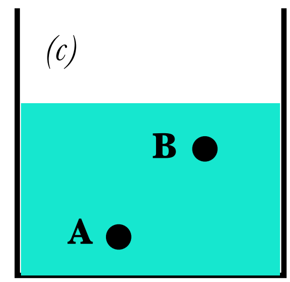
PHYS 2130 Additional Problems
Week 9 (Fluids)

Questions (1 point each)

a) A ___ is able to change its volume to fill the container it's in.
A) solid **B) liquid** **C) gas** **D) fluid**

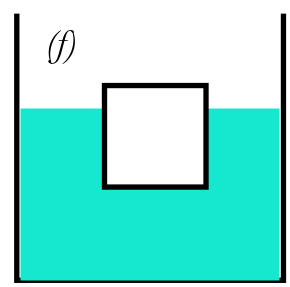
b) Which of the following types of force can exert a pressure?
A) friction **B) normal** **C) tension**



c) In the figure to the right, which point has the larger pressure?
A) A **B) B** **C) Both the same**

d) When I drink through a straw, which of the following happens?
A) My mouth increases the pressure of air in the straw.
B) The air in the straw pulls the liquid up into my mouth.
C) The atmosphere pushes the liquid up into my mouth.

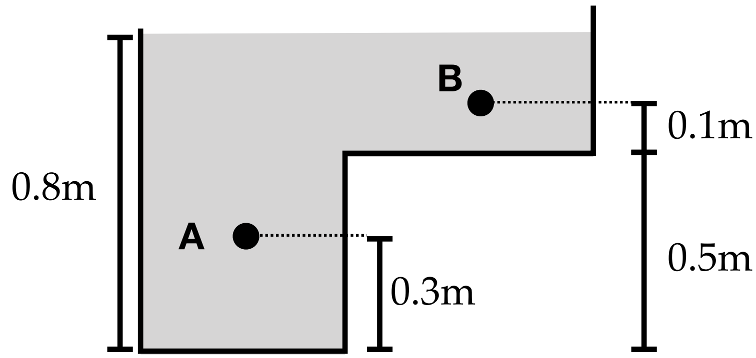
e) The force of buoyancy acts on
A) objects denser than water
B) objects less dense than water
C) both of these



f) The density of this object floating is water is closest to
A) 250kg/m³ **B) 500kg/m³** **C) 750kg/m³**

g) When a pipe widens, the water flowing through the pipe
A) speeds up **B) slows down**

1. This container is filled with water (density ρ=1000 kg/m^3). Atmospheric pressure is P_{atm}=1.01×10^5 Pa. Find the pressure at points A and B.

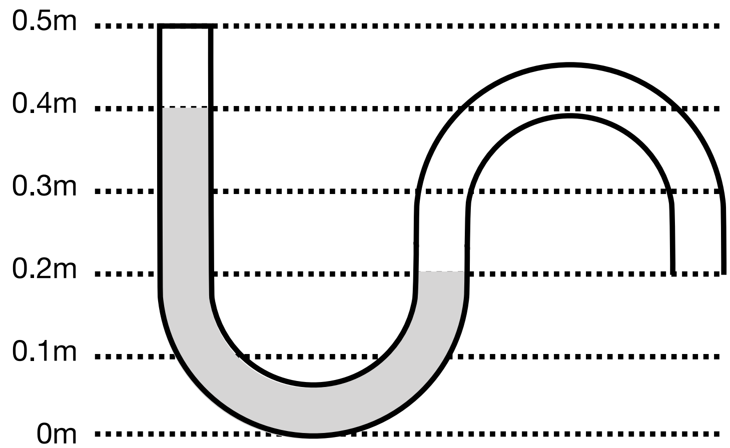


The pressure in a fluid is equal to $P = P_0 + \rho_f g d$ where d is the distance below the reference pressure P_0. The water is in contact with the atmosphere, so the pressure at the top of the water is P_{atm} and we should measure the depths from the surface.

Point A is a distance 0.8m–0.3m = 0.5m below the surface, so $P_A = P_{atm} + \rho g d$ = 101,000 + (1000)(9.8)(0.5)=**105,900Pa.**

Point B is a distance 0.8m–(0.5m+0.1m)=0.2m below the surface, so its pressure is
$P_B = P_{atm} + \rho g d$ = 101,000 + (1000)(9.8)(0.2)=**102,960Pa.**

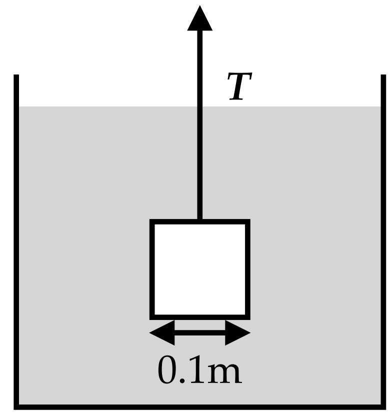
2. A glass tube is bent into the shape shown, and filled with water. The right end of the tube is open to the air, but the left end of the tube is sealed. What is the pressure of the gas inside the sealed left end?



In this picture, the reference point is the place where the liquid water is in contact with the open atmosphere, which is on the right side at y=0.2m. The gas in the sealed end is at the same pressure as the surface of the water on the left, which is at 0.4m, which is 0.2m above the reference point. Thus the pressure will be less than atmospheric pressure:

$P = P_{atm} + \rho_f g d = 101{,}000 + (1000)(9.8)(-0.2) =$ **99,040Pa.**

3. An iron cube with side 0.1m and density 7900 kg/m^3 is suspended in water by a string.
a) Use the density to find the mass of the block.
b) What is the force of buoyancy B on the cube?
c) What is the tension T in the rope?



a) The mass of the block is can be found from the density and the volume:

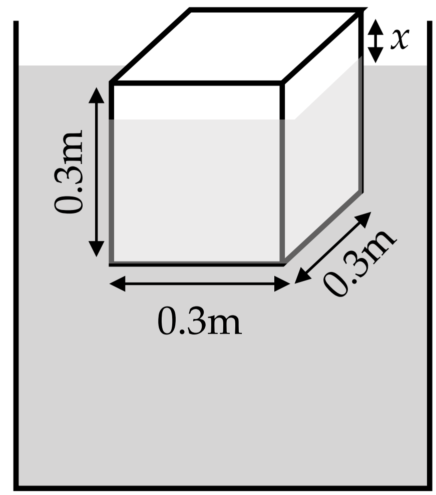
$$m = \rho V = (7900\text{kg/m}^3)(0.1\text{m})^3 = \mathbf{7.9kg}$$

b) The buoyancy force on the box is
$B = \rho_f g V = (1000\text{kg/m}^3)(9.8\text{m/s}^2)(0.1\text{m})^3 = \mathbf{9.8N}$.

c) The forces acting on the block are its weight (down), the tension (up), and the buoyancy (up). The block is stationary so
$T + B - mg = 0 \implies T = mg - B$

Thus $T = mg - B = 77.4\text{N} - 9.8\text{N} = \mathbf{67.6N.}$

4. A cube with side 0.3m and density 700 kg/m³ floats in water. What is the distance x between the top of the cube and the surface of the water?



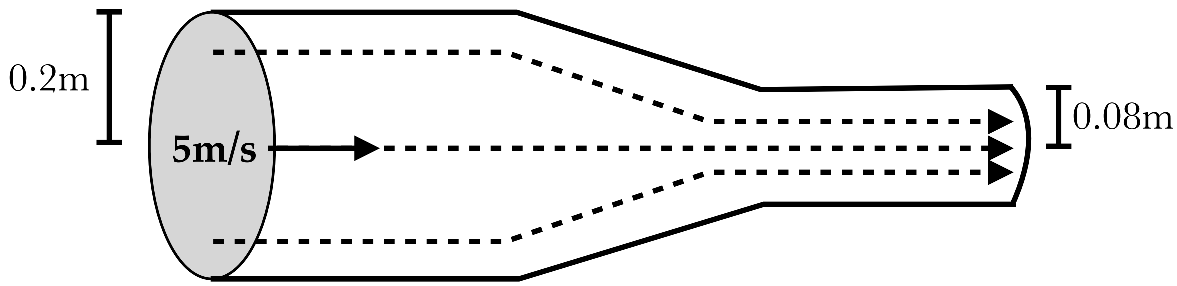
The hard way: the block feels two forces which balance one another: the weight downward and the buoyancy upward. The weight is $W=mg$, and the mass of the block is $m = \rho V = (700)(0.3)^3 = 18.9$kg, so $W=(63\text{kg})(9.8\text{m/s}^2) = 185.2$N. The buoyancy force is $B = \rho_f g V_{uw}$. The volume underwater V_{uw} is a rectangular solid which is 0.3m × 0.3m × $(0.3 - x)$m, and so

$$B = (1000)(9.8)[(0.3)(0.3)(0.3 - x)] = 882(0.3 - x) = 264.6 - 882x.$$

Thus $264.6 - 882x = 185.2 \implies 882x = 79.38 \implies x = \frac{79.38}{882}$=**0.09m** or 9cm.

The easy way: the fraction of a floating object under the surface is $\frac{\rho_{object}}{\rho_f} = \frac{700}{1000} = 0.7$. Thus the fraction that is *above* the water is 1–0.7 = 0.3 or 30%, and 30% of 0.3m is (30%)(0.3m) = **0.09m.**

5. Water enters a narrowing pipe, moving at 5m/s as shown. The radius of the pipe at the opening is 0.2m, but it narrows so that the radius at the other end is 0.08m. When water flows steadily, the water flow rate $Q=Av$ remains constant.



How fast is the water moving when it leaves the pipe?

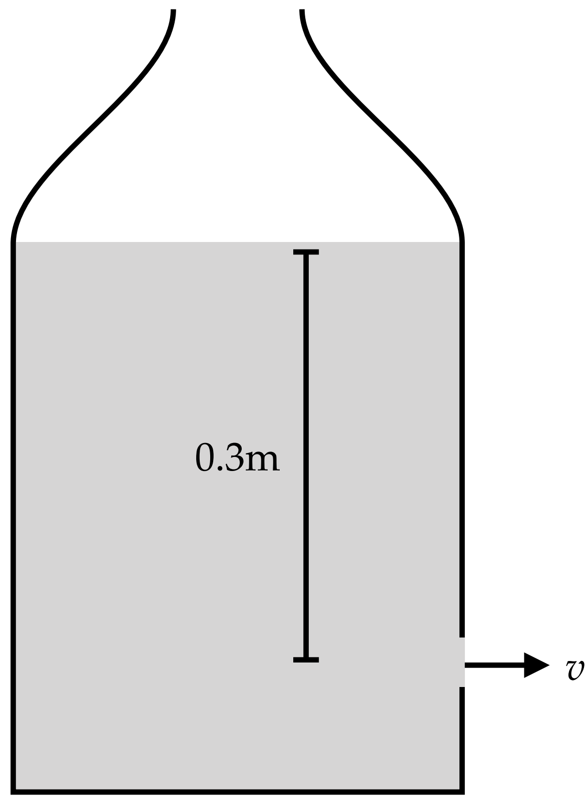
The flow rate through a tube is $Q=Av$.
On the left side, the cross-sectional area of the tube is $A = \pi r^2 = \pi(0.2\text{m})^2 = 0.126\text{m}^2$, and so the flow rate is $Q=(0.126\text{m}^2)(5\text{m/s}) = 0.628\text{m}^3/\text{s}$.

On the right side, the area is $A=\pi(0.08)^2 = 0.0201\text{m}^2$, and so the flow rate is $(0.0201)v$.

These must be equal, so

$$0.0201v = 0.628 \implies v = \frac{0.628}{0.0201} = \mathbf{31m/s}.$$

6. A bottle of water has a hole in it, 0.3 meters below the water level. The pressure of the water once it leaves the hole is atmospheric pressure. Find the speed of the water as it leaves the bottle.



Bernoulli's equation says that in a fluid, the pressure at any point is

$$P = P_0 + \rho g d - \frac{1}{2}\rho v^2.$$

We will treat the surface of the water as the reference point, so the pressure at the hole is

$$P = P_{atm} + (1000)(9.8)(0.3) - \frac{1}{2}(1000)v^2$$

But the pressure at the hole is also P_{atm} because it is in contact with the atmosphere, so

$$P_{atm} = P_{atm} + 2940 - 500v^2 \implies 500v^2 = 2940 \implies v = \sqrt{\frac{2940}{500}}$$

$=$**2.4m/s.**