Experiment 2

Determining the Masses of a Nickel and a Penny

Equipment needed: 5 pennies, 5 nickels, 1 centimeter scaled ruler.

For this experiment you will use an Excel spread sheet already generated for this experiment and found in the Content section on Pilot. This file is named “Penny and Nickel Worksheet”. Select the file and then **Download** the file and **Open** the file **in Excel**. The Download button is below the preview of the file when you open the file in Pilot.

In the last experiment you were given tables of measured quantities so that you could determine the density of two objects along with their associated uncertainties. In this experiment you will measure the diameters and heights of a Nickel and of a Penny. The average values of these dimensions will be used in an equation to determine the volume of each.

(Equation 1)

In the above equation, V represents the volume, D represents the diameter of the coin, while H represents the height of the coin.

By knowing the densities for each of the coin types you can determine the average mass for the penny and the average mass for the nickel.

(Equation 2)

M represents the mass, and ρ represents the density.

U.S. coins are not minted from pure metals these days. They are made from a combination of metals. The U.S. nickel is a Copper coin plated with Nickel. The percentages are: 75% Copper and 25% Nickel. The U.S. penny (after 1982) is a Zinc coin plated with Copper. The percentages are: 97.5% Zinc and 2.5% Copper. Using these percentages, and the densities of each of the metals (Copper, Zinc, Nickel) listed on the Excel spread sheet worksheet, determine the average densities for the penny and for the nickel.

Since both coins are thin, and you are using a centimeter scaled ruler to measure with, the height of a stack of 5 coins will be measured (5 pennies for one set of measurements, 5 nickels for another set of measurements). From this the height of a single coin can be determined by dividing the height for a stack of five coins by 5.

Measure the diameter of each coin type 5 times and determine an average diameter for the penny, and an average diameter for the nickel. Since you have 5 of each coin type measure the diameter of each individual coin once and enter these diameters in the appropriate table on the Excel spread sheet worksheet.

Part 1: Penny

Using the percentages listed above for the metal composition of the penny write the Excel equation to determine the Average Density of a Penny in the yellow box provided. For the five measurements of the Diameter of Pennies use your centimeter scaled ruler and measure directly across each of the pennies’ diameters and record them in the Diameter of Pennies table. Notice that you are measuring in centimeters (not millimeters). A centimeter is approximately equal to the width of your smallest finger nail. Make sure that you estimate to the hundredths place of each of your measurements as accurately as you can. Just as you did in Experiment 1 use the AVERAGE function to determine the Average Diameter of Penny. Then use the STDEV function to determine the standard deviation of the 5 diameter measurements. You will recall that the equation for the Total Uncertainty of a measured quantity is:

Where σ represents the standard deviation of the 5 measurements, and sys represents the systematic uncertainty of each measured value.

When measuring the Height of Penny Stack make sure that the zero position on your centimeter scale aligns a perfectly as you can with the bottom surface of the stack. If your ruler has a little space between the end of the ruler and the zero mark, move the stack to the edge of a table or book cover and align the zero mark to the bottom of the stack. Again, estimate each of your measurements to the nearest hundredths place. With each height measurement jostle the coins together and restack them. This will allow them to settle differently on top of each other slightly. Once you have all five measurements determine the Average Height of Penny Stack, the Standard Deviation of the Height, and the Total Uncertainty of the Height.

Use equation 1 to determine the Volume of the Penny Stack. Write an Excel equation to determine this. Write another Excel equation to determine the Volume of a single Penny.

Next, write an Excel equation to determine the Mass of a single Penny and its associated Total Uncertainty using equation 2 to guide you.

Finally, show the range values (from lowest to highest) of the mass.

Part 2: Nickel

This part is done exactly the same way as part 1, except you are using the five nickels.

Results

Discuss whether, or not, the calculated masses for the penny and for the nickel are acceptable. Handbook values are: Penny = 2.5 grams; Nickel = 5.0 grams.

Questions for Discussion

1. In the Results section above you discussed whether the calculated values are in agreement with the accepted handbook values. If either of these are not in agreement what possible reasons can you give as to why they are not. Refer to the process of how you measured the diameter and the height of the stack and relate it to the equation for the volume of the stack.
2. Use the percent error equation (found in experiment 1) to show how close your calculated values for the mass of the penny and for the mass of the nickel are to the accepted values. Again, use a reasonable maximum % Error when doing the comparisons.
3. A student wants to increase the number of coins stacked on top of each other to increase the accuracy of determining the volume for one coin. Would this technique work? Consider your answer for question 1 in answering this question.
4. Devise a different method of measuring the volume of the coins that would result in a more accurate value than measuring a stack of coins.