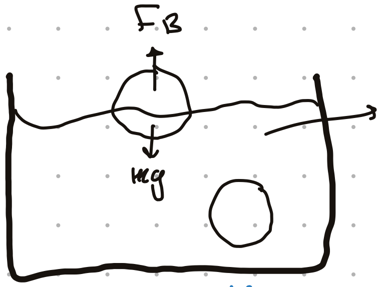
Buoyancy Ch.12



تصادم جزيئات الماء مع الطالبة

$F_B \leftarrow$ Buoyant force

$$F_B = \rho V_d g$$

$\rho \rightarrow$ density of liquid

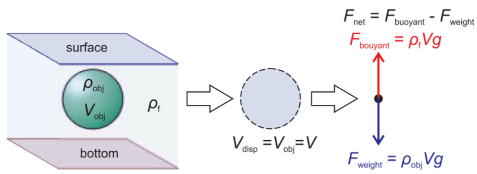
$V_d \rightarrow$ displacment Volume حجم السائل المزاح → إلى تحت المي

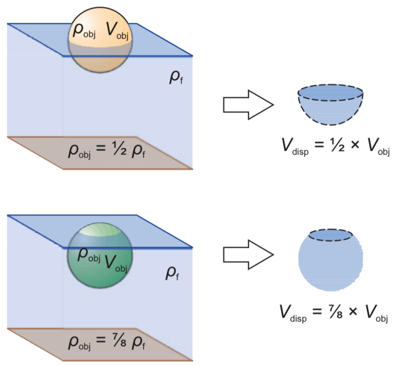
الوزن الظاهري

Appalent weight = Actual weight − weight of displacment Liquid or gas

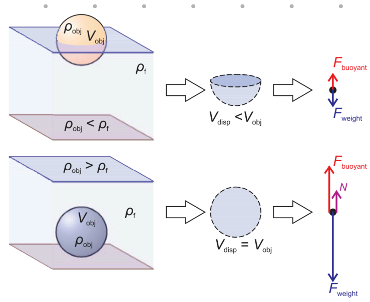
لما تحمل واحد وهو في المي بكون أخف

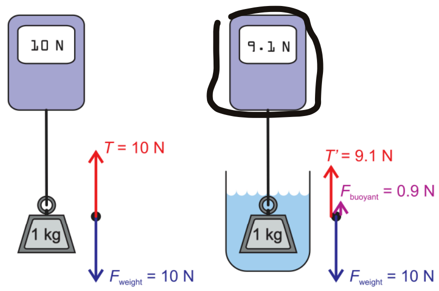
Key concept:
Buoyancy is the upward force exerted on an object that is fully or partially submerged in a fluid, resulting from the increase in pressure with depth.

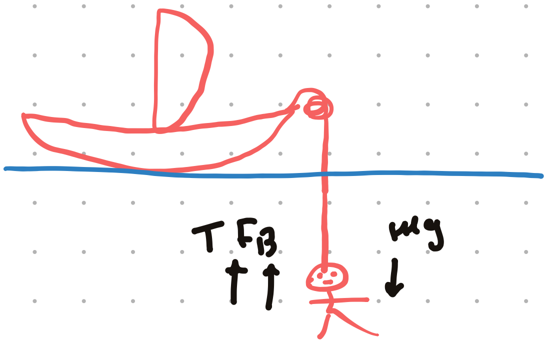




إذا كانت ρ للجسم أكبر من السائل لا يطفو







12.1) $F_B + T - mg = 0$

$T = mg - F$

$T = mg - \rho V_d g = 1250 - 900 = 350$ N

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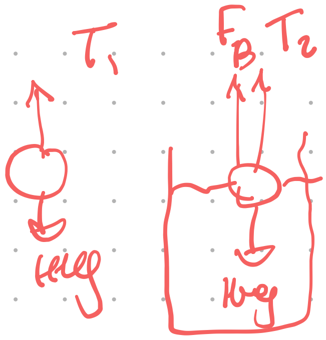
12.2)



$$T_1 - mg = 0$$

$$F_B + T_2 - mg = 0$$

$$T_1 - T_2 - F_B = 0$$

$$V_2 = \frac{T_1 - T_2}{\rho g V_2} \leftarrow F_B = T_1 - T_2 = 160 N$$

$$\rho_w g V_L = T_1 - T_2$$

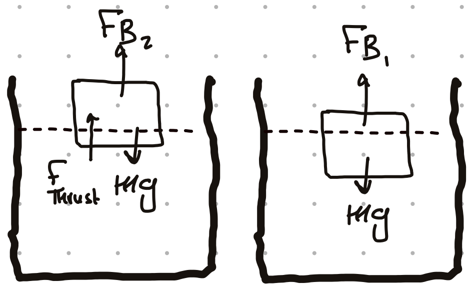
$$\frac{160}{1000 \cdot (10)} = 0.016 m^2$$

But $V_L = \frac{4}{3}\pi r_L^2$

$$r = = \sqrt[3]{\frac{3V_L}{4\pi}} = \sqrt[3]{\frac{3(0.016)}{4\pi}} = 15.6 cm$$

Example 12.3 ***Synchronised swimmer***

Problem: A person will typically float with just 4% of their volume above the surface of the water. If a 55 kg synchronized swimmer is performing a manoeuver in which they raise 30% of their volume out of the water and hold themselves there, what 'thrust' force must they generate by kicking their legs?



$$F_{B_1} - mg = 0$$

$$F_{B_2} + F_{Thrust} - mg = 0$$

$$\rightarrow F_{B_1} - F_{B_2} - F_{Thrust} = 0$$

$$F_{Thrust} = F_{B_1} - F_{B_2} \longrightarrow \rho V_1 g - \rho V_2 g = \rho (V_1 - V_2)$$

$$= 0.264 g V$$

$$F_{B_1} - mg = 0$$

$$0.96 \rho g V = mg$$

$$V = \frac{m}{0.96\rho} = \frac{55}{0.96(1000)} = 0.057 m^3$$

149 N

Example 12.4 ***Is it gold?***

Problem: **A person is paid for a job with a 0.100 kg 'gold' coin. Suspicious, the person decides to check to see if the coin is really gold (ρ_{gold} = 19 300 kg m^{-3}). They hang the coin on a piece of string and submerge it in water. The apparent mass while the coin is submerged is 0.0912 kg. Is the coin gold?**

$$T_2 = (0.0192)(10) = 0.912$$

$$F_B = T_1 - T_2 = (1 - 0.912) = 0.088$$

$$\rho V g \longrightarrow V_d = \frac{F_B}{\rho_w g} = \frac{0.088}{(1000)(10)} = 8.8 \times 10^{-6}\ m^3$$

if the coin is pure, then its mass should be given by

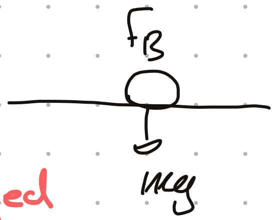
$$m = \rho_{gold} V_{coin} = \rho_{gold} V_{disp}$$

$$19300 * 8.8 \times 10^{-6} = 0.170\ kg$$

Since the above weight is larger than actual

the coin is not pure

12.1 A swimmer finds that she just floats in water. If she weighs 70 kg what is her volume ($\rho_{water} = 1 \times 10^3$ kg m^{-3})?



all of the swimmer body is sub merged

$$V_s = \frac{m_s}{\rho} = \frac{70}{1000} = 0.07\ m^3$$

12.2 Law 2 of the game of soccer specifies that the ball is an air-filled sphere with a circumference of 68–70 cm, and a mass of 410–450 g. A particular ball has a circumference of 69 cm, and a mass of 430 g. Calculate the fraction of the volume of this ball that floats above the surface of water.

$$F_B = \rho_w V_{dip} g = mg$$

$$V_{dis} = \frac{m}{\rho_w} = \frac{0.43}{1000} = 4.3 \times 10^{-4}\ m^3$$

$$\frac{V - V_{dis}}{V} \longrightarrow V = \frac{4}{3}\pi r^2 = 5.57 \times 10^{-3}\ m^3$$

12.5 A helium shortage forces some under-funded meteorologists to investigate alternative gases to use in their weather balloons. They settle on methane (PCH4 0.657 kg m-3). What is the minimum radius of a methane filled weather balloon that will allow the same minimum payload as the helium filled balloon in Problem 12.4?

$F_B = m_B g - mg = 0$

$m = \frac{F_B}{g} - m_B$

$= \frac{\rho_{air} V_B g - \rho_{He} V_0}{g} =$

$V = \frac{4}{3}\pi r^2$

$= 0.52$

$= 0.53\ Kg$

$m = (\rho_{air} - \rho_{CH_4}) \underbrace{V_B}_{\frac{4}{3}\pi r^2}$

$r = \sqrt[3]{\frac{3m}{4\pi(\rho_{air} - \rho_{CH_4})}} \rightarrow \sqrt[3]{\frac{3(0.53)}{4\pi(1.18 - 0.657)}} = 0.624\ m$

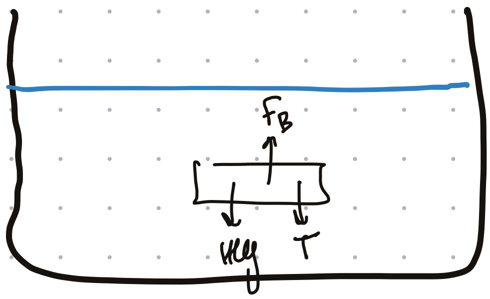
12.6 A piece of polystyrene packaging material (density = 25 kg m^{-3}) that has a mass of 0.2 kg is tethered to the bottom of a container of water (density = 1×10^3 kg m^{-3}) with a piece of string. What is the tension in the string?

$F_B - T = mg = 0$

$T = F_B - mg = \rho_w V_{dis} g - mg$

$T = \frac{1000}{25}(0.2)(10) - 0.2(10)$

$T = 78 N$



12.7 In an experiment to determine the density of an unknown material, its apparent weight when fully submerged in water is measured. The apparent weight in water is 17.5 N and the weight in air is 27.5 N. What is the density of the material?

$F_B = \rho_w V_{dis} g$ = actulal – apperment