NTSC 395
HOMEWORK #1-- SOLUTIONS

Questions 2 and 3 ask what you predict will be your results for density if you repeated the experiment with half as many coins and then with twice as many coins.

Remember that density is the ratio of mass/volume; density measures how much mass is contained within a certain volume. So if you have twice as many coins, you should measure twice as much mass. However, twice as many coins should also displace twice as much water yielding a volume that is twice as great as in the original experiment. Therefore, if both mass and volume double, the ratio stays the same. Let' s look at this with some constructed data. Suppose you measure 5 objects; their aggregate mass is 20 g and their displaced volume is 5 cm^3. Therefore, the density of this sample is:

$$\text{density} = \rho = \frac{\text{mass}}{\text{volume}} = \frac{20\text{ g}}{5\text{ cm}^3} = 4\text{ g}/\text{cm}^3$$

Now, suppose both mass and volume double when we use twice as many items of this substance :

$$\text{density} = \rho = \frac{\text{mass}}{\text{volume}} = \frac{40\text{ g}}{10\text{ cm}^3} = 4\text{ g}/\text{cm}^3$$

In both cases, the density is the same. Since density is the ratio of mass and volume, the value of density should stay unchanged no matter how many cents you used in your measurements.

This tells you a very important point about density : density is a basic property of a substance and does not change if the sample size changes. Certainly the mass of a greater number of coins will increase, but so will the volume. The density will be the same if you (accurately) measure one, 10, 100 or 1000 coins.

Several of you made some very insightful comments about the accuracy of this experiment. You noted that if you used fewer coins, the displacement would become so small that it would be hard to measure the displacement of water in the graduated cylinder accurately. You also noted that if you used many coins, then your measurements for both mass and volume would be more accurate. These observations do not mean that the density is acutally changing value; rather, they point out that the accuracy of your observations will increase with a larger sample size.

Questions 4 and 5 asked for densities of common substances, and also for the densities of some very high density and low density objects. In showing the solution for these question, let me also show explicitly what I mean by citing references.

For the objects whose densities I asked you to find in question 4, we have :

• density has a density (at 4^o C) of 1 g/cm^3

• air has a density (at 0^o C and surface pressure) of $1.29 \times 10^{-3}\ g / \text{cm}^3$
•copper has a density of $8.92\ g / \text{cm}^3$

Notice the proper use of units; you must always use the proper set of units and show them clearly and consistently.

Some students noted that osmium is the densest metal found on Earth, with a density of $22.5\ g / \text{cm}^3$, which is slightly greater than the density of iridium. (http://hypertextbook.com/facts/2007/KarmenHo.shtml).

Many students found that aerogel is regarded as the lowest density solid known. For an interesting display of some very high and low density objects, see the table on order of magnitudes of densities, found at :
http : // en.wikipedia.org/wiki/Orders_of _magnitude _ (density)

Please see above for an example of proper citation of websources. The basic idea is that you should provide enough specific information to allow the reader to find and look up your source easily. Simply stating : ' Wikipedia : osmium' is not sufficient.

Question 6 asks you to calculate the population density of Chicago and of your hometown. The data we need are the population and land area of the cities. For Chicago, these data are :

population : 2, 853, 114
(http : // en.wikipedia.org/wiki/Chicago_metropolitan _area)

land area : 227.2 square miles (mi^2)

$$\text{population density} = \frac{\text{population}}{\text{land area}} = \frac{2,853,114\ \text{people}}{227.2\ \text{mi}^2} = 12\,557.7\ \text{people} / \text{mi}^2$$

Note use of units throughout the presentation of data and throughout the calculation.