Archimedes' Principle states *the buoyant force on a body immersed in a fluid is equal to the weight of the fluid displaced.* This can be expressed by the formula:

$$F_B = \rho_F \, g V_F \tag{1}$$

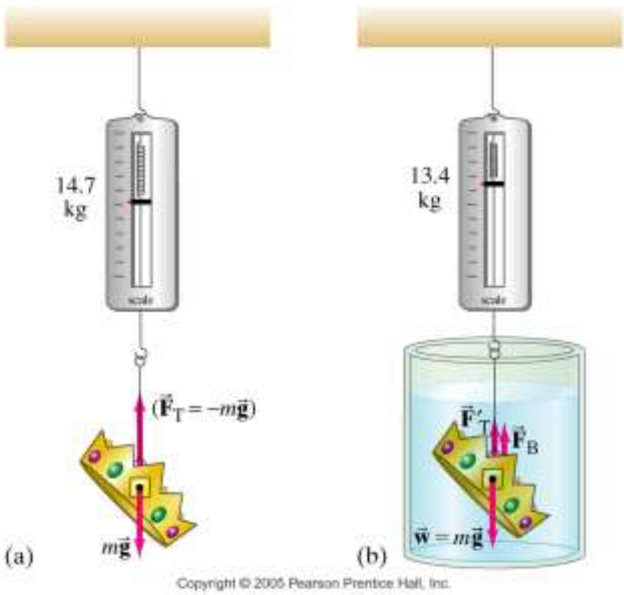

Figure 1: Crown weight out and in water

If the object is denser than the fluid, it can be suspended from a force sensor as shown in Fig. 1a, then the buoyant F_B can be measured and if the density of the fluid (ρ_F) is known, we can solve for the density of the object (ρ_o) .

$$\sum F = 0$$

$$F_T + F_B - m_O \, g = 0$$

Thus the buoyant force is just the difference between the weight in air and the weight in water.

$$F_B = m_0 \; g - F_T \tag{2}$$

By Archimedes principle we know

$$F_B = \rho_F \, g V_F$$

so we can solve for V_f and then use the fact that $V_o = V_f$. Since

$$\rho_o = \frac{m_o}{V_o} \tag{3}$$

Substituting and rearranging we find:

$$\rho_0 = \left(\frac{m_o \, g}{m_o \, g - F_T} \right) \rho_F \tag{4}$$

Procedures:

Sinking Objects:

You will use a force sensor to measure the weight in air, and the weight in two different liquids, of two different cylindrical masses. Use Eqn. 4 to calculate the density of each material make up of the cylinders. You will do this for water and rubbing alcohol.

Remember you need the density of the fluids. Rubbing alcohol is typically alcohol mixed with water - look on the bottle to see type of alcohol and mixture with water. Use the internet to determine fluid densities. Once the material densities are calculated, use the internet to hypothesize the two materials of the cylinders. (Be sure to include all URL sites accessed.)

If you are writing a formal lab report – please repeat this process 3 times for each liquid. Take the standard deviation for the measurements and discuss results examining accuracy (from hypothesized materials) and precision by examination of the standard deviations.

Floating Objects:

For objects that float, we can see from Fig. 2, that

$$\rho_F V_F g = \rho_o V_o g \tag{5}$$

If h_o is the height of the object and h_F is the depth to which the object sinks, then $V_o = A h_o$ and $V_F = A h_F$, then

$$\rho_F A h_F = \rho_o A h_o \tag{6}$$

Thus

$$\rho_o = \frac{h_F}{h_o} \rho_F \tag{7}$$

We will use this formula to determine the density of two cylindrical objects.

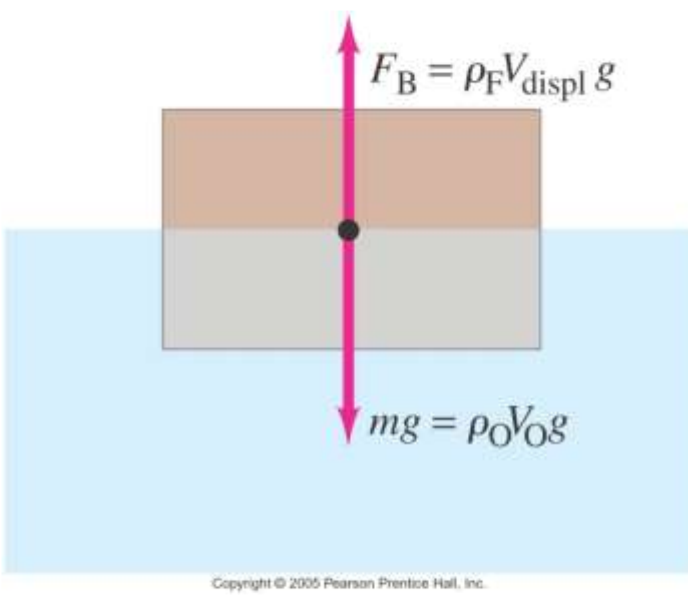

Figure 2: Image of floating wooden block

Procedure

Select a block of wood or other available material, and take a measurement of the total height of the block.

Float this block in water. Measure the fraction of the block that is underwater by using the gridded scale on the block. Measures the gridded height. Use Eqn 7 to calculate the density of the material.

Repeat again after drying the block off – use the electronic calipers to make the 2nd measurement.

Compare values – what can you say about precision of the two measurements? Explain.

Is the grid on the wood easier to use than the calipers? Explain reasoning.

How could you combine these measurement devices to improve precision? Explain.

Use this measurement to determine the density of the floating object.

Use the internet to hypothesize what type of wood/material was floating due to the calculated density.

Does the material identified and its density found consistent with the material floated? Explain.

Formal Lab report additional Questions/Procedure:

Looking at the two measurements taken above - comment on precision.

Take an additional three more measurements by removing the block – drying it as best as possible and re-placing it in the fluid. Use the best method hypothesized above.

What was found as the precision of the repeated measurements?

How did the values compare with the hypothesized material's density found on the internet? Discuss.