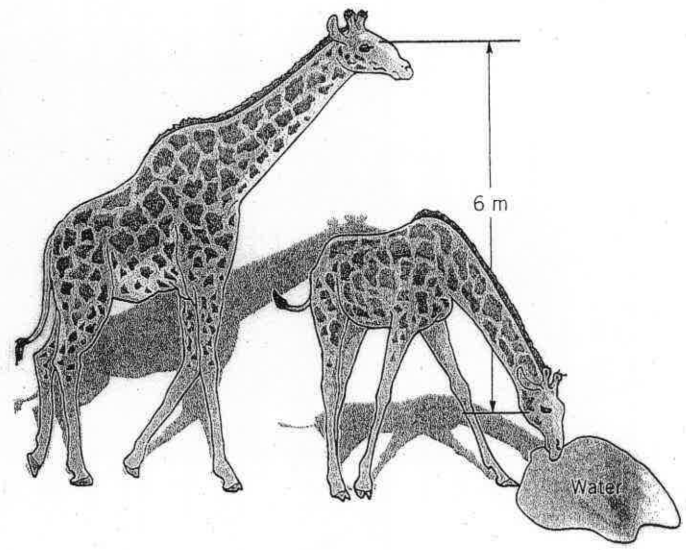
2.11

(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.



■ FIGURE P2.11

(a) For hydrostatic pressure change,

$$\Delta p = \gamma h = \left(9.80 \frac{kN}{m^2}\right)(6\,m) = 58.8 \frac{kN}{m^2} = \underline{\underline{58.8\,kPa}}$$

(b) To compare with pressure in human heart convert pressure in part (a) to mm Hg:

$$58.8 \frac{kN}{m^2} = \gamma_{Hg} h_{Hg} = \left(133 \frac{kN}{m^3}\right) h_{Hg}$$

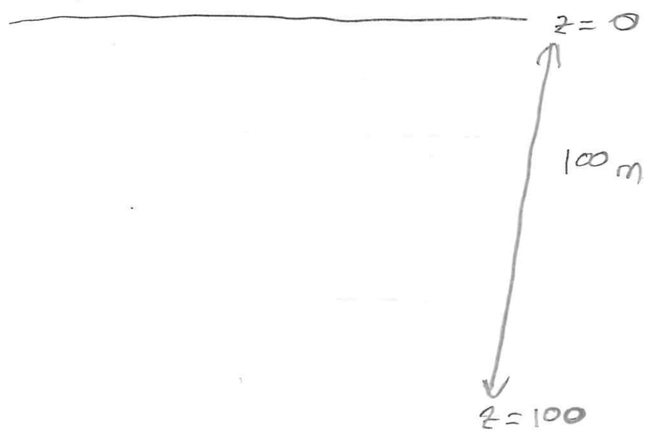
$$h_{Hg} = (0.442\,m)\left(10^3 \frac{mm}{m}\right) = 442\,mm\,Hg$$

Thus, the pressure change in the giraffes' head is $\underline{\underline{442\,mm\,Hg}}$ compared with $\underline{\underline{120\,mm\,Hg}}$ in the human heart.

11 br

Sample Problem 2

[redacted]



$$\rho(z) = 1000 + 1.1z$$

Hydrostatic Pressure $\dfrac{dp}{dz'} = -\rho g$

z' increases upwards, z increases downwards $\Big\} \Rightarrow dz' = -dz$

$$\therefore \frac{dp}{dz} = g(1000 + 1.1z)$$

$$dp = (1000g + 1.1zg)\, dz$$

$$p\Big]_{z=0}^{z=z} = 1000g\, z\Big|_0 + 1.1g \frac{z^2}{2}\Big|_0$$

$g = 10$

$p(z=0) = 0$

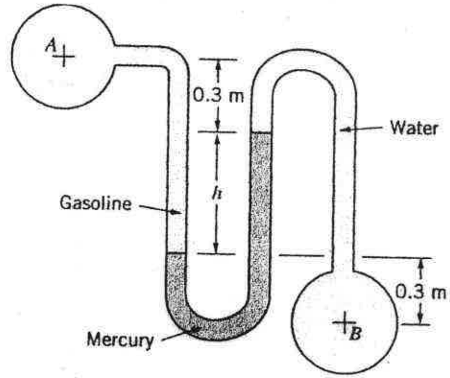
$$\Rightarrow 10^4 z + 5.5 z^2$$

@ $z = 100 \Rightarrow 1055000$ Pa

≈ 10 atmospheres

2.27

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.



■ FIGURE P2.27

$$p_A + \gamma_{gas}(0.3\,m + h) - \gamma_{Hg}\,h + \gamma_{H_2O}(0.3\,m + h) = p_B$$

Thus,

$$h = \frac{p_A - p_B + \gamma_{gas}(0.3\,m) + \gamma_{H_2O}(0.3\,m)}{\gamma_{Hg} - \gamma_{gas} - \gamma_{H_2O}}$$

where $p_B = -\gamma_{Hg}(0.150\,m)$, so that

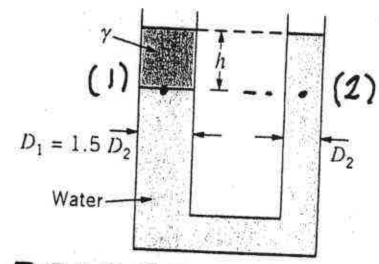
$$h = \frac{20\,kPa - \left[-\left(133\,\frac{kN}{m^3}\right)(0.150\,m)\right] + (0.65)\left(9.81\,\frac{kN}{m^3}\right)(0.3\,m) + \left(9.80\,\frac{kN}{m^3}\right)(0.3\,m)}{133\,\frac{kN}{m^3} - (0.65)\left(9.81\,\frac{kN}{m^3}\right) - 9.80\,\frac{kN}{m^3}}$$

$$= \underline{\underline{0.384\,m}}$$

27 br

2.31.

2.31 The U-shaped tube shown in Fig. P2.31 initially contains water only. A second liquid with specific weight, γ, 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.



■ FIGURE P2.31

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

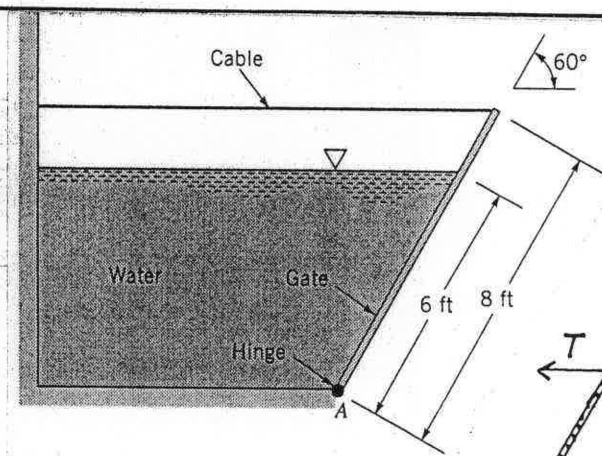
$$p_2 = \gamma_{H_2O} h$$

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. $\underline{\underline{\text{No.}}}$

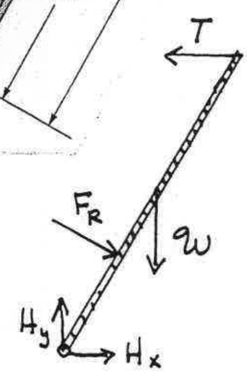
31 bi

2.43

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.



■ FIGURE P2.43



$F_R = \gamma h_c A \quad \text{where} \quad h_c = \left(\frac{6\,ft}{2}\right)\sin 60°$

Thus,

$F_R = \left(62.4\,\frac{lb}{ft^3}\right)\left(\frac{6\,ft}{2}\right)(\sin 60°)(6\,ft \times 4\,ft)$

$= 3890\ lb$

To locate F_R,

$y_R = \dfrac{I_{xc}}{y_c A} + y_c \quad \text{where} \quad y_c = 3\,ft$

so that

$y_R = \dfrac{\frac{1}{12}(4\,ft)(6\,ft)^3}{(3\,ft)(6\,ft \times 4\,ft)} + 3\,ft = 4.0\ ft$

```
You can also use
     2(yu^3-yl^3)
yR=  ------------
      3(yu^2-yl^2)
with yl=0 and yu=6
```

For equilibrium,

$\sum M_H = 0$

and

$T\,(8\,ft)(\sin 60°) = w\,(4\,ft)(\cos 60°) + F_R\,(2\,ft)$

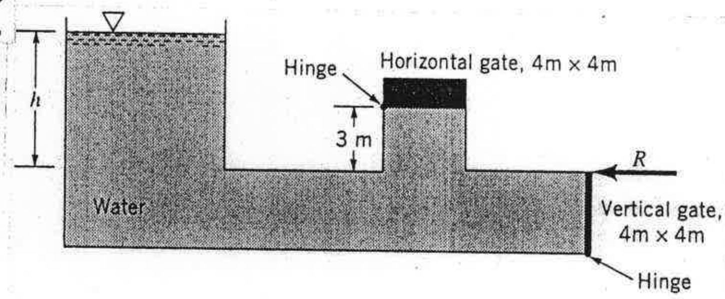
$T = \dfrac{(800\,lb)(4\,ft)(\cos 60°) + (3890\,lb)(2\,ft)}{(8\,ft)(\sin 60°)}$

$= \underline{\underline{1350\ lb}}$

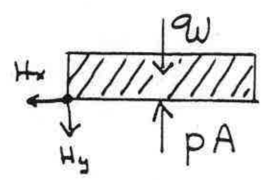
43 br

2.47

2.47 Two square gates close two openings in a conduit connected to an open tank of water as 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 homogeneous horizontal gate and the horizontal force, R, acting on the vertical gate that is required to keep the gates closed until this depth is reached. The weight of the vertical gate is negligible, and both gates are hinged at one end as shown. Friction in the hinges is negligible.



■ FIGURE P2.47



For horizontal gate,

$$\Sigma M_H = 0$$

so that

$$\mathcal{W} = pA$$ where p is the water pressure on the bottom surface.

Thus, $p = \gamma_{H_2O}(2m)$

so that

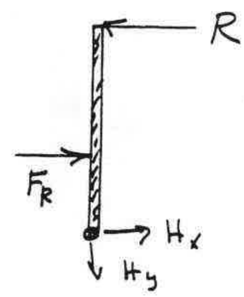
$$\mathcal{W} = \left(9800\frac{N}{m^3}\right)(2m)(4m \times 4m) = \underline{\underline{314\ kN}}$$

For vertical gate,

$F_R = \gamma h_c A$ where $h_c = 7m$

so that

$$F_R = \left(9800\frac{N}{m^3}\right)(7m)(4m \times 4m)$$
$$= 1100\ kN$$



To locate F_R

$$y_R = \frac{I_{xc}}{y_c A} + y_c = \frac{\frac{1}{12}(4m)(4m)^3}{(7m)(4m \times 4m)} + 7m = 7.191m$$

You can also use

```
      2(yu^3-yl^3)
yR=   ------------
       3(yu^2-yl^2)
with yl=5 and yu=9
```

For equilibrium

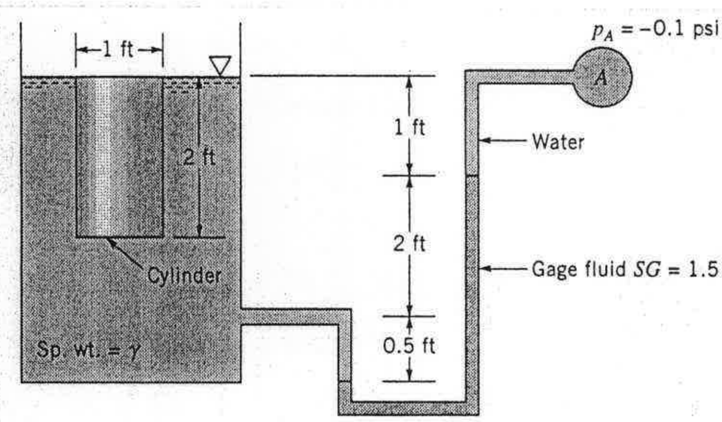
$\Sigma M_H = 0$ so that

$$R = \frac{(1100\ kN)(9m - 7.191m)}{4m} = \underline{\underline{497\ kN}}$$

47 br

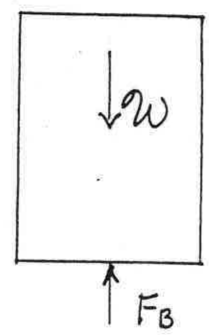
2.79

2.79 A 1-ft-diameter, 2-ft-long cylinder floats in an open tank containing a liquid having a specific weight γ. 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.



■ FIGURE P2.79

From a free-body-diagram of the cylinder



$$\sum F_{vertical} = 0$$

so that

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

$$= \frac{\pi\gamma}{2} \qquad (1)$$

A manometer equation gives,

$$\gamma(3.5\,ft) - (SG)(\gamma_{H_2O})(2.5\,ft) - \gamma_{H_2O}(1\,ft) = p_A$$

so that

$$\gamma(3.5\,ft) - (1.5)\left(62.4\,\frac{lb}{ft^3}\right)(2.5\,ft) - \left(62.4\,\frac{lb}{ft^3}\right)(1\,ft) = \left(-0.1\,\frac{lb}{in.^2}\right)\left(\frac{144\,in.^2}{ft^2}\right)$$

and

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

Thus, from Eq. (1)

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

79 br