Chapter 14

2. The magnitude F of the force required to pull the lid off is $F = (p_o - p_i)A$, where p_o is the pressure outside the box, p_i is the pressure inside, and A is the area of the lid. Recalling that 1N/m^2 = 1 Pa, we obtain

$$p_i = p_o - \frac{F}{A} = 1.0\times10^5 \text{ Pa} - \frac{480 \text{ N}}{77\times10^{-4} \text{ m}^2} = 3.8\times10^4 \text{ Pa}.$$

5. The pressure difference between two sides of the window results in a net force acting on the window.

The air inside pushes outward with a force given by p_iA, where p_i is the pressure inside the room and A is the area of the window. Similarly, the air on the outside pushes inward with a force given by p_oA, where p_o is the pressure outside. The magnitude of the net force is $F = (p_i - p_o)A$. With 1 atm = 1.013×10^5 Pa, the net force is

$$\begin{aligned} F &= (p_i - p_o)A = (1.0 \text{ atm} - 0.96 \text{ atm})(1.013\times10^5 \text{ Pa/atm})(3.4 \text{ m})(2.1 \text{ m}) \\ &= 2.9\times10^4 \text{ N}. \end{aligned}$$

6. Knowing the standard air pressure value in several units allows us to set up a variety of conversion factors:

(a) $P = \left(28 \text{ lb/in.}^2\right)\left(\dfrac{1.01\times10^5 \text{ Pa}}{14.7 \text{ lb/in}^2}\right) = 190 \text{ kPa}$.

(b) $(120 \text{ mmHg})\left(\dfrac{1.01\times10^5 \text{Pa}}{760 \text{ mmHg}}\right) = 15.9 \text{ kPa}$, $\quad (80 \text{ mmHg})\left(\dfrac{1.01\times10^5 \text{ Pa}}{760 \text{ mmHg}}\right) = 10.6 \text{ kPa}$.

11. The hydrostatic blood pressure is the gauge pressure in the column of blood between feet and brain. We calculate the gauge pressure using Eq. 14-7.

(a) The gauge pressure at the brain of the giraffe is

$$\begin{aligned} p_{\text{brain}} &= p_{\text{heart}} - \rho g h = 250 \text{ torr} - (1.06\times10^3 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(2.0 \text{ m})\frac{1 \text{ torr}}{133.33 \text{ Pa}}. \\ &= 94 \text{ torr}\ . \end{aligned}$$

(b) The gauge pressure at the feet of the giraffe is

$$p_{\text{feet}} = p_{\text{heart}} + \rho g h = 250 \text{ torr} + (1.06\times10^3 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(2.0 \text{ m})\frac{1 \text{ torr}}{133.33 \text{ Pa}} = 406 \text{ torr}$$
$$\approx 4.1\times10^2 \text{ torr.}$$

(c) The increase in the blood pressure at the brain as the giraffe lowers its head to the level of its feet is

$$\Delta p = p_{\text{feet}} - p_{\text{brain}} = 406 \text{ torr} - 94 \text{ torr} = 312 \text{ torr} \approx 3.1\times10^2 \text{ torr.}$$

17. The pressure p at the depth d of the hatch cover is $p_0 + \rho g d$, where ρ is the density of ocean water and p_0 is atmospheric pressure. Thus, the gauge pressure is $p_{\text{gauge}} = \rho g d$, and the minimum force that must be applied by the crew to open the hatch has magnitude $F = p_{\text{gauge}} A = (\rho g d)A$, where A is the area of the hatch.

Substituting the values given, we find the force to be

$$F = p_{\text{gauge}} A = (\rho g d)A = (1024 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(100 \text{ m})(1.2 \text{ m})(0.60 \text{ m})$$
$$= 7.2\times10^5 \text{ N.}$$

35. The problem intends for the children to be completely above water. The total downward pull of gravity on the system is

$$3(356 \text{ N}) + N\rho_{\text{wood}} g V$$

where N is the (minimum) number of logs needed to keep them afloat and V is the volume of each log:

$$V = \pi(0.15 \text{ m})^2 (1.80 \text{ m}) = 0.13 \text{ m}^3.$$

The buoyant force is $F_b = \rho_{\text{water}} g V_{\text{submerged}}$, where we require $V_{\text{submerged}} \le NV$. The density of water is 1000 kg/m^3. To obtain the minimum value of N, we set $V_{\text{submerged}} = NV$ and then round our "answer" for N up to the nearest integer:

$$3(356 \text{ N}) + N\rho_{\text{wood}} g V = \rho_{\text{water}} g N V \implies N = \frac{3(356 \text{ N})}{gV(\rho_{\text{water}} - \rho_{\text{wood}})}$$

which yields $N = 4.28 \to 5$ logs.

37. For our estimate of $V_{\text{submerged}}$ we interpret "almost completely submerged" to mean

$$V_{\text{submerged}} \approx \frac{4}{3}\pi r_o^3 \quad \text{where } r_o = 60 \text{ cm}.$$

Thus, equilibrium of forces (on the iron sphere) leads to

$$F_b = m_{\text{iron}} g \implies \rho_{\text{water}} g V_{\text{submerged}} = \rho_{\text{iron}} g \left(\frac{4}{3}\pi r_o^3 - \frac{4}{3}\pi r_i^3\right)$$

where r_i is the inner radius (half the inner diameter). Plugging in our estimate for $V_{\text{submerged}}$ as well as the densities of water (1.0 g/cm^3) and iron (7.87 g/cm^3), we obtain the inner diameter:

$$2r_i = 2r_o \left(1 - \frac{1.0\ \text{g/cm}^3}{7.87\ \text{g/cm}^3}\right)^{1/3} = 57.3\ \text{cm}.$$

41. Let V_i be the total volume of the iceberg. The non-visible portion is below water, and thus the volume of this portion is equal to the volume V_f of the fluid displaced by the iceberg. The fraction of the iceberg that is visible is

$$\text{frac} = \frac{V_i - V_f}{V_i} = 1 - \frac{V_f}{V_i}.$$

Since iceberg is floating, Eq. 14-18 applies:

$$F_g = m_i g = m_f g \quad \Rightarrow \quad m_i = m_f.$$

Since $m = \rho V$, the above equation implies

$$\rho_i V_i = \rho_f V_f \quad \Rightarrow \quad \frac{V_f}{V_i} = \frac{\rho_i}{\rho_f}.$$

Thus, the visible fraction is

$$\text{frac} = 1 - \frac{V_f}{V_i} = 1 - \frac{\rho_i}{\rho_f}.$$

(a) If the iceberg ($\rho_i = 917\ \text{kg/m}^3$) floats in salt water with $\rho_f = 1024\ \text{kg/m}^3$, then the fraction would be

$$\text{frac} = 1 - \frac{\rho_i}{\rho_f} = 1 - \frac{917\ \text{kg/m}^3}{1024\ \text{kg/m}^3} = 0.10 = 10\%.$$

(b) On the other hand, if the iceberg floats in fresh water ($\rho_f = 1000\ \text{kg/m}^3$), then the fraction would be

$$\text{frac} = 1 - \frac{\rho_i}{\rho_f} = 1 - \frac{917\ \text{kg/m}^3}{1000\ \text{kg/m}^3} = 0.083 = 8.3\%.$$