

4.10 A simple shower for remote locations is designed with a cylindrical tank 500 mm in diameter and 1.800 m high as shown in Fig. P4.10. The water flows through a flapper valve in the bottom through a 75-mm-diameter opening. The flapper must be pushed upward to open the valve. How much force is required to open the valve?

hydrostatic pressure:

$$P = \rho g h$$

$$= (1000 \text{ kg/m}^3) \cdot 9.81 \frac{\text{m}}{\text{s}^2} \cdot 1.8 \text{ m}$$

$$= 17658 \text{ Pa}$$

Valve

$$D = 75 \text{ mm} = 0.075 \text{ m}$$

$$A = \frac{\pi D^2}{4} = \frac{\pi (0.075)^2}{4}$$

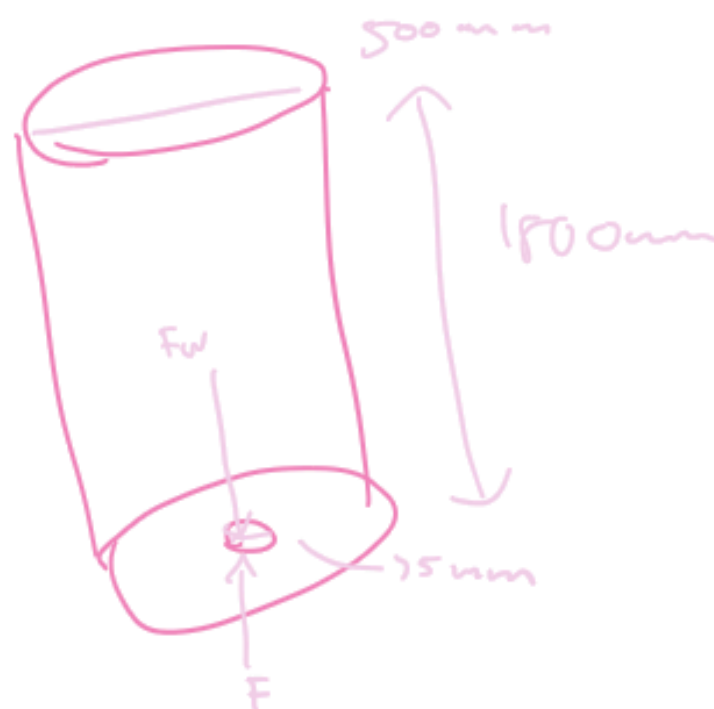
$$A = 0.00442 \text{ m}^2$$

$$F = P \cdot A$$

$$= 17658 \text{ Pa} \cdot 0.00442 \text{ m}^2$$

$$F = 78 \text{ N}$$

just find the force
at the bottom
of tank.



4.2 The flat left end of the tank shown in Fig. P4.1 is secured with a bolted flange. If the inside diameter of the tank is 30 in and the internal pressure is raised to +23.6 psig calculate the total force that must be resisted by the bolts in the flange.

- pressure acting on force
- Need resultant force
- Bolts are preventing end cap from being blown off

$$A = \frac{\pi (30)^2}{4}$$

Given :

Find: Total force resisted by bolts

$$D = 30 \text{ in}$$

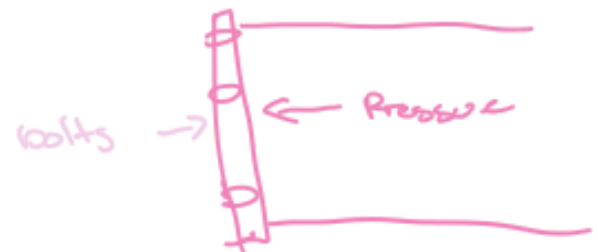
$$P = 23.6 \text{ psig}$$

Pressure force of end plate: $F = pA$

Area of end plate: $A = \frac{\pi D^2}{4}$

$$A = \frac{\pi (30)^2}{4} = 706.9 \text{ in}^2$$

$$F_{\text{bolts}} = (23.6 \frac{\text{lb}_f}{\text{in}^2}) (706.9 \text{ in}^2) = 16682 \text{ lb}_f$$



4.17 If the wall in Fig. P4.17 is 4 m long, calculate the total force on the wall due to the oil pressure. Also determine the location of the center of pressure and show the resultant force on the wall.

$$L = \frac{h}{\sin \theta} = \frac{1.4 \text{ m}}{\sin 45} = 1.98 \text{ m}$$

Area of plane:

$$A = bL = 4 \text{ m} (1.98) = 7.92 \text{ m}^2$$

Hydrostatic resultant

$$F = \rho g h_c A$$

$$h_c = \frac{h}{2} = \frac{1.4 \text{ m}}{2} = 0.7 \text{ m}$$

$$F = 860 \frac{\text{kg}}{\text{m}^3} \cdot 9.81 \frac{\text{m}}{\text{s}^2} \cdot 7.92 \text{ m}^2 \cdot 0.7 \text{ m}$$

$$F = 46772.5104 \approx 46.8 \text{ kN}$$

$$h_{cp} = h_c + \frac{I_G \sin^2 \theta}{A h_c}$$

$$I_G = \frac{bL^3}{12} = \frac{4(1.98)^3}{12} = 2.59 \text{ m}^4$$

$$h_{cp} = 0.7 + \frac{(2.59)(0.5)}{(7.92)(0.7)}$$

$$h_{cp} = 0.934 \text{ m} \quad \text{vertical depth to center}$$

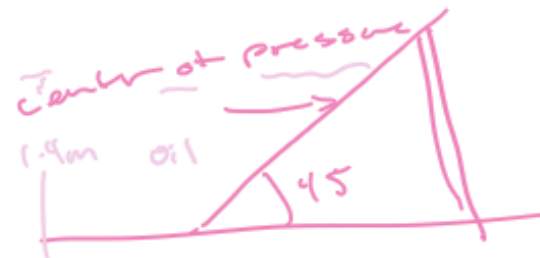
Wall length $b = 4 \text{ m}$

$$h = 1.4 \text{ m}$$

$$\rho = 860 \text{ kg/m}^3 \rightarrow P = 860 \text{ kg/m}^3$$

$$\theta = 45^\circ$$

$$g = 9.81 \text{ m/s}^2$$



$$L_p = \frac{h_{cp}}{\sin \theta} = \frac{0.934}{\sin 45} = 1.32 \text{ m}$$

4.38 For the oil tank shown in Fig. 4.23, compute the magnitude and location of the total force on each vertical end wall. The tank is 1.2 m long.

$$\gamma = 0.90(9.81) = 8.829 \text{ kN/m}^3$$

$$h = .6 + 0.6 + 0.3 = 1.5 \text{ m}$$

$$A = (1.2)(1.5) = 1.8 \text{ m}^2$$

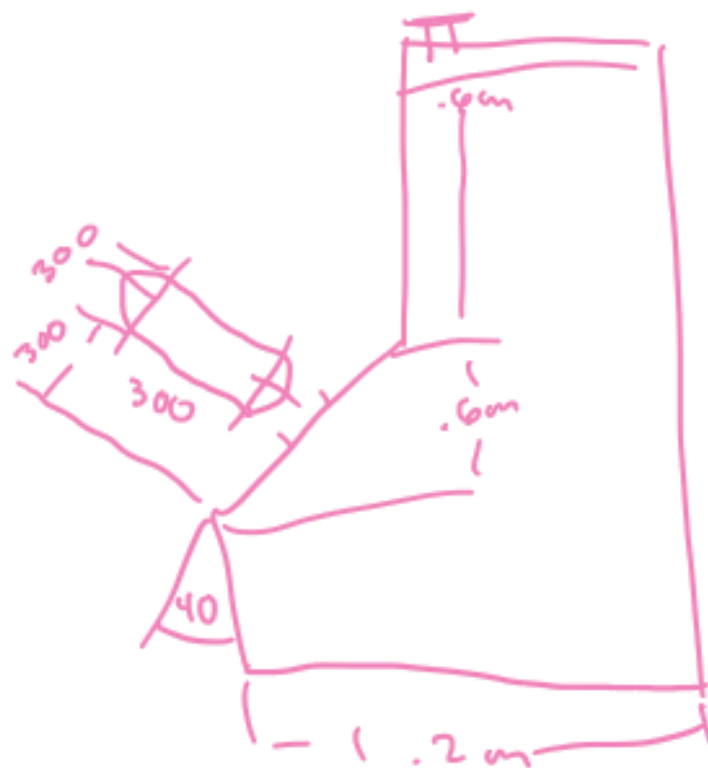
$$h_c = \frac{1.5}{2} = .75 \text{ m}$$

$$F = \gamma A h_c = 8.829(1.8)(0.75) = 11.92 \text{ kN}$$

$$h_{cp} = h_c + \frac{I_G}{A h_c}$$

$$I_G = \frac{bh^3}{12} = \frac{1.2(1.5^3)}{12} = .3375 \text{ m}^4$$

$$h_{cp} = .75 + \frac{0.3375}{1.8(0.75)} = 1.00 \text{ m}$$



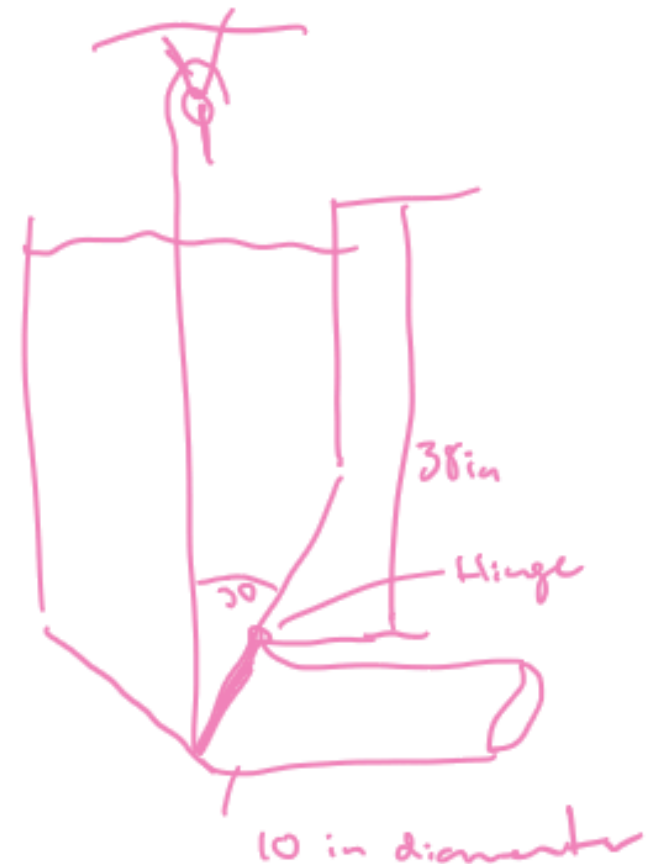
4.42 Figure P4.42 shows a tank of water with a circular pipe connected to its bottom. A circular gate seals the pipe opening to prohibit flow. To drain the tank, a winch is used to pull the gate open. Compute the amount of force that the winch cable must exert to open the gate.

$$\gamma = 62.416 / \text{ft}^3$$

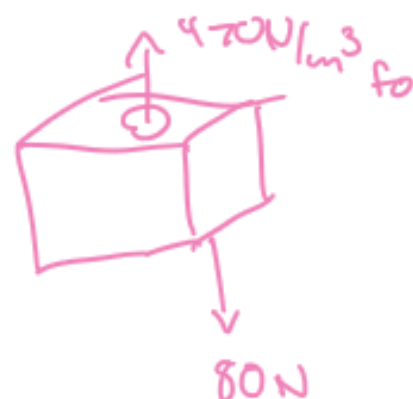
$$P = \gamma h = (62.4)(3.167) \approx 197.616 / \text{ft}^2$$

$$A = \frac{\pi D^2}{4} = \frac{\pi (.833)^2}{4} = .545 \text{ ft}^2$$

$$F = PA = (197.6)(0.545) = 107.716$$



5.8 A steel cube 100 mm on a side weighs 80 N. We want to hold the cube in equilibrium under water by attaching a light foam buoy to it. If the foam weighs 470 N/m^3 what is the minimum required volume of the buoy?



$$F_B = \gamma_{\text{water}} V \quad \Sigma F_y = 0$$

$$V_s = (0.1 \text{ m})^3 = 0.001 \text{ m}^3$$

$$F_{Bs} = \gamma_w V_s = (9810)(0.001) = 9.81 \text{ N}$$

$$80 - 9.81 = 70.19 \text{ N (Net downward)}$$

$$W_f = 470 V_f$$

$$B_f = 9810 V_f$$

$$B_f - W_f = (9810 - 470) V_f = 9340 V_f$$

$$9340 V_f = 70.19$$

$$V_f = \frac{70.19}{9340} = 0.00751 \text{ m}^3$$

$$V_f = 7.5 \times 10^{-3} \text{ m}^3$$

$$= 7.5 \text{ L}$$

5.24 A brass weight is to be attached to the bottom of the cylinder described in Problems 5.22 and 5.23, so that the cylinder will be completely submerged and neutrally buoyant in water at 95°C

The brass is to be a cylinder with the same diameter as the original cylinder as shown in Fig. P5.24. What is the required thickness of the brass?

The details of the loaded cylinder are as follows:

The cylinder is submerged completely in water. The water is at 95 degrees centigrade. The height of the cylinder excluding the load is 750 mm.

There is a brass plate at the bottom part of the cylinder labeled as γ_{brass} equals 84 kN per meter cubed. The height of this brass plate is labeled as t equals question mark.

$$H = 0.75 \text{ m}$$

$$D = 0.45 \text{ m}$$

$$\text{Sub height} = 0.60 \text{ m}$$

$$\text{exposed height} = 0.15 \text{ m}$$

$$W = B$$

$$\gamma_c V = \gamma_k V_{\text{sub}}$$

$$\gamma_c (0.75) = \gamma_k (0.60)$$

$$\gamma_k = 8.0 \text{ kN/m}^3$$

$$\gamma_c = \frac{0.60}{0.75} (8.0) = 6.4 \text{ kN/m}^3$$

$$\gamma_c = 6.4 \text{ kN/m}^3$$

$$\gamma_{\text{brass}} = 84 \text{ kN/m}^3$$

$$\gamma_w (95^\circ\text{C}) = 9.4 \text{ kN/m}^3$$

$$\text{Cylinder height} = 0.75 \text{ m}$$

$$t = \frac{0.75 (\gamma_w - \gamma_c)}{\gamma_{\text{brass}} - \gamma_w}$$

$$\gamma_w - \gamma_c = 9.4 - 6.4 = 3.0$$

$$0.75 \times 3.0 = 2.25$$

$$84 - 9.4 = 74.6$$

$$t = \frac{2.25}{74.6} = 0.0302 \text{ m} = 30 \text{ mm}$$



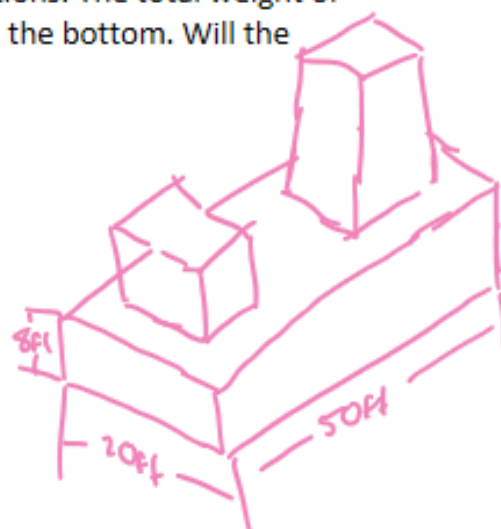
5.41 The large platform shown in Fig. P5.41 carries equipment and supplies to offshore installations. The total weight of the system is 450 000 lb, and its center of gravity is even with the top of the platform, 8 ft from the bottom. Will the platform be stable in seawater in the position shown?

The details of the raft are as follows:

The length of the raft is 50 feet. The breadth of the raft is 20 feet. The height is 8 feet.

There is a point in the middle of the raft labeled as c.g.

There are two blocks, one large and one small, placed on top of the raft.



$$W = \gamma_{sw} V$$

$$W = 450,000 \text{ lb}$$

$$\gamma_{sw} = 64 \frac{\text{lb}}{\text{ft}^3}$$

$$V = \frac{450,000}{64} = 7031.25 \text{ ft}^3$$

$$A = LB = 50 \times 20 = 1000 \text{ ft}^2$$

$$T = \frac{V}{A} = \frac{7031.25}{1000} = 7.031 \text{ ft}$$

$$y_B = \frac{T}{2}$$

$$y_B = \frac{7.031}{2} = 3.516 \text{ ft}$$

$$BM = \frac{I}{V}$$

$$I = \frac{LB^3}{12} = \frac{50(20^3)}{12} = 33333.3 \text{ ft}^4$$

$$BM = \frac{33333.3}{7031.25} = 4.741 \text{ ft}$$

$$y_m = y_B + BM = 3.516 + 4.741 = 8.257 \text{ ft}$$

$$y_G = 8.0 \text{ ft}$$

$$GM = y_m - y_G = 8.257 - 8.000$$

$$GM = 0.257 \text{ ft} \quad GM > 0 \text{ stable}$$

5.61 A boat is shown in Fig. P5.61. Its geometry at the water line is the same as the top surface. The hull is solid. Is the boat stable?

The details of the boat are as follows:

The boat has a length of 5.5 meters and a breadth of 2.4 meters. The part of the boat above the water surface has a height of 0.3 meters.

The part of the boat below the water surface has a height of 1.5 meters.

The bottom of the boat has a triangular tip. The height of the triangle alone is labeled as 0.6 meters.

$$A_t = \frac{1}{2}(2.4)(0.6) = 0.72 \text{ m}^2$$

$$A_r = (2.4)(0.9) = 2.16 \text{ m}^2$$

$$A = 0.72 + 2.16 = 2.88 \text{ m}^2$$

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

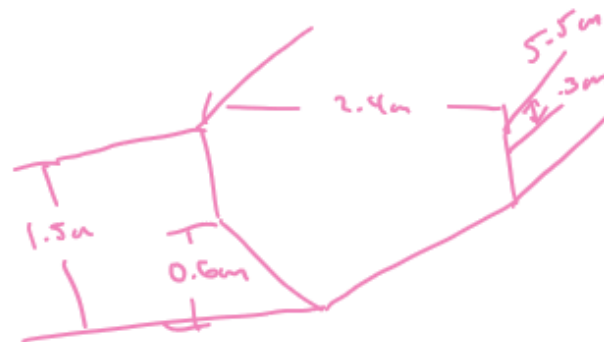
$$y_t = \frac{2}{3}(0.6) = 0.4 \text{ m}$$

$$y_r = 0.6 + \frac{0.9}{2} = 1.05 \text{ m}$$

$$y_b = \frac{A_t y_t + A_r y_r}{A_t + A_r}$$

$$= \frac{(0.72)(0.4) + (2.16)(1.05)}{2.88}$$

$$y_b = 0.888 \text{ m}$$



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

$$BM = \frac{I}{V} = \frac{6.336}{15.84} = 0.400 \text{ m}$$

$$y_m = y_b + BM$$

$$= 0.888 + 0.400 = 1.288 \text{ m}$$

$$GM = y_m - y_G > 0$$

Stable