Problem Assignment for Lesson 1

1.1. A very powerful vacuum cleaner has a hose [01] ______ cm in diameter. With no nozzle on the hose, what is the weight (N) of the heaviest brick it can lift? The atmospheric pressure is 1.00 atm.

1.2. Find the pressure (atm) at the bottom of a swimming pool [02] ______ ft deep. The atmospheric pressure is 1.00 atm.

1.3. Do Lab 1.1, Pressure in a Liquid. (See description.) Enter (a) the height \( h \) (m) of the liquid from the top of the liquid in the bottle to the top of the liquid in the tube, (b) the pressure, \( P - P_0 \) (Pa), of the air in the bottle relative to atmospheric pressure, and (c) the density (kg/m\(^3\)) of the liquid.

1.4. Do Lab 1.2, Buoyancy. Enter (a) the weight \( W \) (N) of the beaker (taken from the second part of the video) (b) the force \( F \) (N) of the beaker on the scale after the object is lowered into the water, (c) the buoyant force \( B \) (N) of the water on the object, (d) the volume \( V \) (m\(^3\)) of the object, and (e) the density \( \rho \) (kg/m\(^3\)) of the object. Give the answers to parts (a) and (b) to 4 significant figures. Give the answers to parts (c) and (d) to 3 significant figures. Give the answer to part (e) to 2 significant figures.

1.5. The density of a block of wood is [03] ______ kg/m\(^3\). Its mass is 689 g. We tie the block to the bottom of a swimming pool using a single strand of string so that the block is entirely submerged. Find the tension (N) in the string.

1.6. A glass of water weighs 4.78 N. A steel bolt weighs [04] ______ N. The density of steel is 7.86 g/cm\(^3\). We tie the bolt to a string and lower the bolt into the glass of water so that the bolt is fully submerged in the water but is not touching the bottom or side of the glass. (a) How much does the glass of water weigh (N) now? (b) What is the tension (N) in the string?

1.7. A raft is made of solid wood and is 2.31 m long and 1.59 m wide. The raft is floating in a lake. A woman who weighs [05] ______ lb steps onto the raft. How much further (cm) into the water does the raft sink? You do not need the thickness of the raft or the density of the wood to solve this problem.
1.8. Consider a man whose weight is \( w = \underline{06} \) lb. Find the minimum radius (m) of a helium balloon that will lift him off the ground. The density of helium gas is 0.178 kg/m\(^3\), and the density of air is 1.29 kg/m\(^3\). Neglect the weight of the deflated balloon itself. Assume that the shape of the balloon is a sphere. Neglect the buoyant force of the air on the man. (b) If we replace the helium with hydrogen gas, how much more weight (lb) can the balloon lift? The density of hydrogen gas is 0.089 kg/m\(^3\). (Find how much weight in excess of \( w \) the same balloon inflated to the same volume can lift.) Caution: the answer is not \( w \) anymore. The buoyant force is the same. Only the weight of the gas has changed.

1.9. Challenge problem. (extra credit) A block of wood floats on water. The density of the wood is \( \underline{07} \) g/cm\(^3\). Its mass is 243 g. Find the minimum mass (g) of lead we must attach to the block so that it will sink, along with the lead. The density of lead is 11.3 g/cm\(^3\). Caution: you must take into account the buoyant force on the lead, as well as on the wood.

1.10. I find that I can blow 1000 cm\(^3\) of air through a drinking straw in \( \underline{08} \) s. The diameter of the straw is 5 mm. Find the velocity (m/s) of the air through the straw. Give the answer to 2 significant figures.

1.11. Suppose the wind speed in a hurricane is \( \underline{09} \) mph (mi/h). (a) Find the difference in air pressure (Pa) outside a home and inside a home (where the wind speed is zero). The density of air is 1.29 kg/m\(^3\). (b) If a window is 61 cm wide and 108 cm high, find the net force (lb) on the window due to the pressure difference inside and outside the home.
Lab 1.1: Pressure in a Liquid

In this lab you will measure the density of an unknown liquid. You do this by forcing the liquid up a tube using a known amount of pressure (see figure).

Watch the video, Lab 1-1 Pressure in a liquid. At the end of the video, record the gauge pressure $P - P_0$ of the air in the bottle. Note that $P - P_0$ is the pressure relative to atmospheric pressure. Also note that the units of pressure measured by the gauge are oz/in$^2$ (16 oz $= 1$ lb).

To determine the height $h$ of the liquid in the tube, double click on the file named logger pro lab1-1 in your CMBL folder. This will start the Logger Pro program. In the center of the window, there will be an image of the lab. (Compare with the figure.) There will also be a white meter stick in the image. Use the Set Scale tool to set the scale of the image to that meter stick. Use the Photo Distance tool to measure the distance from the top of the liquid in the bottle to the top of the liquid in the tube. Compare the image with the figure on this page.

Using $P = P_0 + \rho gh$, calculate the density $\rho$ of the liquid.
Lab 1.2: Buoyancy

In this lab, we will measure the buoyant force of water on some object submerged in the water.

Watch the video, Lab 1-2 Buoyancy. Record the weight $W$ of the container of water, the mass $m$ of the object, and the force $F$ of the container of water on the scale when the object is submerged in the water.

From Newton’s Third Law, we know that the buoyant force of the water on the object is equal and opposite to the force of the object on the water. The force of the water on the object is upward, so the force of the object on the water is downward. When we submerge the object in the water, the force on the scale increases by an amount equal to the buoyant force $B$ of the water on the object: $F = W + B$. Knowing the values of $W$ and $F$, we can easily calculate $B$.

From $B = \rho_{\text{water}} g V$, we can then calculate the volume $V$ of the object and its density $\rho_{\text{object}} = m/V$. 