}) = \mathbf{1.32\ m}$



4.28



$a = 10\ \text{in}/\cos 30° = 11.55\ \text{in}$

$L_c = a + 8 + \bar{y} = 11.55 + 8.0 + 8.48 = 28.03\ \text{in}$

$h_c = L_c \cos 30° = 24.27\ \text{in}\ [2.023\ \text{ft}]$

$F_R = \gamma h_c A$

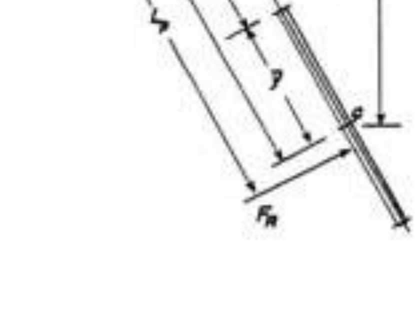
$$= (1.10)(62.4\ \text{lb/ft}^3)(2.023\ \text{ft})\frac{(628.3\ \text{in}^2)(1\ \text{ft}^2)}{144\ \text{in}^2}$$

$\mathbf{F_R = 605.8\ lb}$

$$L_p - L_c = \frac{I_c}{L_c A} = \frac{17\ 562\ \text{in}^4}{(28.03\ \text{in})(628.3\ \text{in}^2)} = 0.997$$

$= \mathbf{7.135\ in}$

$L_p = L_c + 7.135\ \text{in} = \mathbf{29.03\ in}$



4.42 $h_c = 38 + y = 38 + 5 \cos 30° = 42.33$ in

$L_c = h_c/\cos 30° = 48.88$ in

$F_R = \gamma h_c A$

$A = \pi(10)^2/4 = 78.54$ in^2

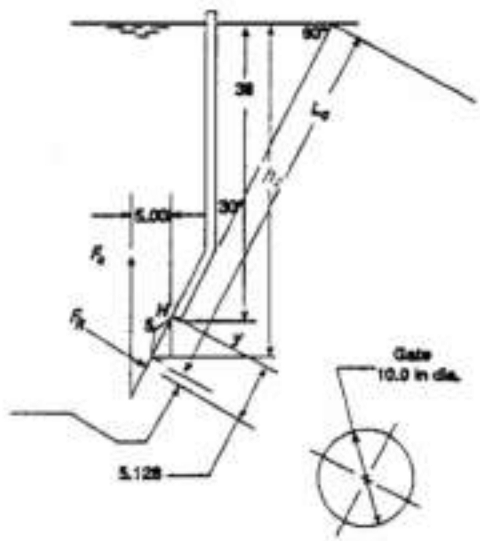
$$F_R = \frac{62.4 \text{ lb}}{\text{ft}^3} \cdot \frac{42.33 \text{ in} \cdot 78.54 \text{ in}^2}{1728 \text{ in}^3/\text{ft}^3}$$

$$\boldsymbol{F_R = 120.1 \text{ lb}}$$

$$I_c = \frac{\pi(10)^4}{64} = 490.9 \text{ in}^4$$

$$L_p - L_c = \frac{I_c}{L_c A}$$

$$L_p - L_c = \frac{490.9 \text{ in}^4}{(48.88 \text{ in})(78.54 \text{ in}^2)} = \mathbf{0.128 \text{ in}}$$



Sum moments about hinge at top of gate.

$$\Sigma M_H = 0 = F_R(5.128) - F_c(5.00)$$

$$F_c = \frac{(120.1 \text{ lb})(5.128 \text{ in})}{5.00 \text{ in}} = \mathbf{123.2 \text{ lb} = \text{cable force}}$$

5.8 $w - F_b - F_{SP} = 0 = W - \gamma_o V_d - F_{SP}$

$F_{SP} = w - \gamma_o V_d = 14.6 \text{ lb} - (0.90)(62.4 \text{ lb/ft}^3)(40 \text{ in}^3)\ \dfrac{1 \text{ ft}^3}{1728 \text{ in}^3}$

$F_{SP} = \mathbf{13.3\ lb}$

5.24 $w_c - F_{b_c} + w_B - F_{b_B} = 0$

$\gamma_c V_c - \gamma_w V_c + \gamma_B V_B - \gamma_w V_B = 0$

$\gamma_c A \cdot L - \gamma_w A \cdot L + \gamma_B A \cdot t - \gamma_w A \cdot t = 0$

$t(\gamma_B - \gamma_w) = L(\gamma_w - \gamma_c)$

$t = L\ \dfrac{\gamma_w - \gamma_c}{\gamma_B - \gamma_w} = 750 \text{ mm}\ \dfrac{(9.44 - 6.46)\text{kN/m}^3}{(84.0 - 9.44)\text{kN/m}^3} = \mathbf{30.0\ mm}$

5.41 $w = F_b = \gamma_{sw} V_d = \gamma_{sw} AX$

$X = \dfrac{w}{\gamma_{sw} A} = \dfrac{450000 \text{ lb}}{(64.0 \text{ lb/ft}^3)(20 \text{ ft})(50 \text{ ft})}$

$= 7.031 \text{ ft}$

$y_{cb} = X/2 = 3.516 \text{ ft}$

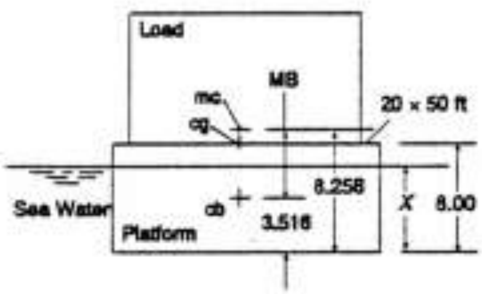
$I = (50)(20)^3/12 = 3.333 \times 10^4 \text{ ft}^4$

$V_d = AX = (20)(50)(7.031)\text{ft}^3 = 7031 \text{ ft}^3$

$\text{MB} = I/V_d = 4.741 \text{ ft}$

$y_{mc} = y_{cb} + \text{MB} = 3.516 + 4.741$

$= \mathbf{8.256\ ft} > \boldsymbol{y_{cg}}$**—stable**



5.61 Entire hull:

$y_{cg} = \dfrac{A_1 y_1 + A_2 y_2}{A_T}$

$= \dfrac{(.72)(.40) + (2.88)(1.2)}{3.60}$

$y_{cg} = 1.040 \text{ m}$

Submerged Volume:

$y_{cb} = \dfrac{(.72)(0.4) + (2.16)(1.05)}{2.88}$

$= 0.8875 \text{ m}$

$V_d = (2.88)(5.5) = 15.84 \text{ m}^3$

$I = 5.5(2.4)^3/12 = 6.336 \text{ m}^4$

$y_{mc} = y_{cb} + I/V_d = 0.8875 + 0.40 = \mathbf{1.2875\ m} > y_{cg}$**—stable**