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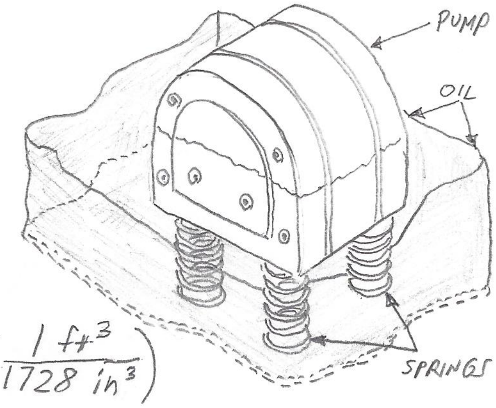
MET 330 HOMEWORK 1.6

CHAPTER 5

5-8) GIVEN: SPECIFIC GRAVITY OF OIL = $sg = 0.90$

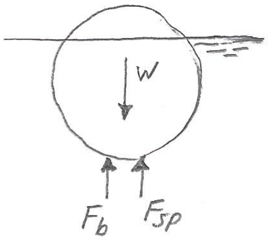
TOTAL WEIGHT OF PUMP = 14.6 lb

SUBMERGED VOLUME = 40 in³



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

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

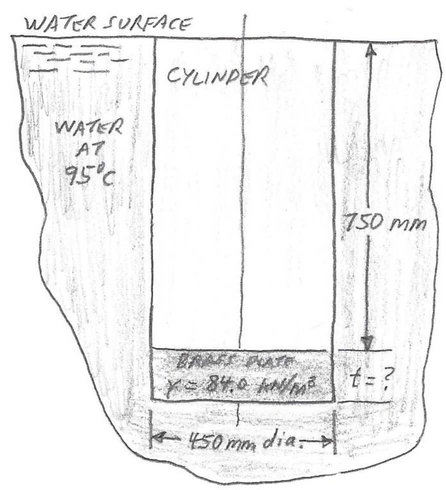


SUPPORTING FORCE EXERTED BY SPRINGS:

$$F_{sp} = 13.3\ \text{lb}$$

5-24) GIVEN: - CYLINDER IS SUBMERGED AND NEUTRALLY BUOYANT AT 95°C

- BRASS PLATE IS SAME DIAMETER AS CYLINDER
- CYLINDER = 450 mm DIAMETER



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

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

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

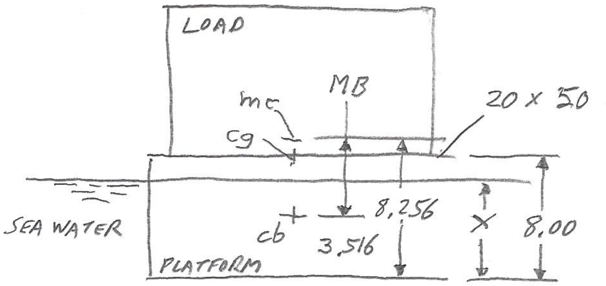
$$t(\gamma_B - \gamma_w) = L(\gamma_w - \gamma_c)$$

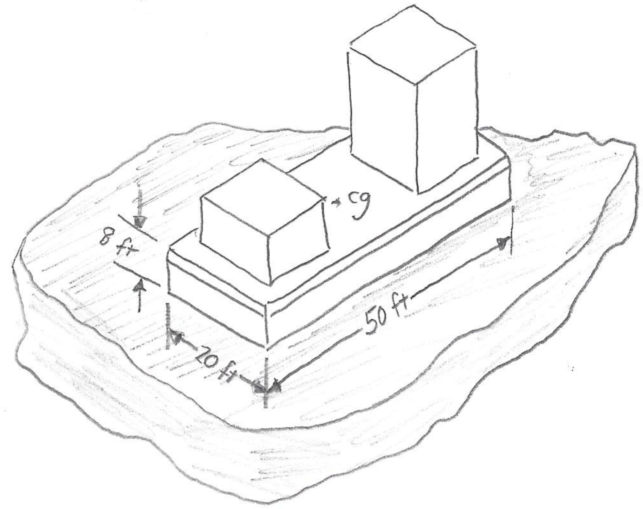
$$t = L\left(\frac{\gamma_w - \gamma_c}{\gamma_B - \gamma_w}\right) = 750\ \text{mm}\ \frac{(9.44 - 6.46)\ \text{kN/m}^3}{(84.0 - 9.44)\ \text{kN/m}^3}$$

$$t = 30.0\ \text{mm}$$

5-41) GIVEN: TOTAL WEIGHT OF SYSTEM = 450,000 lb

CENTER OF GRAVITY = 8 ft FROM BOTTOM OF PLATFORM





$W = F_b = \gamma_{sw} V_d = \gamma_{sw} A X$

$X = \frac{W}{\gamma_{sw} A} = \frac{450000 \text{ lb}}{(64.0 \text{ lb/ft}^3)(20 \text{ ft})(50 \text{ ft})} = 7.031 \text{ ft}$

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

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

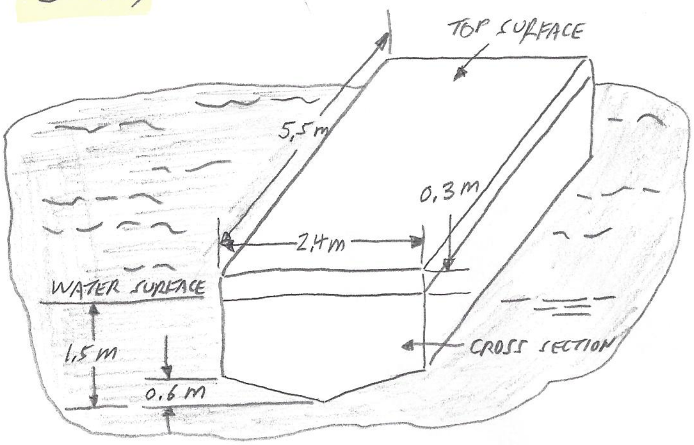
$V_d = AX = (20 \text{ ft})(50 \text{ ft})(7.031 \text{ ft}) = 7031 \text{ ft}^3$

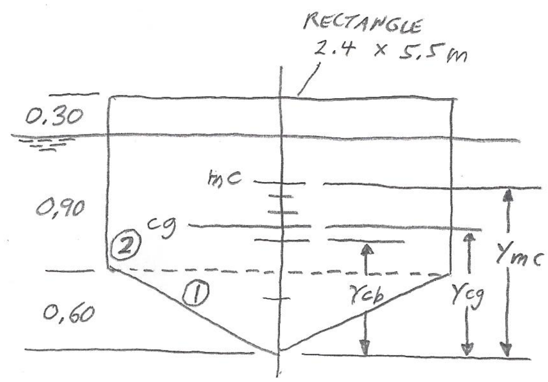
$MB = \frac{I}{V_d} = 4.741 \text{ ft}$

$y_{mc} = y_{cb} + MB = 3.516 \text{ ft} + 4.741 \text{ ft} = 8.256 \text{ ft}$

$y_{mc} = 8.256 \text{ ft} > y_{cg} \longrightarrow$ STABLE

5-61) IS THIS BOAT STABLE?





ENTIRE HULL:

$$Y_{cg} = \frac{A_1 Y_1 + A_2 Y_2}{A_T} = \frac{(0.72\ m^2)(0.40\ m) + (2.88\ m^2)(1.2\ m)}{3.60\ m^2} = 1.040\ m$$

SUBMERGED VOLUME:

$$Y_{cb} = \frac{(0.72)(0.40) + (2.16)(1.05)}{2.88} = 0.8875\ m$$

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

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

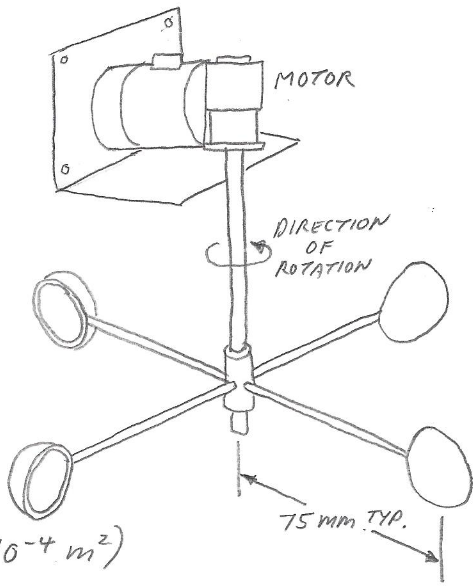
$$Y_{mc} = Y_{cb} + \frac{I}{V_d} = 0.8875\ m + 0.40\ m$$

$$Y_{mc} = 1.2875\ m > Y_{cg} \rightarrow \text{STABLE}$$

17.11) V = LINEAR VELOCITY OF EACH CUP

$$V = r\omega = (0.075\ m)\left(\frac{20\ rev}{min}\right)\left(\frac{2\pi\ rad}{rev}\right)\left(\frac{1\ min}{60\ s}\right) = 0.157\ m/s$$

$$A = \frac{\pi D^2}{4} = \frac{\pi(0.025\ m)^2}{4} = 4.91 \times 10^{-4}\ m^2$$



FROM TABLE 17.1

$C_D = 1.35$

a) AIR AT 30°C

$\rho = 1.164\ kg/m^3$

$$F_D = C_D\left(\tfrac{1}{2}\rho v^2\right)A$$

$$F_D = (1.35)(0.5)(1.164\ kg/m^3)(0.157\ m/s)^2(4.91 \times 10^{-4}\ m^2)$$

$$F_D = 9.5 \times 10^{-6}\ kg \cdot m/s^2 = 9.56\ \mu N$$

$$TORQUE = 4F_D r = (4)(9.56 \times 10^{-6}\ N)(0.075\ m) = 2.85 \times 10^{-6}\ N \cdot m$$

TORQUE = 2.85 μN·m

b) GASOLINE

$\rho = 680\ kg/m^3$

$$F_D = (1.35)(0.5)(680\ kg/m^3)(0.157\ m/s)^2(4.91 \times 10^{-4}\ m^2)$$

$$F_D = 5.56 \times 10^{-3}\ kg \cdot m/s^2 = 5.56\ mN$$

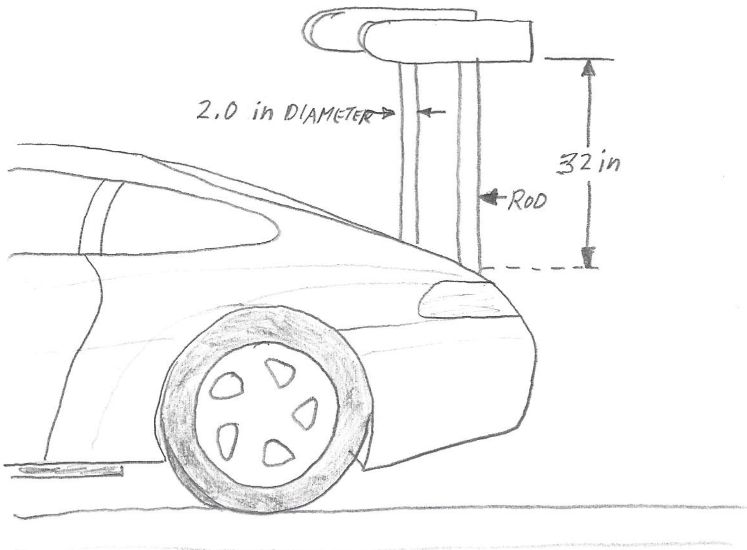
$$TORQUE = 4F_D r = (4)(5.56 \times 10^{-3}\ N)(0.075\ m) = 1.67 \times 10^{-3}\ N \cdot m$$

TORQUE = 1.67 mN·m

$$RATIO\ \frac{T_G}{T_A} = \frac{1.67 \times 10^{-3}\ N \cdot m}{2.85 \times 10^{-6}\ N \cdot m} = 586$$

17-14) GIVEN: AIR = -20° F

SPEED = 150 mph



$$F_D = C_D\left(\frac{1}{2}\rho v^2\right)A$$

$$N_R = \frac{vD}{\nu} = \frac{(220)(0.167)}{1.16 \times 10^{-4}} = 3.15 \times 10^5 \longrightarrow C_D = 0.8$$

$$v = \frac{150\ mi}{h} \times \frac{5280\ ft}{1\ mi} \times \frac{1\ hr}{3600\ s} = 220\ ft/s$$

$$D = 2.0\ in\left(\frac{1\ ft}{12\ in}\right) = 0.167\ ft$$

FROM APPENDIX E.2 $\longrightarrow$ $\nu = 1.17 \times 10^{-4}\ ft^2/s$

$\rho = 2.80 \times 10^{-3}$ SLUGS/ft

$$A = DL = (0.167\ ft)(64\ in)\left(\frac{1\ ft}{12\ in}\right) = 0.889\ ft^2$$

$$F_D = 0.8(0.5)(2.80 \times 10^{-3}\ lb \cdot s^2/ft^4)(220\ ft/s)^2(0.889\ ft^2)$$

$$F_D = 48.2\ lb$$

17-16) $F_D = C_D\left(\frac{1}{2}\rho v^2\right)A = C_D(0.5)(2.80 \times 10^{-3})(147)^2(A)$

$F_D = (30.12)(C_D)(A)$

$V = \frac{100\ mi}{h} \times \frac{5280\ ft}{1\ mi} \times \frac{1\ hr}{3600\ s} = 147\ ft/s$

$A = (9\ in)(60\ in)\left(\frac{1\ ft^2}{144\ in^2}\right) = 3.75\ ft^2$ FOR DESIGNS a, c, d.

FOR DESIGN b: $y = (9\ in)\sin 45° = 6.36\ in$

$h = 2y = (12.73\ in)\left(\frac{1\ ft}{12\ in}\right) = 1.06\ ft$

$A = h \times l = (1.06\ ft)(5.0\ ft) = 5.303\ ft^2$

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a) SQUARE CYLINDER: $L = (9\ in)\left(\frac{1\ ft}{12\ in}\right) = 0.75\ ft$

$N_R = \frac{vL}{\nu} = \frac{(147\ ft/s)(0.75\ ft)}{(1.17 \times 10^{-4})} = 9.42 \times 10^5 \longrightarrow C_D \approx 2.10$

$F_D = (30.12)(2.10)(3.75\ ft^2) \longrightarrow$ $F_D = 237\ lb$

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b) ASSUME $C_D = 1.60$

$F_D = (30.12)(1.60)(5.303\ ft^2) \longrightarrow$ $F_D = 256\ lb$ (HIGHEST)

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c) CIRCULAR CYLINDER: $D = 9.0\ in = 0.75\ ft$

$N_R = \frac{vD}{\nu} = \frac{(147\ ft/s)(0.75\ ft)}{(1.17 \times 10^{-4})} = 9.42 \times 10^5 \longrightarrow C_D = 0.30$

$F_D = (30.12)(0.30)(3.75\ ft^2) \longrightarrow$ $F_D = 33.9\ lb$

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d) ELLIPTICAL CYLINDER: $L = 18\ in = 1.50\ ft$ $\quad L/h = 2.0$

$h = 9.00\ in = 0.75\ ft$

$N_R = \frac{vL}{\nu} = \frac{(147\ ft/s)(1.50\ ft)}{(1.16 \times 10^{-4})} = 1.88 \times 10^6 \longrightarrow C_D \approx 0.25$

$F_D = (30.12)(0.25)(3.75\ ft^2) \longrightarrow$ $F_D = 28.2\ lb$ (LOWEST)

17-26) $R_{ts}/\Delta = 0.06$ (FROM TABLE 17.2)

$R_{ts} = 0.06(\Delta) = (0.06)(125 \text{ TONS})(2240 \text{ lb/TON})$

$R_{ts} = 16800 \text{ lb}$

$P_E = R_{ts} V = (16800 \text{ lb})(50 \text{ ft/s}) = \dfrac{840000 \text{ lb}\cdot\text{ft/s}}{550 \text{ lb}\cdot\text{ft/s (hp)}}$

$P_E = 1527 \text{ hp}$

17-30) $F_L = C_L(\frac{1}{2}\rho v^2)A$

$F_D = C_D(\frac{1}{2}\rho v^2)A$

$C_L = 0.90 \longrightarrow C_D = 0.05 \longrightarrow A = bc = (6.8 \text{ m})(1.4 \text{ m}) = 9.52 \text{ m}^2$

$V = \dfrac{200 \text{ km}}{h} \times \dfrac{10^3 \text{ km}}{\text{km}} \times \dfrac{1h}{3600 \text{ s}} = 55.56 \text{ m/s}$

a) AT 200 m, $\rho = 1.202 \text{ kg/m}^3$ (APPENDIX E)

$F_L = (0.90)(0.5)(1.202)(55.56)^2(9.52) = 1.59 \times 10^{-4} \text{ kg}\cdot\text{m/s}^2$

$F_L = 1.59 \times 10^4 \text{ N} \longrightarrow F_L = 15.9 \text{ kN}$

$F_D = \dfrac{0.05}{0.90} \times (1.59 \times 10^4 \text{ N}) \longrightarrow F_D = 883 \text{ N}$

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b) AT 10000 m, $\rho = 0.4135 \text{ kg/m}^3$

$F_L = (0.9)(0.5)(0.4135)(55.56)^2(9.52) = 5.47 \times 10^3 \text{ N}$

$F_L = 5.47 \text{ kN}$

$F_D = \dfrac{0.05}{0.90} \times (5.47 \times 10^3 \text{ N}) \longrightarrow F_D = 304 \text{ N}$