

Physics 151 Class Exercise: Fluids 2 - KEY

1. A solid block is suspended from a spring scale. When the block is in air the scale reads 35.0 N, when immersed in water the scale reads 31.1 N, and when immersed in oil the scale reads 31.8 N. **(a)** What is the density of the block? **(b)** What is the density of the oil?

$$\begin{aligned} \text{(a)} \quad T &= mg \\ m &= \frac{T}{g} = \frac{35.0 \text{ N}}{9.81 \frac{\text{m}}{\text{s}^2}} = 3.57 \text{ kg} \end{aligned}$$

$$\begin{aligned} \Sigma F_y &= 0 \\ T + B - mg &= 0 \\ T + \rho_w Vg - mg &= 0 \end{aligned}$$

$$\begin{aligned} V &= \frac{mg - T}{\rho_w g} = \frac{35.0 \text{ N} - 31.1 \text{ N}}{\left(1000 \frac{\text{kg}}{\text{m}^3}\right)\left(9.81 \frac{\text{m}}{\text{s}^2}\right)} = 3.98 \times 10^{-4} \text{ m}^3 \\ \rho_{\text{block}} &= \frac{m}{V} = \frac{3.57 \text{ kg}}{3.98 \times 10^{-4} \text{ m}^3} = \boxed{8.97 \times 10^3 \text{ kg/m}^3} \end{aligned}$$

$$\begin{aligned} \text{(b)} \quad \Sigma F_y &= 0 \\ T + B - mg &= 0 \\ T + \rho_{\text{oil}} Vg - mg &= 0 \end{aligned}$$

$$\begin{aligned} \rho_{\text{oil}} &= \frac{mg - T}{Vg} \\ &= \frac{35.0 \text{ N} - 31.8 \text{ N}}{\left(3.98 \times 10^{-4} \text{ m}^3\right)\left(9.81 \frac{\text{m}}{\text{s}^2}\right)} \\ &= \boxed{821 \text{ kg/m}^3} \end{aligned}$$

2. A river narrows at a rapids from a width of 12 m to a width of 4.0 m. The depth of the river before the rapids is 2.7 m; the depth in the rapids is 0.85 m. Find the speed of water flowing in the rapids, given that its speed before the rapids is 2.2 m/s. Assume the river has a rectangular cross section.

$$\begin{aligned} A_1 v_1 &= A_2 v_2 \\ w_1 d_1 v_1 &= w_2 d_2 v_2 \\ v_2 &= \frac{w_1 d_1 v_1}{w_2 d_2} \\ &= \frac{(12 \text{ m})(2.7 \text{ m})\left(2.2 \frac{\text{m}}{\text{s}}\right)}{(4.0 \text{ m})(0.85 \text{ m})} \\ &= \boxed{21 \text{ m/s}} \end{aligned}$$