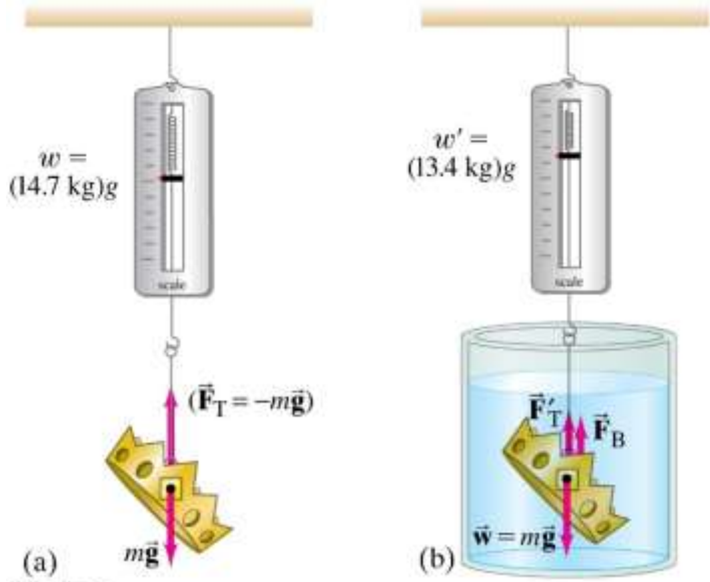
PHYS101 Lab: Density and Archimedes' Principle
Instructor: James Cutright

Your entire group can email the spreadsheet for this lab to me as their submission for the lab. Make sure to answer the questions at the end of the lab in your excel sheet.

Equipment Needed:

Triple Beam Balance	Ruler
Three Unidentified Metal Samples	String
Micrometer 0-25 mm (Optional)	Large Graduated Cylinder
Micrometer 25-50 mm (Optional)	

Theory: Buoyant force is the upward force resulting from an object being wholly or partially immersed in a fluid. A body immersed wholly or partially in a fluid experiences a buoyant force equal in magnitude to the weight of the volume of fluid that it displaced.



If you weigh and object out of water, and then submerge it in water the apparent weight of the object will decrease. This change in weight that you see on the scale will allow you to determine the density of the material that you are studying. You can do this with something called "Specific Gravity". Specific Gravity is the comparison of the density of a material to the density of water. That means that water is considered our "coordinate system".

By definition, the specific gravity is:

$$SG = \frac{\rho_{sample}}{\rho_{water}}$$

When an object is fully submerged in water, the amount of water volume that it displaces is equal to the volume of the object. If we multiply the top and bottom of the Specific Gravity equation by the volume of the sample/water displaced and by gravity, we will get the weight of the sample and the weight of the water displaced:

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$$SG = \frac{\rho_{sample}}{\rho_{water}} = \frac{(\rho_{sample})(V_{sample})g}{(\rho_{water})(V_{water})g} = \frac{W_{sample}}{W_{water}}$$

It just so happens that the weight of the water that is displaced by the object is also the buoyant force when the object is submerged in water, i.e. $F_B = W_{water}$. The buoyant force is equal to the difference in the original weight of the object out of water, and the apparent weight when it is submerged:

$$F_B = W_{water} = W_{sample} - W'_{sample}$$

This provides a very quick way, then, to determine the specific gravity of an object with an unknown density, just dunk it in water!

$$SG = \frac{W_{sample}}{W_{water}} = \frac{W_{sample}}{W_{sample} - W'_{sample}} = \frac{M_{sample}}{M_{sample} - M'_{sample}}$$

Notice that in the math I canceled out the acceleration of gravity, since you are actually measuring the mass of the samples. Once you know the specific gravity, you can multiply by the known density of water, 1000 kg/m^3, to determine the density of the sample.

$$\rho_{sample} = SG_{sample}(\rho_{water})$$

A simplified way to measure the density of an unknown sample is to use the fundamental definition of mass density, the ratio of the mass to the volume.

$$\rho = \frac{m}{V}$$

Procedure for Each Sample:

1. Measure the diameter and length of the sample and record the results.
2. Each sample is a cylinder. You should be able to determine the volume of the cylinder, since: $V = \pi r^2 h$.
3. Measure the mass of a sample of metal out of water.
4. Fill a graduated cylinder with enough water that you can easily submerge a sample in it.
5. Record how much water is in the graduated cylinder. Make sure to read the bottom of the meniscus, not the top.
6. Tie a string to the sample and tie the other end of the string to the bottom of your triple beam balance. If you submerge the object in the water, you will notice that the weight of the object decreases. That is the apparent weight of the object.
7. With the sample in the water you can measure its apparent weight and the final volume of the water in the graduated cylinder. You can use this to find the volume of water displaced, which happens to be equal to the total volume of the object.
8. You should now have enough data to calculate the density of each of your samples with three different methods:
    1. Measure mass of the object. Measure the dimensions of the object and calculate the volume. Use the definition of density.

   2. Measure the mass and volume of the object. Use the definition of density.
   3. Measure the Specific Gravity of the Sample. Use the definition of specific gravity and density to find the density of the sample.

9. Use the table of identified samples to calculate the % error associated with each of your density calculations.

Questions: Make sure to include the answers to the questions in your excel sheet.

1. Based on your data, are all three methods valid methods for calculating the density of a sample?
2. Do you think that you could identify a material based only on its density?