PROBLEM 1.44

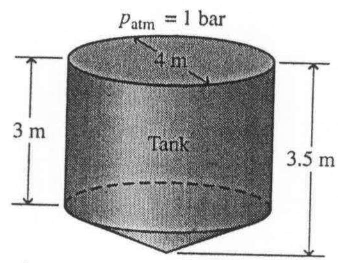

Fig. P1.44

(a) The depth at the center of the cistern is 3.5 m and the corresponding pressure at the center (p_c) in kPa is as follows

$$p_c = p_{atm} + \rho g h = 1\ \text{bar}\left|\frac{100\ \text{kPa}}{1\ \text{bar}}\right| + (987.1\ \frac{\text{kg}}{\text{m}^3})(9.8\ \frac{\text{m}}{\text{s}^2})(3.5\ \text{m})\left|\frac{1\ \text{N}}{1\frac{\text{kg}\cdot\text{m}}{\text{s}^2}}\right|\left|\frac{1\ \text{kPa}}{10^3\ \frac{\text{N}}{\text{m}^2}}\right| =$$

$$p_c = 100\ \text{kPa} + 33.9\ \text{kPa} = 133.9\ \text{kPa}$$

(b) The force acting on the bottom (F_{tot}) of the tank is the sum of the weight of the water plus the force of the atmosphere. The force of the atmosphere (F_{atm}) in kN is

$$F_{atm} = p_{atm}\pi\frac{D^2}{4} = 1\ \text{bar}\left|\frac{10^5\ \frac{\text{N}}{\text{m}^2}}{1\ \text{bar}}\right|\pi\frac{(4\text{m})^2}{4}\left|\frac{1\ \text{kN}}{10^3\ \text{N}}\right| = 12.6\times10^2\,\text{kN}$$

The weight of the water is given by

$$m_w g = \rho V g \qquad (1)$$

where ρ is the density of the water and g is the acceleration of gravity which were both given. The total volume of the water in the tank (V) is equal to the volume of a cylinder having a diameter, $D = 4$ m and a length, $L = 3$ m plus the volume of a cone having $D = 4$ m and a height, $H = 0.5$ m. Thus,

$$V = V_{cyl} + V_{cone} = \pi L\left(\frac{D^2}{4}\right) + \left(\frac{1}{3}\right)\pi H\left(\frac{D^2}{4}\right) = \pi\left(\frac{D^2}{4}\right)\left(L + \frac{H}{3}\right) = \pi(4\ \text{m}^2)\left(3 + \frac{0.5}{3}\right)\text{m} = 39.8\ \text{m}^3$$

Substituting values into Eq. (1)

$$\rho g V = 987.1\frac{\text{kg}}{\text{m}^3}\left(9.8\frac{\text{m}}{\text{s}^2}\right)(39.8\ \text{m}^3)\left|\frac{1\ \text{N}}{1\frac{\text{kg}\cdot\text{m}}{\text{s}^2}}\right|\left|\frac{1\ \text{kN}}{10^3\,\text{N}}\right| = 3.85\times10^2\ \text{kN}$$

Finally, the total force acting on the bottom of the tank is

$$F_{tot} = \text{weight} + F_{atm} = 3.85\times10^2\,\text{kN} + 12.6\times10^2\,\text{kN} = 16.5\times10^2\,\text{kN}$$