1. (5 points) Consider a 10.0 cm x 10.0 cm x 10.0 cm cube of balsa wood that is floating in Lake Michigan (fresh water). What is the percentage of the cube that is above the water?

\[
V = \text{Volume of cube} = 10.0 \times 10.0 \times 10.0 = 1000 \text{ cm}^3 \\
V_{\text{above}} = \frac{V}{2} = 500 \text{ cm}^3 \\
\rho_{\text{water}} = 1.0 \text{ g/cm}^3 \\
F_B = \text{Bouyant force} = \rho_{\text{water}} V_{\text{above}} g = \rho_{\text{water}} V g \\
= \rho_{\text{balsa}} (V_{\text{above}} + V_{\text{below}}) g = \rho_{\text{freshwater}} V_{\text{below}} g \\
\Rightarrow \frac{V_{\text{below}}}{V_{\text{above}} + V_{\text{below}}} = \frac{\rho_{\text{balsa}}}{\rho_{\text{water}}} = \frac{0.16 \text{ g/cm}^3}{1.0 \text{ g/cm}^3} = 0.16 \\
\Rightarrow \frac{V_{\text{above}}}{V_{\text{above}} + V_{\text{below}}} = 1 - 0.16 = 0.84 \text{ % below} \quad \text{above}
\]

2. (5 points) Water flows through a 6" diameter pipe at a rate of 5.0 gallons/sec. What is the velocity of water flowing through the pipe in m/s?

\[
\text{Volume} \quad \frac{dV}{dt} = \frac{dm}{dt} \\
\rho = \rho_{\text{H}_2\text{O}} = \text{Water density} \\
\frac{dV}{dt} = 5 \text{ gal/sec} = 5 \text{ gal} \times \frac{3.79 \times 10^{-3} \text{ m}^3}{\text{gal}} = 1.9 \times 10^{-2} \text{ m}^3/\text{s} \\
A = \pi \left( \frac{3}{4} \right) (0.0254 \text{ m})^2 = 1.9 \times 10^{-3} \text{ m}^2 \\
\text{velocity} = \frac{\Delta x}{\Delta t} \\
\Rightarrow V = \frac{1.04 \text{ m/s}}{5 \text{ gal/sec}} = 1.0 \text{ m/s}
\]
c. (5 points) The water flow into a smaller pipe that is 3” in diameter. What is the velocity of the water now?

\[ V_1 A_1 = V_2 A_2 \]

\[ V_2 = \frac{V_1 A_1}{A_2} = \frac{1.9 \times 10^{-2} m^3}{s}{11 \left(1.5 \times 2.54 \times 10^{-2} \right)^2} = 1.04 \left(\frac{6}{3} \right)^2 \approx 4.16 m/s \]

\( \Rightarrow 4 \times \text{GREATER}! \)

d. (5 points) Water is flowing in a fire hose with a velocity of 1.0 m/s and a pressure of 200000 Pa. At the nozzle the pressure decreases to atmospheric pressure (1.013 x 10^5 Pa), there is no change in height. Use the Bernoulli equation to calculate the velocity of the water exiting the nozzle.

\[ P_1 + \frac{1}{2} \rho_1 V_1^2 + \rho_1 g h_1 = P_2 + \frac{1}{2} \rho_2 V_2^2 + \rho_2 g h_2 \]

\( \rho_1 = \rho_2 = 1 g/cc \) (incompressible fluid)

\( P_1 = 2 \times 10^5 Pa \)

\( P_2 = 1.013 \times 10^5 Pa \)

\( h_1 = h_2 \)

\( \Rightarrow V_1 = 1 m/s \quad V_2 = ? \)

\( \Rightarrow P_1 - P_2 = (2 \times 10^5 - 1.013 \times 10^5) Pa = \frac{1}{2} \rho (V_2^2 - V_1^2) \)

\[ \frac{(10^5 Pa)}{10^3 kg/m^3} = V_2^2 - (1)^2 \]

\[ \Rightarrow V_2 = 14 m/s \]