33. **THINK** The iron anchor is submerged in water, so we apply Archimedes' principle to calculate its volume and weight in air.

EXPRESS The anchor is completely submerged in water of density ρ_w. Its apparent weight is $W_{app} = W - F_b$, where $W = mg$ is its actual weight and $F_b = \rho_w gV$ is the buoyant force.

ANALYZE (a) Substituting the values given, we find the volume of the anchor to be

$$V = \frac{W - W_{app}}{\rho_w g} = \frac{F_b}{\rho_w g} = \frac{200\ \text{N}}{(1000\ \text{kg/m}^3)(9.8\ \text{m/s}^2)} = 2.04 \times 10^{-2}\ \text{m}^3 .$$

(b) The mass of the anchor is $m = \rho_{Fe} g$, where ρ_{Fe} is the density of iron (found in Table 14-1). Therefore, its weight in air is

$$W = mg = \rho_{Fe} Vg = (7870\ \text{kg/m}^3)(2.04 \times 10^{-2}\ \text{m}^3)(9.80\ \text{m/s}^2) = 1.57 \times 10^3\ \text{N} .$$

LEARN In general, the apparent weight of an object of density ρ that is completely submerged in a fluid of density ρ_f can be written as $W_{app} = (\rho - \rho_f)Vg$.

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

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

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

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

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

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

40. If the alligator floats, by Archimedes' principle the buoyancy force is equal to the alligator's weight (see Eq. 14-17). Therefore,

$$F_b = F_g = m_{H_2O}\, g = (\rho_{H_2O} A h) g .$$

If the mass is to increase by a small amount $m \to m' = m + \Delta m$, then

$$F_b \rightarrow F_b' = \rho_{H_2O} A(h+\Delta h)g \,.$$

With $\Delta F_b = F_b' - F_b = 0.010mg$, the alligator sinks by

$$\Delta h = \frac{\Delta F_b}{\rho_{H_2O} Ag} = \frac{0.01mg}{\rho_{H_2O} Ag} = \frac{0.010(130\text{ kg})}{(998\text{ kg/m}^3)(0.20\text{ m}^2)} = 6.5\times10^{-3}\text{ m} = 6.5\text{ mm}\,.$$

44. (a) Since the lead is not displacing any water (of density ρ_w), the lead's volume is not contributing to the buoyant force F_b. If the immersed volume of wood is V_i, then

$$F_b = \rho_w V_i g = 0.900\,\rho_w V_{\text{wood}}\, g = 0.900\,\rho_w g\left(\frac{m_{\text{wood}}}{\rho_{\text{wood}}}\right),$$

which, when floating, equals the weights of the wood and lead:

$$F_b = 0.900\,\rho_w g\left(\frac{m_{\text{wood}}}{\rho_{\text{wood}}}\right) = (m_{\text{wood}} + m_{\text{lead}})g\,.$$

Thus,

$$m_{\text{lead}} = 0.900\rho_w\left(\frac{m_{\text{wood}}}{\rho_{\text{wood}}}\right) - m_{\text{wood}} = \frac{(0.900)(1000\,\text{kg/m}^3)(3.67\,\text{kg})}{600\text{ kg/m}^3} - 3.67\text{ kg}$$
$$= 1.84\text{ kg}.$$

(b) In this case, the volume $V_{\text{lead}} = m_{\text{lead}}/\rho_{\text{lead}}$ also contributes to F_b. Consequently,

$$F_b = 0.900\rho_w g\left(\frac{m_{\text{wood}}}{\rho_{\text{wood}}}\right) + \left(\frac{\rho_w}{\rho_{\text{lead}}}\right) m_{\text{lead}}\, g = (m_{\text{wood}} + m_{\text{lead}})g,$$

which leads to

$$m_{\text{lead}} = \frac{0.900\,(\rho_w/\rho_{\text{wood}})m_{\text{wood}} - m_{\text{wood}}}{1 - \rho_w/\rho_{\text{lead}}} = \frac{1.84\text{ kg}}{1-(1.00\times10^3\text{ kg/m}^3/1.13\times10^4\text{ kg/m}^3)}$$
$$= 2.01\text{ kg}.$$

58. We use Bernoulli's equation:

$$p_2 - p_i = \rho g D + \frac{1}{2}\rho\left(v_1^2 - v_2^2\right)$$

where $\rho = 1000$ kg/m^3, $D = 180$ m, $v_1 = 0.40$ m/s, and $v_2 = 9.5$ m/s. Therefore, we find $\Delta p = 1.7 \times 10^6$ Pa, or 1.7 MPa. The SI unit for pressure is the pascal (Pa) and is equivalent to N/m^2.