1. The pressure increase is the applied force divided by the area: $\Delta p = F/A = F/\pi r^2$, where r is the radius of the piston. Thus $\Delta p = (42\,\mathrm{N})/\pi(0.011\,\mathrm{m})^2 = 1.1 \times 10^5\,\mathrm{Pa}$. This is equivalent to 1.1 atm.

13. 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. The downward force of the water on the hatch cover is $(p_0 + \rho g d)A$, where A is the area of the cover. If the air in the submarine is at atmospheric pressure then it exerts an upward force of $p_0 A$. The minimum force that must be applied by the crew to open the cover has magnitude $F = (p_0 + \rho g d)A - p_0 A = \rho g d A = (1025\,\mathrm{kg/m^3})(9.8\,\mathrm{m/s^2})(100\,\mathrm{m})(1.2\,\mathrm{m})(0.60\,\mathrm{m}) = 7.2 \times 10^5\,\mathrm{N}$.

20. The gauge pressure you can produce is

$$p = -\rho g h = -\frac{\left(1000\,\mathrm{kg/m^3}\right)\left(9.8\,\mathrm{m/s^2}\right)\left(4.0\times10^{-2}\,\mathrm{m}\right)}{1.01\times10^{5}\,\mathrm{Pa/atm}} = -3.9\times10^{-3}\ \mathrm{atm}$$

where the minus sign indicates that the pressure inside your lung is less than the outside pressure.

24. (a) Archimedes' principle makes it clear that a body, in order to float, displaces an amount of the liquid which corresponds to the weight of the body. The problem (indirectly) tells us that the weight of the boat is $W = 35.6$ kN. In salt water of density $\rho' = 1100\,\mathrm{kg/m^3}$, it must displace an amount of liquid having weight equal to 35.6 kN.

(b) The displaced volume of salt water is equal to

$$V' = \frac{W}{\rho' g} = \frac{35600}{(1100)(9.8)} = 3.30 \text{ m}^3 \ .$$

In freshwater, it displaces a volume of $V = W/\rho g = 3.63\,\mathrm{m}^3$, where $\rho = 1000\,\mathrm{kg/m^3}$. The difference is $V - V' = 0.33\,\mathrm{m}^3$.

32. (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

$$F_b = \rho_w V_i g = 0.90\rho_w V_{\text{wood}} g = 0.90\rho_w g\left(\frac{m_{\text{wood}}}{\rho_{\text{wood}}}\right),$$

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

$$F_b = 0.90\rho_w g\left(\frac{m_{\text{wood}}}{\rho_{\text{wood}}}\right) = (m_{\text{wood}} + m_{\text{lead}})g .$$

Thus,

$$\begin{aligned} m_{\text{lead}} &= 0.90\rho_w\left(\frac{m_{\text{wood}}}{\rho_{\text{wood}}}\right) - m_{\text{wood}} \\ &= \frac{(0.90)(1000\,\text{kg/m}^3)(3.67\,\text{kg})}{600\,\text{kg/m}^3} - 3.67\,\text{kg} = 1.84\,\text{kg} \approx 1.8\ \text{kg} . \end{aligned}$$

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

$$F_b = 0.90\rho_w g\left(\frac{m_{\text{wood}}}{\rho_{\text{wood}}}\right) + \left(\frac{\rho_w}{\rho_{\text{lead}}}\right) m_{\text{lead}} g = (m_{\text{wood}} + m_{\text{lead}})g,$$

which leads to

$$\begin{aligned} m_{\text{lead}} &= \frac{0.90(\rho_w/\rho_{\text{wood}})m_{\text{wood}} - m_{\text{wood}}}{1 - \rho_w/\rho_{\text{lead}}} \\ &= \frac{1.84\,\text{kg}}{1 - \left(1.00\times10^3\,\text{kg/m}^3/1.13\times10^4\,\text{kg/m}^3\right)} = 2.0\ \text{kg} . \end{aligned}$$

39. We use the equation of continuity. Let v_1 be the speed of the water in the hose and v_2 be its speed as it leaves one of the holes. $A_1 = \pi R^2$ is the cross-sectional area of the hose. If there are N holes and A_2 is the area of a single hole, then the equation of continuity becomes

$$v_1 A_1 = v_2 (N A_2) \implies v_2 = \frac{A_1}{N A_2} v_1 = \frac{R^2}{N r^2} v_1$$

where R is the radius of the hose and r is the radius of a hole. Noting that $R/r = D/d$ (the ratio of diameters) we find

$$v_2 = \frac{D^2}{N d^2} v_1 = \frac{(1.9\,\text{cm})^2}{24(0.13\,\text{cm})^2}(0.91\,\text{m/s}) = 8.1\ \text{m/s}\ .$$

45. (a) The equation of continuity leads to

$$v_2 A_2 = v_1 A_1 \implies v_2 = v_1 \left(\frac{r_1^2}{r_2^2} \right)$$

which gives $v_2 = 3.9\,\mathrm{m/s}$.

(b) With $h = 7.6\,\mathrm{m}$ and $p_1 = 1.7 \times 10^5\,\mathrm{Pa}$, Bernoulli's equation reduces to

$$p_2 = p_1 - \rho g h + \frac{1}{2}\rho\left(v_1^2 - v_2^2\right) = 8.8 \times 10^4 \text{ Pa} .$$