(See Fluids in the News article titled "Giraffe's blood pressure," Section 2.3.1.) (a) Determine the change in hydrostatic pressure in a giraffe’s head as it lowers its head from eating leaves 6 m above the ground to getting a drink of water at ground level as shown in Fig. P2.11. Assume the specific gravity of blood is $SG = 1$. (b) Compare the pressure change calculated in part (a) to the normal 120 mm of mercury pressure in a human’s heart.

\[ \Delta p = \gamma \cdot h = \left( 9.80 \frac{\text{kg}}{\text{m}^2} \right)(6 \text{ m}) = 58.8 \frac{\text{N}}{\text{m}^2} = 58.8 \text{kPa} \]

(b) To compare with pressure in human heart:

\[ 58.8 \frac{\text{N}}{\text{m}^2} = \gamma_{\text{Hg}} \cdot h_{\text{Hg}} = \left( 133 \frac{\text{kN}}{\text{m}^2} \right) h_{\text{Hg}} \]

\[ h_{\text{Hg}} = \left( 0.442 \text{ m} \right) \left( 10^3 \frac{\text{mm}}{\text{m}} \right) = 442 \text{ mm Hg} \]

Thus, the pressure change in the giraffe’s head is 442 mm Hg compared with 120 mm Hg in the human heart.
Sample Problem 2

Hydrostatic Pressure \[ \frac{dp}{dz} = - \rho g \]

2' increases upwards
2' increases downwards \[ \int_{z}^{z_0} = -d\bar{z} = -dz \]

\[ \therefore \frac{dp}{dz} = \rho (1000 + 1.12) \]

\[ dp = (1000 \rho + 1.12g) \, dz \]

\[ p(z_2) = 1000 \rho z_2 + 1.12g \frac{z_2^2}{2} \]

\[ \rho = 10 \]

\[ p(z=0) = 0 \]

\[ \Rightarrow 10 \frac{4}{2} + 5.5 \frac{z^2}{2} \]

\[ @ \, z = 100 \Rightarrow 1055000 \text{ Pa} \]

\[ \approx 10 \text{ atmospheres} \]
2.26 For the inclined-tube manometer of Fig. P2.26 the pressure in pipe A is 0.8 psi. The fluid in both pipes A and B is water, and the gage fluid in the manometer has a specific gravity of 2.6. What is the pressure in pipe B corresponding to the differential reading shown?

\[ \frac{P_A}{\gamma_{h_2o} \left( \frac{g}{12 \text{ ft}} \right)} - \frac{\gamma_{gf} \left( \frac{g}{12 \text{ ft}} \right) \sin 30^\circ}{\gamma_{h_2o} \left( \frac{g}{12 \text{ ft}} \right)} = P_B \]

(where \( \gamma_{gf} \) is the specific weight of the gage fluid)

Thus,

\[ P_B = P_A - \frac{\gamma_{gf} \left( \frac{g}{12 \text{ ft}} \right) \sin 30^\circ}{\gamma_{h_2o} \left( \frac{g}{12 \text{ ft}} \right)} \]

\[ = (0.8 \frac{\text{lb}}{\text{in}^2})(144 \frac{\text{in}^2}{\text{ft}^2}) - (2.6)(62.4 \frac{\text{lb}}{\text{ft}^2}) \left( \frac{g}{12 \text{ ft}} \right)(0.5) = 0.424 \text{ psi} \]

2.27 The differential mercury manometer of Fig. P2.27 is connected to pipe A containing gasoline (SG = 0.65) and to pipe B containing water. Determine the differential reading, \( h \), corresponding to a pressure in A of 20 kPa and a vacuum of 150 mm Hg in B.

\[ \frac{P_A + \gamma_{gas}(0.3m + h)}{\gamma_{h_2o}h + \gamma_{h_2o}(0.3m + h)} = P_B \]

Thus,

\[ h = \frac{P_A - P_B + \gamma_{gas}(0.3m) + \gamma_{h_2o}(0.3m)}{\gamma_{h_2o} - \gamma_{gas} - \gamma_{h_2o}} \]

where \( P_B = -\gamma_{hg}(0.150\text{m}) \frac{\text{at}}{20} \text{ atm} \)

\[ h = \frac{20 \text{ kPa} - \left[ -\left(133 \frac{\text{kN}}{\text{m}^2}\right)(0.150\text{m}) \right] + (0.65)(4.81 \frac{\text{kN}}{\text{m}^2})(0.3\text{m}) + (9.80 \frac{\text{kN}}{\text{m}^2})(0.3\text{m})}{133 \frac{\text{kN}}{\text{m}^2} - (0.65)(4.81 \frac{\text{kN}}{\text{m}^2}) - 9.80 \frac{\text{kN}}{\text{m}^2}} \]

\[ = 0.384 \text{ m} \]

2.22
2.31 The U-shaped tube shown in Fig. P2.31 initially contains water only. A second liquid with specific weight $\gamma$, less than water is placed on top of the water with no mixing occurring. Can the height, $h$, of the second liquid be adjusted so that the left and right levels are at the same height? Provide proof of your answer.

The pressure at point (1) must be equal to the pressure at point (2) since the pressures at equal elevations in a continuous mass of fluid must be the same. Since,

$$P_1 = \gamma h$$

and

$$P_2 = \gamma_{H_2O} h$$

these two pressures can only be equal if $\gamma = \gamma_{H_2O}$. Since $\gamma \neq \gamma_{H_2O}$ the configuration shown in the figure is not possible. No.
2.43 A homogeneous, 4-ft-wide, 8-ft-long rectangular gate weighing 800 lb is held in place by a horizontal flexible cable as shown in Fig. P2.43. Water acts against the gate, which is hinged at point A. Friction in the hinge is negligible. Determine the tension in the cable.

\[ F_R = \gamma h_c A \quad \text{where} \quad h_c = \left(\frac{6\, \text{ft}}{12\, \text{ft}}\right) \sin 60^\circ \]

Thus,
\[ F_R = \left(62.4 \, \text{lb/ft}^3\right) \left(\frac{6\, \text{ft}}{12\, \text{ft}}\right) \left(8\, \text{ft}\times 4\, \text{ft}\right) \]
\[ = 3890 \, \text{lb} \]

To locate \( F_R \),
\[ y_R = \frac{I_x}{y_c A} + y_c \quad \text{where} \quad y_c = 3 \, \text{ft} \]

so that
\[ y_R = \frac{1}{12} (4\, \text{ft})(6\, \text{ft})^3 + 3 \, \text{ft} = 4.0 \, \text{ft} \]

For equilibrium,
\[ \sum M_H = 0 \]
and
\[ T (8\, \text{ft})(\sin 60^\circ) = 9W (4\, \text{ft})(\cos 60^\circ) + F_R (2\, \text{ft}) \]

\[ T = \frac{(800 \, \text{lb})(4\, \text{ft})(\cos 60^\circ) + (3890 \, \text{lb})(2\, \text{ft})}{(8\, \text{ft})(\sin 60^\circ)} \]
\[ = 1350 \, \text{lb} \]
2.47 Two square gates close two openings in a canal. (a) Two gates open at the same time. Determine the weight of each gate, \( W \), and the forces acting on the gates shown in Fig. P2.47.

When the water depth, \( h \), reaches 5 m, it is desired that both gates open at the same time. Determine the weight of the gate and the horizontal force, \( F \), acting on the gate.

\[ \text{For horizontal gate,} \]

\[ \Sigma M_H = 0 \]

\[ W \text{ at } A \text{ and } B = 5 \text{ m} \]

\[ \text{Thus, } W = \text{area of gate} \times \text{water pressure on the gate} \]

\[ \text{For vertical gate,} \]

\[ \Sigma F_y = 0 \]

\[ \text{Thus, } F = \text{area of gate} \times \text{water pressure on the gate} \]

You can also use

\[ y_R = \frac{2(y_R - y_{10})}{3(y_{10} - y_{11})} \]

with \( y_{10} = 5 \) and \( y_{11} = 9 \)
A 1-ft-diameter, 2-ft-long cylinder floats in an open tank containing a liquid having a specific weight $\gamma$. A U-tube manometer is connected to the tank as shown in Fig. P2.79. When the pressure in pipe $A$ is 0.1 psi below atmospheric pressure, the various fluid levels are as shown. Determine the weight of the cylinder. Note that the top of the cylinder is flush with the fluid surface.

From a free-body-diagram of the cylinder

$$\sum F_{\text{Vertical}} = 0$$

So that

$$W = F_B = \gamma \left( \frac{\pi}{4} \right)(1\text{ft})^2(2\text{ft}) = \frac{\pi \gamma}{2}$$

A manometer equation gives,

$$\gamma (3.5\text{ft}) - (\text{SG of H}_2\text{O})(2.5\text{ft}) - \delta_{\text{H}_2\text{O}}(1\text{ft}) = F_A$$

So that

$$\gamma (3.5\text{ft}) - (1.5)(22.4 \frac{\text{lb}}{\text{ft}^3})(2.5\text{ft}) - (62.4 \frac{\text{lb}}{\text{ft}^3})(1\text{ft}) = 0.1 \text{ in}^2(12\text{ lb})$$

and

$$\gamma = 80.6 \frac{\text{lb}}{\text{ft}^3}$$

Thus, from Eq. (1)

$$W = \left( \frac{\pi}{2} \frac{\text{ft}^3}{\text{lb}} \right)(80.6 \frac{\text{lb}}{\text{ft}^3}) = 127 \text{ lb}$$