CHAPTER 13: Fluids

5. To find the specific gravity of the fluid, take the ratio of the density of the fluid to that of water, noting that the same volume is used for both liquids.

$$SJ_{\text{fluid}} = \frac{\rho_{\text{fluid}}}{\rho_{\text{water}}} = \frac{\left(m/V\right)_{\text{fluid}}}{\left(m/V\right)_{\text{water}}} = \frac{m_{\text{fluid}}}{m_{\text{water}}} = \frac{89.22\,\text{g} - 35.00\,\text{g}}{98.44\,\text{g} - 35.00\,\text{g}} = \boxed{0.8547}$$

6. The specific gravity of the mixture is the ratio of the density of the mixture to that of water. To find the density of the mixture, the mass of antifreeze and the mass of water must be known.

$$m_{\text{antifreeze}} = \rho_{\text{antifreeze}} V_{\text{antifreeze}} = SG_{\text{antifreeze}} \rho_{\text{water}} V_{\text{antifreeze}} \qquad m_{\text{water}} = \rho_{\text{water}} V_{\text{water}}$$

$$SG_{\text{mixture}} = \frac{\rho_{\text{mixture}}}{\rho_{\text{water}}} = \frac{m_{\text{mixture}}/V_{\text{mixture}}}{\rho_{\text{water}}} = \frac{m_{\text{antifreeze}} + m_{\text{water}}}{\rho_{\text{water}} V_{\text{mixture}}} = \frac{SG_{\text{antifreeze}} \rho_{\text{water}} V_{\text{antifreeze}} + \rho_{\text{water}} V_{\text{water}}}{\rho_{\text{water}} V_{\text{mixture}}}$$

$$= \frac{SG_{\text{antifreeze}} V_{\text{antifreeze}} + V_{\text{water}}}{V_{\text{mixture}}} = \frac{(0.80)(5.0\text{ L}) + 4.0\text{ L}}{9.0\text{ L}} = \boxed{0.89}$$

8. The pressure is given by Eq. 13-3.

$$P = \rho g h = (1000)\left(9.80\,\text{m/s}^2\right)(35\,\text{m}) = \boxed{3.4 \times 10^5\ \text{N/m}^2} \approx 3.4\,\text{atm}$$

12. The pressure difference on the lungs is the pressure change from the depth of water.

$$\Delta P = \rho g \Delta h \quad \rightarrow \quad \Delta h = \frac{\Delta P}{\rho g} = \frac{(85\,\text{mm-Hg})\left(\frac{133\,\text{N/m}^2}{1\text{ mm-Hg}}\right)}{\left(1.00 \times 10^3\ \text{kg/m}^3\right)\left(9.80\,\text{m/s}^2\right)} = 1.154\,\text{m} \approx \boxed{1.2\,\text{m}}$$

$\boxed{13.}$ The force exerted by the gauge pressure will be equal to the weight of the vehicle.

$$mg = PA = P\left(\pi r^2\right) \quad \rightarrow$$

$$m = \frac{P\pi r^2}{g} = \frac{(17.0\,\text{atm})\left(\frac{1.013 \times 10^5\ \text{N/m}^2}{1\text{ atm}}\right)\pi\left[\tfrac{1}{2}(0.225\,\text{m})\right]^2}{\left(9.80\,\text{m/s}^2\right)} = \boxed{6990\,\text{kg}}$$

15. (*a*) The absolute pressure is given by Eq. 13-6b, and the total force is the absolute pressure times the area of the bottom of the pool.

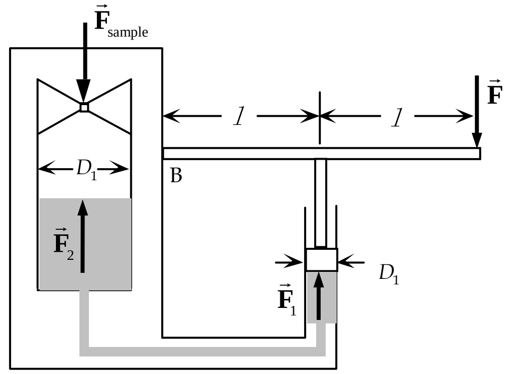
$$P = P_0 + \rho g h = 1.013 \times 10^5\ \text{N/m}^2 + \left(1.00 \times 10^3\ \text{kg/m}^3\right)\left(9.80\,\text{m/s}^2\right)(1.8\,\text{m})$$

$$= 1.189 \times 10^5\ \text{N/m}^2 \approx \boxed{1.2 \times 10^5\ \text{N/m}^2}$$

$$F = PA = \left(1.189 \times 10^5\ \text{N/m}^2\right)(28.0\,\text{m})(8.5\,\text{m}) = \boxed{2.8 \times 10^7\,\text{N}}$$

(*b*) The pressure against the side of the pool, near the bottom, will be the same as the pressure at the bottom. Pressure is not directional. $P = \boxed{1.2 \times 10^5\ \text{N/m}^2}$

20. Consider the lever (handle) of the press. The net torque on that handle is 0. Use that to find the force exerted by the hydraulic fluid upwards on the small cylinder (and the lever). Then Pascal's principle can be used to find the upwards force on the large cylinder, which is the same as the force on the sample.



$$\sum \tau = F(2l) - F_1 l = 0 \quad \rightarrow \quad F_1 = 2F$$

$$P_1 = P_2 \quad \rightarrow \quad \frac{F_1}{\pi\left(\frac{1}{2}d_1\right)^2} = \frac{F_2}{\pi\left(\frac{1}{2}d_2\right)^2} \quad \rightarrow$$

$$F_2 = F_1\left(d_2/d_1\right)^2 = 2F\left(d_2/d_1\right)^2 = F_{\text{sample}} \quad \rightarrow$$

$$P_{\text{sample}} = \frac{F_{\text{sample}}}{A_{\text{sample}}} = \frac{2F\left(d_2/d_1\right)^2}{A_{\text{sample}}} = \frac{2(350\,\text{N})(5)^2}{4.0\times10^{-4}\,\text{m}^2} = \boxed{4.4\times10^7\,\text{N/m}^2} \approx 430\,\text{atm}$$

27. The difference in the actual mass and the apparent mass is the mass of the water displaced by the rock. The mass of the water displaced is the volume of the rock times the density of water, and the volume of the rock is the mass of the rock divided by its density. Combining these relationships yields an expression for the density of the rock.

$$m_{\text{actual}} - m_{\text{apparent}} = \Delta m = \rho_{\text{water}} V_{\text{rock}} = \rho_{\text{water}} \frac{m_{\text{rock}}}{\rho_{\text{rock}}} \quad \rightarrow$$

$$\rho_{\text{rock}} = \rho_{\text{water}} \frac{m_{\text{rock}}}{\Delta m} = \left(1.00\times10^3\,\text{kg/m}^3\right)\frac{9.28\,\text{kg}}{9.28\,\text{kg} - 6.18\,\text{kg}} = \boxed{2990\,\text{kg/m}^3}$$

28. (*a*) When the hull is submerged, both the buoyant force and the tension force act upward on the hull, and so their sum is equal to the weight of the hull, if the hill is not accelerated as it is lifted. The buoyant force is the weight of the water displaced.

$$T + F_{\text{buoyant}} = mg \quad \rightarrow$$

$$T = mg - F_{\text{buoyant}} = m_{\text{hull}}g - \rho_{\text{water}}V_{\text{sub}}g = m_{\text{hull}}g - \rho_{\text{water}}\frac{m_{\text{hull}}}{\rho_{\text{hull}}}g = m_{\text{hull}}g\left(1 - \frac{\rho_{\text{water}}}{\rho_{\text{hull}}}\right)$$

$$= \left(1.6\times10^4\,\text{kg}\right)\left(9.80\,\text{m/s}^2\right)\left(1 - \frac{1.00\times10^3\,\text{kg/m}^3}{7.8\times10^3\,\text{kg/m}^3}\right) = 1.367\times10^5\,\text{N} \approx \boxed{1.4\times10^5\,\text{N}}$$

(*b*) When the hull is completely out of the water, the tension in the crane's cable must be equal to the weight of the hull.

$$T = mg = \left(1.6\times10^4\,\text{kg}\right)\left(9.80\,\text{m/s}^2\right) = 1.568\times10^5\,\text{N} \approx \boxed{1.6\times10^5\,\text{N}}$$

29. The buoyant force of the balloon must equal the weight of the balloon plus the weight of the helium in the balloon plus the weight of the load. For calculating the weight of the helium, we assume it is at 0°C and 1 atm pressure. The buoyant force is the weight of the air displaced by the volume of the balloon.

$$F_{\text{buoyant}} = \rho_{\text{air}}V_{\text{balloon}}g = m_{\text{He}}g + m_{\text{balloon}}g + m_{\text{cargo}}g \quad \rightarrow$$

$$m_{\text{cargo}} = \rho_{\text{air}}V_{\text{balloon}} - m_{\text{He}} - m_{\text{balloon}} = \rho_{\text{air}}V_{\text{balloon}} - \rho_{\text{He}}V_{\text{balloon}} - m_{\text{balloon}} = \left(\rho_{\text{air}} - \rho_{\text{He}}\right)V_{\text{balloon}} - m_{\text{balloon}}$$

$$= \left(1.29\,\text{kg/m}^3 - 0.179\,\text{kg/m}^3\right)\tfrac{4}{3}\pi(7.35\,\text{m})^3 - 930\,\text{kg} = \boxed{920\,\text{kg}} = 9.0\times10^3\,\text{N}$$

32. The difference in the actual mass and the apparent mass of the aluminum is the mass of the air displaced by the aluminum. The mass of the air displaced is the volume of the aluminum times the density of air, and the volume of the aluminum is the actual mass of the aluminum divided by the density of aluminum. Combining these relationships yields an expression for the actual mass.

$$m_{\text{actual}} - m_{\text{apparent}} = \rho_{\text{air}} V_{\text{Al}} = \rho_{\text{air}} \frac{m_{\text{actual}}}{\rho_{\text{Al}}} \quad \rightarrow$$

$$m_{\text{actual}} = \frac{m_{\text{apparent}}}{1 - \dfrac{\rho_{\text{air}}}{\rho_{\text{Al}}}} = \frac{3.0000 \text{ kg}}{1 - \dfrac{1.29 \text{ kg/m}^3}{2.70 \times 10^3 \text{ kg/m}^3}} = \boxed{3.0014 \text{ kg}}$$

42. For the combination to just barely sink, the total weight of the wood and lead must be equal to the total buoyant force on the wood and the lead.

$$F_{\text{weight}} = F_{\text{buoyant}} \quad \rightarrow \quad m_{\text{wood}} g + m_{\text{Pb}} g = V_{\text{wood}} \rho_{\text{water}} g + V_{\text{Pb}} \rho_{\text{water}} g \quad \rightarrow$$

$$m_{\text{wood}} + m_{\text{Pb}} = \frac{m_{\text{wood}}}{\rho_{\text{wood}}} \rho_{\text{water}} + \frac{m_{\text{Pb}}}{\rho_{\text{Pb}}} \rho_{\text{water}} \quad \rightarrow \quad m_{\text{Pb}} \left(1 - \frac{\rho_{\text{water}}}{\rho_{\text{Pb}}} \right) = m_{\text{wood}} \left(\frac{\rho_{\text{water}}}{\rho_{\text{wood}}} - 1 \right) \quad \rightarrow$$

$$m_{\text{Pb}} = m_{\text{wood}} \frac{\left(\dfrac{\rho_{\text{water}}}{\rho_{\text{wood}}} - 1 \right)}{\left(1 - \dfrac{\rho_{\text{water}}}{\rho_{\text{Pb}}} \right)} = m_{\text{wood}} \frac{\left(\dfrac{1}{SG_{\text{wood}}} - 1 \right)}{\left(1 - \dfrac{1}{SG_{\text{Pb}}} \right)} = (3.25 \text{ kg}) \frac{\left(\dfrac{1}{0.50} - 1 \right)}{\left(1 - \dfrac{1}{11.3} \right)} = \boxed{3.57 \text{ kg}}$$