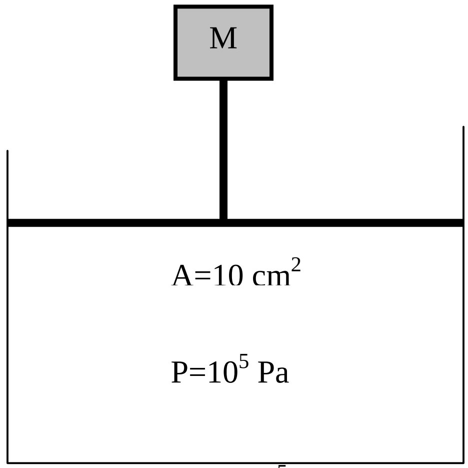
Physics 206a

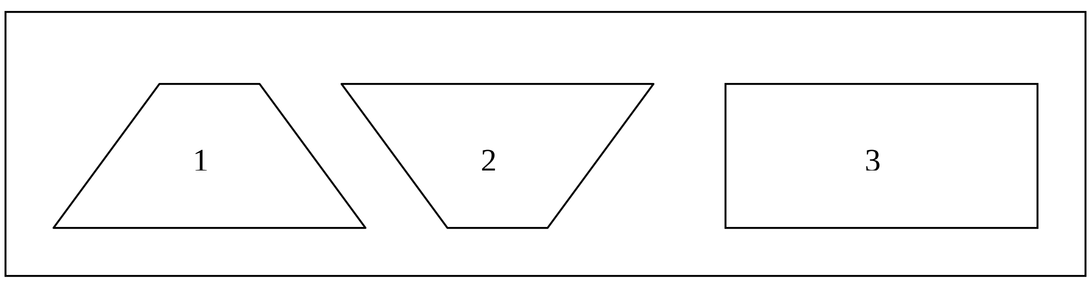
Homework Assignment XII

due April 9, 2007

(Note that this assignment is due on a Monday. This is because you have an exam scheduled for Friday, April 6.)



1. A sample of gas has a pressure of 10^5 Pascals. (By the way: The atmospheric pressure at sea level is 101,325 Pascals.) If this gas is held in a cylinder that is capped with a piston with an area of 10 cm^2, as shown, what mass can be placed on the piston so that it is just supported by the gas? (Assume that the piston and cylinder are housed in a vacuum—i.e., ignore the pressure of surrounding air.)
2. Now, again consider the system in the previous question. Take the pressure of the surrounding air to be 101,325 Pa. If the mass to be supported is 13 kg, what pressure of gas must be used to fill the cylinder?



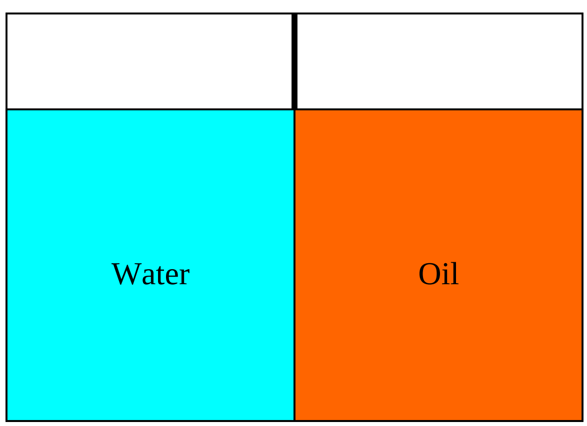
3. The three vessels pictured above are all filled with water and are all sealed. Which one has the highest pressure at the bottom? Which one has the highest pressure at the top? Explain your answers!

4. Molecules of N_2 (nitrogen) in the air have an average speed of $500\frac{\text{meters}}{\text{second}}$ at "room temperature" (about 300 K). (You will be calculating this value for yourselves in a later problem.) Consider a container holding nitrogen at 1 atmosphere of pressure. Assuming their collisions with the walls of the container are perfectly elastic, use the "impulse-momentum theorem" to determine the average number of molecules which impact a 1 cm^2 region of the wall of the container in one second. (Recall that the impulse-momentum theorem says that the total change in momentum in some interval of time is equal to the average force exerted multiplied by the time interval over which that force is exerted.)

5. A cylinder of wood is 17 cm long with a diameter of 3 cm. It has a density of $0.7\frac{\text{gram}}{\text{cm}^3}$. If the piece of wood is placed in water and its long axis is oriented vertically, how high above the surface of the water is the top of the cylinder?

6. Now, the cylinder in the previous problem is placed in a tank of oil, with a density of $0.8\frac{\text{gram}}{\text{cm}^3}$. How high above the oil will the top of the cylinder be found in this case?

7. A cube is to be built of steel sheets. (The cube will be hollow and filled with air when finished.) The density of the steel is $\rho = 7.9\frac{\text{gm}}{\text{cm}^3}$. The sheets of steel are ½ cm thick. What is the minimum width of the cube (i.e., the length of one side) such that the cube will float in water?



8. A tank of oil and a tank of water are separated by a single wall, as shown. Assuming the water and oil levels are the same initially, if a hole is drilled in the wall separating the tanks, which direction will fluid flow? I.e., will the water get into the oil tank or will the oil get into the water tank, or will they both stay put? Explain!

9. Again consider the tanks in the previous problem. Assume the hole is drilled 2 meters above the bottom of the tanks. To what depths, h_w and h_o (for "water" and "oil" respectively), must the tanks be filled for no flow to occur?

10. 2 gallons of water per minute flow through a pipe with a diameter of 5/8 inch. What is the speed at which the water is flowing?

11. If a connector is added to the pipe in the previous problem which increases the diameter to 7/8 inch, at what speed will the water flow through the enlarged section? Which section will have a higher pressure: The large one or the small one?

12. A scientist has a one-liter container of oxygen and two one-liter containers of hydrogen. All three containers are at the same pressure which is 15 pounds per square inch. They are also at the same temperature which is 400 Kelvin (quite hot). He mixes all three containers together and, after he recovers from the injuries he sustains in the ensuing explosion, he repeats the experiment using a stronger container. He finds that he has a container full of water vapor at the end. If the water vapor is allowed to cool to 400 Kelvin and the size of the container is adjusted (perhaps by means of a piston) so that the pressure of the water vapor is 15 pounds per square inch, what will be the volume of the container of water vapor? (This sounds more complicated than it actually is. Try drawing some pictures to help yourself understand what's going on.)

13. If I have a sample of a gas at 310 K at a pressure of 100,000 Pa, what is the volume, V, it occupies?