Example 1

Crew members attempt to escape from a damaged submarine that is submerged 100 m below the surface of the ocean. With what force must a crew member push on a pop-out hatch, which has an area of 1.2 m × 0.60 m, to begin to open it? Take the density of sea water to be 1024 kg/m³ and the pressure inside the submarine to be 1 atm.

\[ P = P_{\text{top}} + \rho gh \]
\[ P = \frac{F}{A} \]

\[ F_{\text{inside}} = F_{\text{outside}} \]
\[ P_{\text{inside}} A + F_{\text{push}} = P_{\text{outside}} A \]

\[ F_{\text{push}} = P_{\text{outside}} A - P_{\text{inside}} A \]
\[ = (P_{\text{top}} + \rho gh)A - P_{\text{inside}} A \]
\[ = (1.01 \times 10^5 + 1024 \times 9.8 \times 100) \times 0.72 - 1.01 \times 10^5 \times 0.72 \]
\[ = 7.23 \times 10^5 \text{ N} \]

\[ \approx \text{approx. equivalent of 160,000 lb} \]
Example 2

A rectangular block of ice with dimensions $2.5 \text{ m} \times 1.7 \text{ m} \times 0.5 \text{ m}$ is floating in water. What is the height of the ice that is floating above the water line?

Data: density of water = $1000 \text{ kg/m}^3$, density of ice = $934 \text{ kg/m}^3$

$$d = ?$$

$$c = 0.5 \text{ m}$$
$$b = 1.7 \text{ m}$$
$$a = 2.5 \text{ m}$$

**FBD for the ice block**

$m_i = \text{mass of ice}$

$m_w = \text{mass of displaced water}$

$$V = ab(c-d)$$

$$\rho_w \left[ ab(c-d) \right] = m_i$$

$$\rho_w \frac{ab(c-d)}{ab \rho_w} = m_i$$

$$c - d = \frac{m_i}{ab \rho_w}$$

$$d = c - \frac{m_i}{ab \rho_w}$$

$$d = \left[ 0.033 \text{ m} \right]$$
Example 3

A horizontal section of pipe with a cross-sectional area of 5.3 cm$^2$ contains water flowing at 30 cm/s at a pressure of $2.3 \times 10^5$ Pa. The next section of the pipe is vertical, with a height of 2.3 m, which then connects with another horizontal section of pipe which has a cross-sectional area of 2.5 cm$^2$.

(a) What is the speed of water flowing in the lower horizontal section of the pipe?

(b) What is the pressure of the water in the lower section? (Hint: Let $y = 0$ be at the level of the lower section of pipe.)

\[
\begin{align*}
A_1 &= 5.3 \text{ cm}^2 \times \left(\frac{1 \text{ m}}{100 \text{ cm}}\right)^2 = 0.00053 \text{ m}^2 \\
A_2 &= 2.5 \text{ cm}^2 \times \left(\frac{1 \text{ m}}{100 \text{ cm}}\right)^2 = 0.00025 \text{ m}^2 \\
v_1 &= 30 \text{ cm/s} = 0.3 \text{ m/s} \\
v_2 &= \ ? \\
h &= 2.3 \text{ m} \\
\rho &= 1000 \text{ kg/m}^3
\end{align*}
\]

(a) \[v_1 A_1 = v_2 A_2\]

\[v_2 = \frac{v_1 A_1}{A_2} = \frac{0.3 \text{ m/s}}{0.00025} = 0.64 \text{ m/s}\]

(b) \[P_1 + \frac{1}{2} \rho v_1^2 + p_1 g y_1 = P_2 + \frac{1}{2} \rho v_2^2 + p_2 g y_2\]

\[P_2 = P_1 + \frac{1}{2} \rho v_1^2 + p_1 g h - \frac{1}{2} \rho v_2^2 = 2.5 \times 10^5 \text{ Pa}\]