6. 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 $1\,\mathrm{N/m^2} = 1\,\mathrm{Pa}$, we obtain

$$p_i = p_o - \frac{F}{A} = 1.0 \times 10^5\,\mathrm{Pa} - \frac{480\,\mathrm{N}}{77 \times 10^{-4}\,\mathrm{m}^2} = 3.8 \times 10^4\ \mathrm{Pa}\ .$$

22. (a) According to Pascal's principle $F/A = f/a \;\rightarrow\; F = (A/a)f$.

(b) We obtain

$$f = \frac{a}{A}F = \frac{(3.80\,\mathrm{cm})^2}{(53.0\,\mathrm{cm})^2}(20.0 \times 10^3\,\mathrm{N}) = 103\ \mathrm{N}\ .$$

The ratio of the squares of diameters is equivalent to the ratio of the areas. We also note that the area units cancel.

27. (a) Let V be the volume of the block. Then, the submerged volume is $V_s = 2V/3$. Since the block is floating, the weight of the displaced water is equal to the weight of the block, so $\rho_w V_s = \rho_b V$, where ρ_w is the density of water, and ρ_b is the density of the block. We substitute $V_s = 2V/3$ to obtain $\rho_b = 2\rho_w/3 = 2(1000\,\text{kg/m}^3)/3 \approx 670\,\text{kg/m}^3$.

(b) If ρ_o is the density of the oil, then Archimedes' principle yields $\rho_o V_s = \rho_b V$. We substitute $V_s = 0.90V$ to obtain $\rho_o = \rho_b/0.90 = 740\,\text{kg/m}^3$.

42. (a) The equation of continuity provides $26 + 19 + 11 = 56$ L/min for the flow rate in the main (1.9 cm diameter) pipe.

(b) Using $v = R/A$ and $A = \pi d^2/4$, we set up ratios:

$$\frac{v_{56}}{v_{26}} = \frac{\frac{56}{\pi(1.9)^2/4}}{\frac{26}{\pi(1.3)^2/4}} \approx 1 \ .$$

43. (a) We use the equation of continuity: $A_1 v_1 = A_2 v_2$. Here A_1 is the area of the pipe at the top and v_1 is the speed of the water there; A_2 is the area of the pipe at the bottom and v_2 is the speed of the water there. Thus $v_2 = (A_1/A_2)v_1 = \left((4.0\,\text{cm}^2)/(8.0\,\text{cm}^2)\right)(5.0\,\text{m/s}) = 2.5\,\text{m/s}$.

(b) We use the Bernoulli equation: $p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$, where ρ is the density of water, h_1 is its initial altitude, and h_2 is its final altitude. Thus

$$\begin{aligned} p_2 &= p_1 + \frac{1}{2}\rho(v_1^2 - v_2^2) + \rho g(h_1 - h_2) \\ &= 1.5\times10^5\,\text{Pa} + \frac{1}{2}(1000\,\text{kg/m}^3)\left((5.0\,\text{m/s})^2 - (2.5\,\text{m/s})^2\right) + (1000\,\text{kg/m}^3)(9.8\,\text{m/s}^2)(10\,\text{m}) \\ &= 2.6\times10^5\ \text{Pa}\ . \end{aligned}$$

47. (a) We use the Bernoulli equation: $p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$, where h_1 is the height of the water in the tank, p_1 is the pressure there, and v_1 is the speed of the water there; h_2 is the altitude of the hole, p_2 is the pressure there, and v_2 is the speed of the water there. ρ is the density of water. The pressure at the top of the tank and at the hole is atmospheric, so $p_1 = p_2$. Since the tank is large we may neglect the water speed at the top; it is much smaller than the speed at the hole. The Bernoulli equation then becomes $\rho g h_1 = \frac{1}{2}\rho v_2^2 + \rho g h_2$ and

$$v_2 = \sqrt{2g(h_1 - h_2)} = \sqrt{2(9.8\,\mathrm{m/s^2})(0.30\,\mathrm{m})} = 2.42\ \mathrm{m/s}\ .$$

The flow rate is $A_2 v_2 = (6.5 \times 10^{-4}\,\mathrm{m^2})(2.42\,\mathrm{m/s}) = 1.6 \times 10^{-3}\ \mathrm{m^3/s}$.

(b) We use the equation of continuity: $A_2 v_2 = A_3 v_3$, where $A_3 = \frac{1}{2}A_2$ and v_3 is the water speed where the area of the stream is half its area at the hole. Thus $v_3 = (A_2/A_3)v_2 = 2v_2 = 4.84\,\mathrm{m/s}$. The water is in free fall and we wish to know how far it has fallen when its speed is doubled to $4.84\,\mathrm{m/s}$. Since the pressure is the same throughout the fall, $\frac{1}{2}\rho v_2^2 + \rho g h_2 = \frac{1}{2}\rho v_3^2 + \rho g h_3$. Thus

$$h_2 - h_3 = \frac{v_3^2 - v_2^2}{2g} = \frac{(4.84\,\mathrm{m/s})^2 - (2.42\,\mathrm{m/s})^2}{2(9.8\,\mathrm{m/s^2})} = 0.90\ \mathrm{m}\ .$$