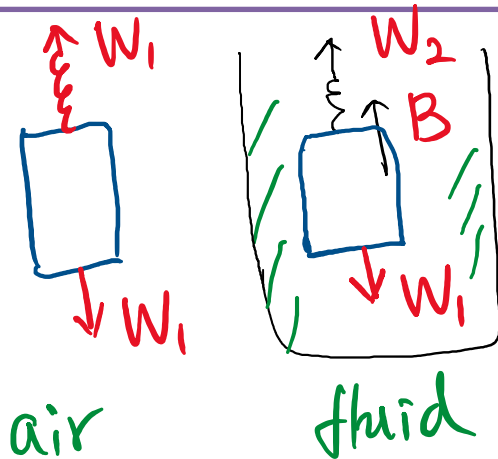


Homework #6

Problem #6.1 The density of an animal is conveniently obtained by weighing it first in air and then immersed in a fluid. Let the weight in air and in the fluid be respectively W_1 and W_2 . If the density of the fluid is ρ_1 , show that the average density ρ_2 of the animal is: $\rho_2 = \rho_1 \frac{W_1}{W_1 - W_2}$.



In fluid: $B = W_1 - W_2$

$$B = \rho_1 V g, \quad V = \frac{m}{\rho_2} = \frac{m \cdot g}{\rho_2 \cdot g} = \frac{W_1}{\rho_2 \cdot g}$$

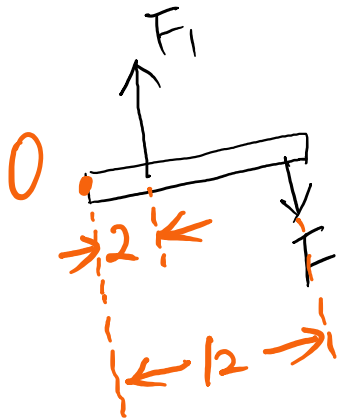
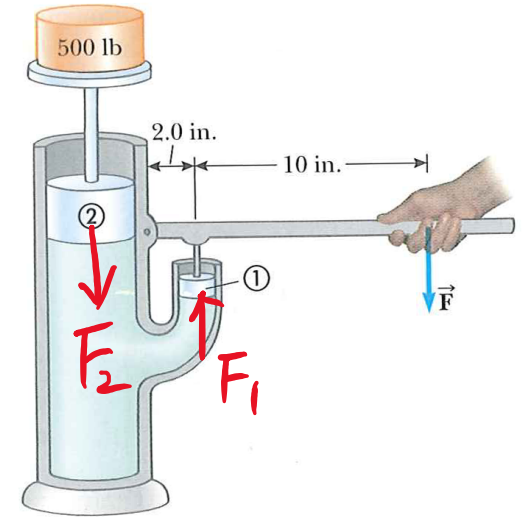
$$\therefore B = \rho_1 \frac{W_1}{\rho_2 \cdot g} \cdot g = \rho_1 \frac{W_1}{\rho_2}$$

$$\therefore W_1 - W_2 = \frac{\rho_1 W_1}{\rho_2}$$

$$\therefore \rho_2 = \frac{\rho_1 W_1}{W_1 - W_2}$$

Problem #6.2 Piston one in the figure has a diameter of 1.0 cm; piston two has a diameter of 6.0 cm. In the absence of friction, determine the force F necessary to support the 226.8 kg weight. Assume the two pistons are at the same height.

$$\begin{aligned} \frac{F_1}{A_1} &= \frac{F_2}{A_2} \quad \therefore F_1 = F_2 \cdot \frac{A_1}{A_2} = F_2 \cdot \frac{\pi r_1^2}{\pi r_2^2} \\ &= F_2 \cdot \left(\frac{r_1}{r_2}\right)^2 = F_2 \cdot \left(\frac{1}{6}\right)^2 \\ &= (226.8 \text{ kg})(9.8 \text{ m/s}^2) \cdot \left(\frac{1}{36}\right) \\ &= \boxed{61.7 \text{ N}} \end{aligned}$$

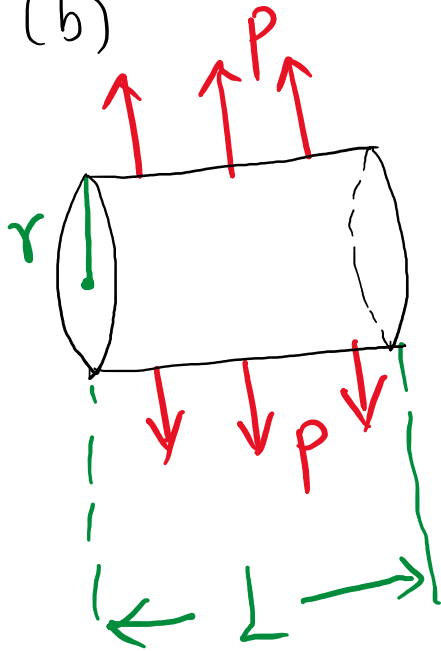


$$\begin{aligned} \tau_{F_1} + \tau_F &= 0 \\ \therefore +F_1 \times 2 \text{ in} - F \times 12 \text{ in} &= 0 \\ \therefore F &= \frac{1}{6} F_1 = \boxed{10.3 \text{ N}} \end{aligned}$$

Problem #6.3 (a) Calculate the difference in blood pressure between the feet and top of the head for a person who is 1.65 m tall. (b) Consider a cylindrical segment of a blood vessel 2.00 cm long and 1.50 mm in diameter. What additional outward force would such a vessel need to withstand in the person's feet compared to a similar vessel in her head?

$$(a) \Delta P = \rho g(\Delta h) = (1060 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(1.65 \text{ m}) = 1.71 \times 10^4 \text{ Pa}$$

$$(b) F_1 = P_1 * A = P_1 * (2\pi r \cdot L), F_2 = P_2 * A = P_2 * (2\pi r \cdot L)$$



$$F_1 - F_2 = (P_1 - P_2) * (2\pi r \cdot L), \quad (A = 2\pi r \cdot L = 9.45 \times 10^{-5} \text{ m}^2)$$

$$= (1.71 \times 10^4 \text{ Pa}) (9.45 \times 10^{-5} \text{ m}^2)$$

$$= 1.61 \text{ N}$$

Problem #6.4 What is the difference between the pressure of the blood in your brain when you stand on your head and the pressure when you stand on your feet? Assume that you are 1.85 m tall. The density of blood is 1060 kg/m^3 . (b) What effect does the increased pressure have on the blood vessels in your brain?

Problem #6.5 As you can tell by watching them in an aquarium, fish are able to remain at any depth in water with no effort. What does this ability tell you about their density? Fish are able to inflate themselves using a sac located under their spinal column. These sacs can be filled with an oxygen-nitrogen mixture that comes from the blood. If a 2.75-kg fish in freshwater inflates itself and increases its volume by 10%, find the net force that the water exerts on it. (c) What is the net external force on it (including gravity)? Does the fish go up or down when it inflates itself?

$$(b) \text{ Before inflation: } \begin{cases} B = mg = (2.75 \text{ kg})(9.8 \text{ m/s}^2) = 27.0 \text{ N} \\ B = \rho V_1 g \end{cases}$$

When V_1 increases by 10%

$$B' = \rho V_1 (1 + 10\%) g = 27.0 \times 1.1 \text{ N} = 29.7 \text{ N}$$

$$(c) \text{ Net force} = B' - mg = 29.7 \text{ N} - 27.0 \text{ N} = 2.7 \text{ N}$$