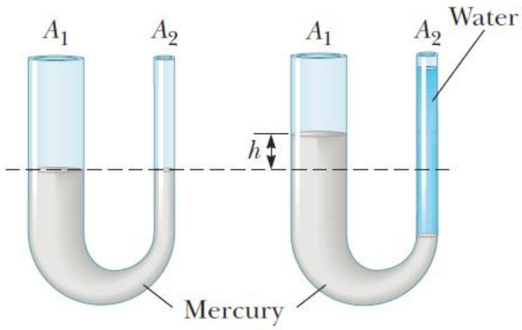
Questions for Module # 18

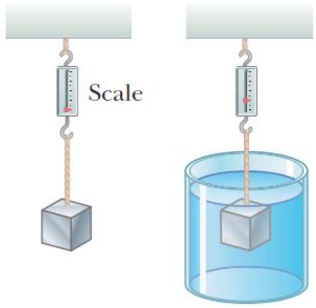
Q.1 Why are these water towers designed as shown instead of as simple cylinders? Clearly these are less stable and more expensive to construct so there must be a good reason!

Q.2 A very powerful vacuum cleaner has a hose 2.86 cm in diameter. One end of the hose is placed perpendicularly on the flat face of a brick, what is the weight of the heaviest brick that the cleaner can lift? [Answer: 65.1N]

Q.3 Mercury is poured into a U-tube as shown in the first figure. The left arm of the tube has cross -sectional area *A*1 of 10.0 cm^2, and the right arm has a cross-sectional area *A*2 of 5.00 cm^2. 100 grams of water are then poured into the right arm as shown in the second figure. (a) Determine the height of the water column in the right arm of the U-tube. (b) Given that the density of mercury is 13.6 g/cm^3, what distance *h* does the mercury rise in the left arm? [Answers: 20cm, 0.49cm]

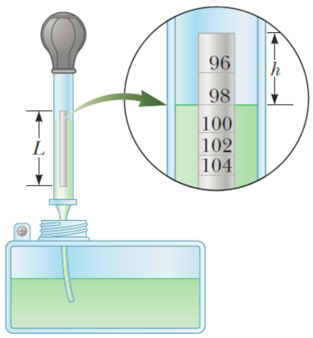


Q.4 The gravitational force exerted on a solid object is 5.00 N. When the object is suspended from a spring scale and submerged in water, the scale reads 3.50 N. Find the density of the object. [Answer: 3.33x10^3 kg/m^3]

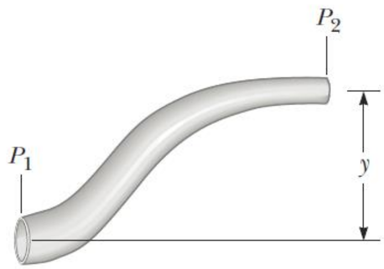


Q.5 A *hydrometer* is an instrument used to determine liquid density. A simple one is sketched in the figure. The bulb of a syringe is squeezed and released to let the atmosphere lift a sample of the liquid of interest into a tube containing a calibrated rod of known density. The rod, of length *L* and average density ρ_0, floats partially immersed in the liquid of density ρ. A length *h* of the rod protrudes above the surface of the liquid. Show that the density of the liquid is given by

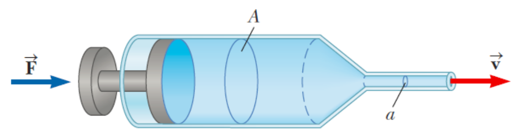
$$\rho = \frac{\rho_0 L}{L - h}.$$



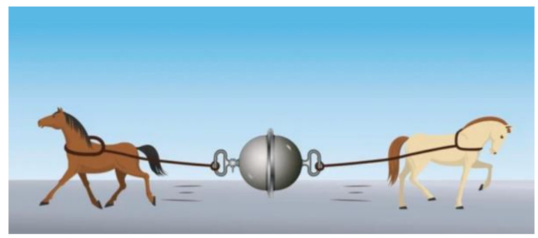
Q .6 Water moves through a constricted pipe in steady, ideal flow. At the lower point shown the pressure is P_1 =1.75 x 10^4 Pa and the pipe diameter is 6.00 cm. At another point y= 0.250 m higher, the pressure is P_2 =1.20 x 10^4 Pa and the pipe diameter is 3.00 cm. Find the speed of flow (a) in the lower section and (b) in the upper section. (c) Find the volume flow rate through the pipe.
[Answers: 0.638 m/s, 2.55 m/s, 1.80 x 10^{-3} m^3 /s]

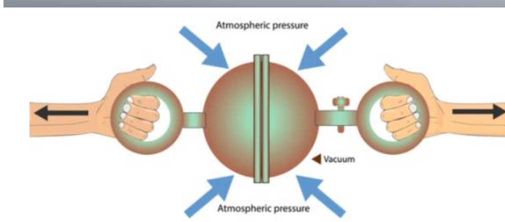


Q.7 A hypodermic syringe contains a medicine with the density of water. The barrel of the syringe has a cross-sectional area A = 2.50 x 10^{-5} m^2, and the needle has a cross-sectional area a = 1.00 x 10^{-8} m^2. In the absence of a force on the plunger, the pressure everywhere is 1.00 atm. A force **F** of magnitude 2.00 N acts on the plunger, making medicine squirt horizontally from the needle. Determine the speed of the medicine as it leaves the needle's tip. [Answer: 12.6 m/sec]



Q.8 In 1657, Otto von Guericke, inventor of the air pump, evacuated a sphere made of two brass hemispheres. Two teams of eight horses each could pull the hemispheres apart only on some trials and then "with greatest difficulty," with the resulting sound likened to a cannon firing. Find the force F required to pull the thin-walled evacuated hemispheres apart in terms the radius R of the hemispheres; P, the pressure inside the hemispheres; and atmospheric pressure P_0.
[Answer: $F = (P_0 - P)\pi R^2$]





Q.9 The hull of an experimental boat is to be lifted above the water by a hydrofoil mounted below its keel. The hydrofoil has a shape like that of an airplane wing. Its area projected onto a horizontal surface is A. When the boat is towed at sufficiently high speed, water of density ρ moves in streamline flow so that its average speed at the top of the hydrofoil is n times larger than its speed v below the hydrofoil. (a) Ignoring the buoyant force, show that the upward lift force exerted by the water on the hydrofoil has a magnitude $F \approx \frac{1}{2}(n^2 - 1)\rho v_b^2 A$. (b) The boat has mass M. Show that the liftoff speed is given by, Solution

$$v \approx \sqrt{\frac{2Mg}{(n^2 - 1)A\rho}}$$