2.93

2.93 A closed tank is filled with water and has a 4-ft-diameter hemispherical dome as shown in Fig. P2.93 A U-tube manometer is connected to the tank. Determine the vertical force of the water on the dome if the differential manometer reading is 7 ft and the air pressure at the upper end of the manometer is 12.6 psi.

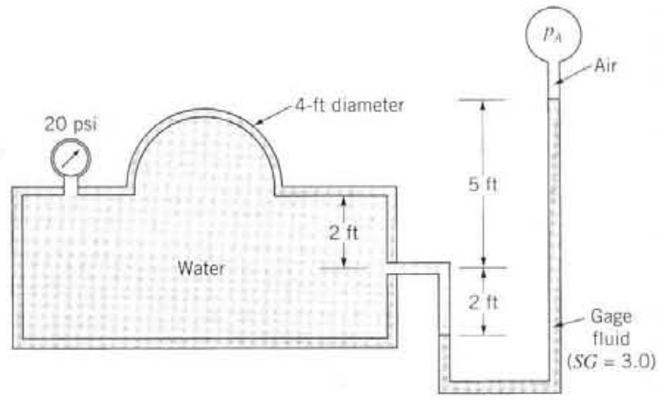
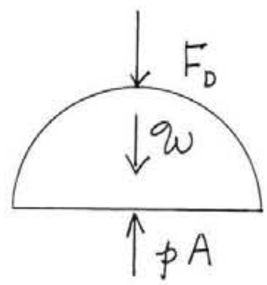


FIGURE P2.93



For equilibrium,

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

so that

$$F_D = pA - W \qquad (1)$$

where F_D is the force the dome exerts on the fluid and p is the water pressure at the base of the dome.

From the manometer,

$$p_A + \gamma_{gf}(7\,ft) - \gamma_{H_2O}(4\,ft) = p$$

so that

$$p = \left(12.6 \frac{lb}{in.^2}\right)\left(144 \frac{in.^2}{ft^2}\right) + (3.0)\left(62.4 \frac{lb}{ft^3}\right)(7\,ft) - \left(62.4 \frac{lb}{ft^3}\right)(4\,ft)$$

$$= 2880 \frac{lb}{ft^2}$$

Thus, from Eq. (1) with volume of sphere $= \frac{\pi}{6}(\text{diameter})^3$

$$F_D = \left(2880 \frac{lb}{ft^2}\right)\left(\frac{\pi}{4}\right)(4\,ft)^2 - \frac{1}{2}\left[\frac{\pi}{6}(4\,ft)^3\right]\left(62.4 \frac{lb}{ft^3}\right)$$

$$= 35{,}100\ lb$$

The force that the vertical force that the water exerts on the dome is 35,100 lb ↑.