

**NOTE: THIS IS THE “LAB MANUAL/INSTRUCTIONS” AND DOES NOT FOLLOW THE EXACT FORMAT THAT YOU MUST USE FOR YOUR LAB WRITE UP. SEE “LAB INFORMATION” SHEET FOR EXACT FORMAT TO BE USED.**

**Title:** The Density of a Metal Cylinder

**Purpose:**

To calculate the density of a metal cylinder by measuring its mass and volume then comparing this density with the handbook value for that particular metal.

**Equipment:** Calipers, Metal Cylinder and Balance Scale

**Theory:**

There are several equations you will need to successfully complete this laboratory experiment. One of them is the volume of a cylinder, which is as follows:

$$V_{cylinder} = V_{cyl} = \pi r^2 h$$

where  $h$  = height and  $r$  = radius

The density,  $\rho_{calculated}$ , is related to the average mass,  $\bar{m}$ , and average volume,  $\bar{V}$ , and will be calculated in the following way:

$$\rho_{exp} = \frac{\bar{m}}{\bar{V}}$$

The arithmetic average of each quantity measured was calculated with the following formula, where  $n$  = the number of measurements:

(Normally you will **not be reminded to include** the 2 **equations below** in the theory, assuming they are relevant!)

$$\bar{x} = \sum_{i=1}^n x_i / n$$

\*\*where the bar over the top of  $r$ ,  $h$ , and  $m$  represents the average value of that measurement.

The Percent Difference between the Handbook value for the density of a cylinder and the calculated value for the density is shown below:

$$\text{Percent Difference} = \frac{|Value_{theoretical} - Value_{experimental}|}{Value_{theoretical}} \times 100$$

**Procedure:**

1. Measure the cylinder's length and diameter using calipers 5 times each. Make sure to measure the dimensions of the cylinder at a different place each of the 5 times and then calculate the average length and average diameter. Calculate the average radius then record all 10 measurements and their averages in a data table. (Don't forget to estimate the random error in your measured values and make sure to record this in the data table as well! You won't be reminded of this in the future!)
2. Measure the mass of the metal cylinder 5 times and calculate the average mass. Record all of these masses in a data table.

**Analysis/Conclusion:**

The uncertainty or random error (which is a measure of the PRECISION of your measuring devices) in your measurements of length, diameter/radius and mass can be obtained by estimation as explained on page 4 of the “Laboratory Information Sheet” under “estimated random error.” Perform error propagation to calculate a **percent error** by using the method of exact differentials taught in class.

Use the following formula to calculate a **percent difference or percent discrepancy** between your experimental result for density and the theoretical/handbook value for density, which you will look up.

$$\text{Percent Difference} = \frac{\left| \text{Value}_{\text{theoretical}} - \text{Value}_{\text{experimental}} \right|}{\text{Value}_{\text{theoretical}}} \times 100$$

The percent difference is a measure of your ACCURACY. (Note that ACCURACY and PRECISION have two different meanings, we will discuss their differences but be thinking about this.)

Finally, in your conclusion, **compare the percent difference** you obtained **to the percent error** you calculated. (*Note: Using the word “compare” above, means you are to state each percentage then discuss the success of your experiment in light of which is the larger percentage. Basically you want to answer the following question: Given the precision of your measuring devices was your experiment successful? [The way to determine this is to determine if your % difference is within your allowed margin of error {i.e. is the % difference less than the % error?}], if the answer is YES then your experiment was successful. Whether your experiment is “successful” or not, you still have several sources of error to account for in your conclusion, e.g. air resistance on ball falling, friction in pulleys, etc. Just restating the random error in your measurements is not allowed, as it is an obvious source of error!)*)