Solutions for Sections 2.1 – 2.4.2

1. The force shown is partially due to a pressure acting uniformly over the area of 100 cm^2. The pressure is nearest:

(D) 346 kPa

The pressure is due to the normal component of the force acting on the area. We have

$$p = \frac{F}{A} = \frac{4000\ \text{N}\cos 30°}{100\times 10^{-4}\ \text{m}^2} = 346\,000\ \text{N/m}^2 \quad \text{or} \quad \underline{346\ \text{kPa}}$$

2. The pressure on the lower surface of the cylinder is 20 kPa. If the variation of pressure in the vertical direction is given by $\partial p/\partial z = -2400$ Pa/m, the pressure on the upper surface is nearest:

(A) 19.52 kPa

Because the variation is constant, the change in pressure can be written as

$$\Delta p = \frac{\partial p}{\partial z}\Delta z = -2400\ \text{Pa/m}\times 0.2\ \text{m} = -480\ \text{Pa}. \quad \therefore p_{\text{upper}} = 20 - 0.48 = \underline{19.52\ \text{kPa}}$$

3. A water-well driller measures the water level in a well to be 20 ft below the surface. The point on the well is 250 ft below the surface. The pressure at the point is estimated to be:

(C) 688 kPa

Using Eq. 2.4.4, the pressure is

$$p = \gamma h = 9810\ \text{N/m}^3 \times (250-20)\ \text{ft}\times 0.3048\ \text{m/ft} = 688\,000\ \text{N/m}^2 \quad \text{or} \quad \underline{688\ \text{kPa}}$$

Or, we could use English units as follows:

$$p = \gamma h = 62.4\times(250-20) = 14{,}350\ \text{lb/ft}^2. \quad \text{Then,} \quad \frac{14{,}350\times 101.3}{14.7\times 144} = \underline{685\ \text{kPa}}$$

The difference between the two numbers is due to the accuracy of the numbers used: 14.7, 9810, 62.4, and 101.3.

4. To calculate the pressure in the standard atmosphere at 6000 m, the lapse rate is used (see Eq. 2.4.8). The percentage error, considering the pressure from Table B.3 in the Appendix to be more accurate, is nearest:

(B) 0.13 %

Equation 2.4.8 yields

$$p = p_{\text{atm}}\left(\frac{T_0 - \alpha z}{T_0}\right)^{g/\alpha R} = 101.3\left(\frac{288.2 - 0.0065\times 6000}{288.2}\right)^{9.81/0.0065\times 287} = 47.15 \text{ kPa}$$

$$\% \text{ error} = \frac{47.21 - 47.15}{47.21}\times 100 = \underline{0.13\ \%}$$