Workshop week 8

3. ***REASONING AND SOLUTION*** The weight of the gold is $W = Mg = \rho Vg$. Therefore,

$$W = (19\ 300\ \text{kg/m}^3)(0.30\ \text{m})(0.30\ \text{m})(0.20\ \text{m})(9.80\ \text{m/s}^2) = \boxed{3400\ \text{N}}$$

Since 1 N = 0.225 lb, W = (3400 N)[(0.225 lb)/(1 N)] = 760 lb. In other words, the movie pirate would have to be capable of carrying a 760-lb chest.

9. **SSM** **WWW** ***REASONING*** The total mass of the solution is the sum of the masses of its constituents. Therefore,

$$\rho_s V_s = \rho_w V_w + \rho_g V_g \tag{1}$$

where the subscripts s, w, and g refer to the solution, the water, and the ethylene glycol, respectively. The volume of the water can be written as $V_w = V_s - V_g$. Making this substitution for V_w, Equation (1) above can be rearranged to give

$$\frac{V_g}{V_s} = \frac{\rho_s - \rho_w}{\rho_g - \rho_w} \tag{2}$$

Equation (2) can be used to calculate the relative volume of ethylene glycol in the solution.

SOLUTION The density of ethylene glycol is given in the problem. The density of water is given in Table 11.1 as $1.000 \times 10^3\ \text{kg/m}^3$. The specific gravity of the solution is given as 1.0730. Therefore, the density of the solution is

$$\rho_s = (\text{specific gravity of solution}) \times \rho_w$$

$$= (1.0730)(1.000 \times 10^3\ \text{kg/m}^3) = 1.0730 \times 10^3\ \text{kg/m}^3$$

Substituting the values for the densities into Equation (2), we obtain

$$\frac{V_g}{V_s} = \frac{\rho_s - \rho_w}{\rho_g - \rho_w} = \frac{1.0730 \times 10^3\ \text{kg/m}^3 - 1.000 \times 10^3\ \text{kg/m}^3}{1116\ \text{kg/m}^3 - 1.000 \times 10^3\ \text{kg/m}^3} = 0.63$$

Therefore, the volume percentage of ethylene glycol is $\boxed{63\%}$.

19. SSM ***REASONING AND SOLUTION*** Using Equation 11.4, we have

$$P_{\text{heart}} - P_{\text{brain}} = \rho g h = (1.000 \times 10^3 \text{ kg/m}^3)(9.80 \text{ m/s}^2)(12 \text{ m}) = \boxed{1.2 \times 10^5 \text{ Pa}}$$

21. ***REASONING*** The magnitude of the force that would be exerted on the window is given by Equation 11.3, $F = PA$, where the pressure can be found from Equation 11.4: $P_2 = P_1 + \rho g h$. Since P_1 represents the pressure at the surface of the water, it is equal to atmospheric pressure, P_{atm}. Therefore, the magnitude of the force is given by

$$F = (P_{\text{atm}} + \rho g h)\, A$$

where, if we assume that the window is circular with radius *r*, its area *A* is given by $A = \pi r^2$.

SOLUTION
a. Thus, the magnitude of the force is

$$F = \left[1.013 \times 10^5 \text{ Pa} + (1025 \text{ kg/m}^3)(9.80 \text{ m/s}^2)(11\,000 \text{ m})\right] \pi (0.10 \text{ m})^2 = \boxed{3.5 \times 10^6 \text{ N}}$$

b. The weight of a jetliner whose mass is 1.2×10^5 kg is

$$W = mg = (1.2 \times 10^5 \text{ kg})(9.80 \text{ m/s}^2) = \boxed{1.2 \times 10^6 \text{ N}}$$

Therefore, the force exerted on the window at a depth of 11 000 m is about three times greater than the weight of a jetliner!

23. SSM ***REASONING AND SOLUTION***

a. The pressure at the level of house A is given by Equation 11.4 as $P = P_{\text{atm}} + \rho g h$. Now the height *h* consists of the 15.0 m and the diameter *d* of the tank. We first calculate the radius of the tank, from which we can infer *d*. Since the tank is spherical, its full mass is given by $M = \rho V = \rho[(4/3)\pi r^3]$. Therefore,

$$r^3 = \frac{3M}{4\pi\rho} \quad \text{or} \quad r = \left(\frac{3M}{4\pi\rho}\right)^{1/3} = \left[\frac{3(5.25\times10^5\,\text{kg})}{4\pi(1.000\times10^3\,\text{kg/m}^3)}\right]^{1/3} = 5.00\ \text{m}$$

Therefore, the diameter of the tank is 10.0 m, and the height h is given by

$$h = 10.0\ \text{m} + 15.0\ \text{m} = 25.0\ \text{m}$$

According to Equation 11.4, the gauge pressure in house A is, therefore,

$$P - P_{\text{atm}} = \rho g h = (1.000\times10^3\ \text{kg/m}^3)(9.80\ \text{m/s}^2)(25.0\ \text{m}) = \boxed{2.45\times10^5\ \text{Pa}}$$

b. The pressure at house B is $P = P_{\text{atm}} + \rho g h$, where

$$h = 15.0\ \text{m} + 10.0\ \text{m} - 7.30\ \text{m} = 17.7\ \text{m}$$

According to Equation 11.4, the gauge pressure in house B is

$$P - P_{\text{atm}} = \rho g h = (1.000\times10^3\ \text{kg/m}^3)(9.80\ \text{m/s}^2)(17.7\ \text{m}) = \boxed{1.73\times10^5\ \text{Pa}}$$

25. ***REASONING AND SOLUTION*** The pump must generate an upward force to counteract the weight of the column of water above it. Therefore, $F = mg = (\rho hA)g$. The required pressure is then

$$P = F/A = \rho g h = (1.00\times10^3\ \text{kg/m}^3)(9.80\ \text{m/s}^2)(71\ \text{m}) = \boxed{7.0\times10^5\ \text{Pa}}$$

40. ***REASONING AND SOLUTION*** The upward buoyant force of the water on the iceberg must equal the weight of the iceberg if it floats, $F_B = W$, so that $\rho_W g V = \rho_i g V_i$. Now

$$V/V_i = \rho_i/\rho_W = (917\ \text{kg/m}^3)/(1025\ \text{kg/m}^3) = 0.895$$

The percent of the volume of the iceberg which is submerged is $\boxed{89.5\%}$.

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47. **SSM** ***REASONING*** The height of the cylinder that is in the oil is given by $h_{\text{oil}} = V_{\text{oil}} / (\pi r^2)$, where V_{oil} is the volume of oil displaced by the cylinder and r is the radius of the cylinder. We must, therefore, find the volume of oil displaced by the cylinder. After the oil is poured in, the buoyant force that acts on the cylinder is equal to the sum of the weight of the water displaced by the cylinder and the weight of the oil displaced by the cylinder. Therefore, the magnitude of the buoyant force is given by $F = \rho_{\text{water}} g V_{\text{water}} + \rho_{\text{oil}} g V_{\text{oil}}$. Since the cylinder floats in the fluid, the net force that acts on the cylinder must be zero. Therefore, the buoyant force that supports the cylinder must be equal to the weight of the cylinder, or

$$\rho_{\text{water}} g V_{\text{water}} + \rho_{\text{oil}} g V_{\text{oil}} = mg$$

where m is the mass of the cylinder. Substituting values into the expression above leads to

$$V_{\text{water}} + (0.725) V_{\text{oil}} = 7.00 \times 10^{-3} \text{ m}^3 \qquad (1)$$

From the figure in the text, $V_{\text{cylinder}} = V_{\text{water}} + V_{\text{oil}}$. Substituting values into the expression for V_{cylinder} gives

$$V_{\text{water}} + V_{\text{oil}} = 8.48 \times 10^{-3} \text{ m}^3 \qquad (2)$$

Subtracting Equation (1) from Equation (2) yields $V_{\text{oil}} = 5.38 \times 10^{-3} \text{ m}^3$.

SOLUTION The height of the cylinder that is in the oil is, therefore,

$$h_{\text{oil}} = \frac{V_{\text{oil}}}{\pi r^2} = \frac{5.38 \times 10^{-3} \text{ m}^3}{\pi (0.150 \text{ m})^2} = \boxed{7.6 \times 10^{-2} \text{ m}}$$
