## ANSWERS TO MULTIPLE CHOICE QUESTIONS

1. $\quad m=\rho_{\text {gold }} V=19.3 \times 10^{3} \mathrm{~kg} / \mathrm{m}^{3} \quad 4.50 \times 10^{-2} \mathrm{~m} \quad 11.0 \times 10^{-2} \mathrm{~m} \quad 26.0 \times 10^{-2} \mathrm{~m}=24.8 \mathrm{~kg}$ and choice (a) is the correct response.
2. On average, the support force each nail exerts on the body is

$$
\overline{F_{1}}=\frac{m g}{1208}=\frac{66.0 \mathrm{~kg} 9.80 \mathrm{~m} / \mathrm{s}^{2}}{1208}=0.535 \mathrm{~N}
$$

so the average pressure exerted on the body by each nail is

$$
P_{\mathrm{av}}=\frac{\overline{F_{1}}}{A_{\text {nail }}}=\frac{0.535 \mathrm{~N}}{1.00 \times 10^{-6} \mathrm{~m}^{2}}=5.35 \times 10^{5} \mathrm{~Pa}
$$

and (d) is the correct choice.
3. From Pascal's principle, $F_{1} / A_{1}=F_{2} / A_{2}$, so if the output force is to be $F_{2}=1.2 \times 10^{3} \mathrm{~N}$, the required input force is

$$
F_{1}=\left(\frac{A_{1}}{A_{2}}\right) F_{2}=\left(\frac{0.050 \mathrm{~m}^{2}}{0.70 \mathrm{~m}^{2}}\right) 1.2 \times 10^{3} \mathrm{~N}=86 \mathrm{~N}
$$

making (c) the correct answer.
4. According to Archimedes's principle, the buoyant force exerted on the bullet by the mercury is equal to the weight of a volume of mercury that is the same as the submerged volume of the bullet. If the bullet is to float, this buoyant force must equal the total weight of the bullet. Thus, for a floating bullet,

$$
\begin{aligned}
& \rho_{\text {mercury }} V_{\text {submerged }} g=\rho_{\text {lead }} V_{\text {bullet }} g \text { and } \\
& \frac{V_{\text {submerged }}}{V_{\text {bullet }}}=\frac{\rho_{\text {lead }}}{\rho_{\text {mercury }}}=\frac{11.3 \times 10^{3} \mathrm{~kg} / \mathrm{m}^{3}}{13.6 \times 10^{3} \mathrm{~kg} / \mathrm{m}^{3}}=0.831
\end{aligned}
$$

so the correct response is (d).
5. The absolute pressure at depth $h$ below the surface of a liquid with density $\rho$, and with pressure $P_{0}$ at its
surface, is $P=P_{0}+\rho g h$. Thus, at a depth of 754 ft in the waters of Loch Ness,

$$
P=1.013 \times 10^{5} \mathrm{~Pa}+1.00 \times 10^{3} \mathrm{~kg} / \mathrm{m}^{3} \quad 9.80 \mathrm{~m} / \mathrm{s}^{2}\left[754 \mathrm{ft}\left(\frac{1 \mathrm{~m}}{3.281 \mathrm{ft}}\right)\right]=2.35 \times 10^{6} \mathrm{~Pa}
$$

and (c) is the correct response.
6. We assume that the air inside the well-sealed house has essentially zero speed and the thickness of the roof is negligible so the air just above the roof and that just below the roof is at the same altitude. Then, Bernoulli's equation gives the difference in pressure just below and just above the roof (with the pressure below being the greatest) as

$$
P_{1}-P_{2}=\frac{1}{2} \rho_{\mathrm{air}} v_{2}^{2}-v_{1}^{2}+\rho_{\mathrm{air}} g y_{2}-y_{1}
$$

or

$$
\Delta P=\frac{1}{2} 1.29 \mathrm{~kg} / \mathrm{m}^{3}\left\{\left[95 \mathrm{mi} / \mathrm{h}\left(\frac{1}{2.237 \mathrm{mi} / \mathrm{h}}\right)\right]^{2}-0\right\}+0=1.2 \times 10^{3} \mathrm{~Pa}
$$

and the correct choice is (a).
7. From the equation of continuity, $A_{1} v_{1}=A_{2} v_{2}$, the speed of the water in the smaller pipe is

$$
v_{2}=\left(\frac{A_{1}}{A_{2}}\right) v_{1}=\left[\frac{\pi 0.250 \mathrm{~m}^{2}}{\pi 0.100 \mathrm{~m}^{2}}\right] 1.00 \mathrm{~m} / \mathrm{s}=6.25 \mathrm{~m} / \mathrm{s}
$$

so (d) is the correct answer.
8. All of these phenomena are the result of a difference in pressure on opposite sides of an object due to a fluid moving at different speeds on the two sides. Thus, the correct response to this question is choice (e). Bernoulli's equation can be used in the discussion of each of these phenomena.
9. The boat, even after it sinks, experiences a buoyant force, $B$, equal to the weight of whatever water it is displacing. This force will support part of the weight, $w$, of the boat. The normal force exerted on the boat by the bottom of the lake will be $n=w-B<w$ will support the balance of the boat's weight. The correct response is (c).
10. The absolute pressure at depth $h$ below the surface of a fluid having density $\rho$ is, $P=P_{0}+\rho g h$ where $P_{0}$ is the pressure at the upper surface of that fluid. The fluid in each of the three vessels has density
$\rho=\rho_{\text {water }}$, the top of each vessel is open to the atmosphere so that $P_{0}=P_{\text {atmo }}$ in each case, and the bottom is at the same depth $h$ below the upper surface for the three vessels. Thus, the pressure $P$ at the bottom of each vessel is the same and (c) is the correct choice.
11. Since the pipe is horizontal, each part of it is at the same vertical level or has the same $y$-coordinate. Thus, from Bernoulli's equation $\left(P+\frac{1}{2} \rho v^{2}+\rho g y=\right.$ constant $)$, we see that the sum of the pressure and the kinetic energy per unit volume $\left(P+\frac{1}{2} \rho v^{2}\right)$ must also be constant throughout the pipe, making (e) the correct choice.
12. Once the water droplets leave the nozzle, they are projectiles with initial speed $v_{0 y}=v_{i}$ and having speed $v_{f}=v_{y}=0$ at their maximum altitude, $h$. From the kinematics equation $v_{y}^{2}=v_{0 y}^{2}+2 a_{y}(\Delta y)$ the maximum height reached is $h=v_{i}^{2} / 2 g$. Thus, if we want to quadruple the maximum height $\left(h^{\prime}=4 h\right)$ we need to double the speed of the water leaving the nozzle $\left(v_{i}^{\prime}=2 v_{i}\right)$. Using the equation of continuity, $A^{\prime} v_{i}^{\prime}=A v_{i}$, it is seen that if $v_{\mathrm{I}}^{\prime}=2 v_{i}$, it is necessary to have $A_{i}^{\prime}=\left(v_{i} / v_{i}^{\prime}\right) A=A / 2$ This says that the area needs to be decreased by a factor of 2 , and the correct choice is (d).

