Volume and Density Lab

Measurements, Calculations and Uncertainties

PHYS 104L

1 Goal

The goal of this week's lab is to check your understanding and skills regarding the measurement process, using measurements in calculations and identifying uncertainties in calculated values. You will also test predictions based on your measurements and calculations.

2 Introduction

In addition to the skills and ideas from the prior two weeks labs, you will need to know a couple additional ideas as well. For one, you will be calculating the **Volumetric Mass Density** of different objects and using this quantity in other calculations. Volumetric mass density (often just referred to as "density") is the ratio of the mass of an object to the volume of space that mass occupies.

$$\text{Density} = \frac{Mass}{Volume}$$

We will be measuring mass in units of grams (g) using a digital mass balance. The density of an object depends on the material it is made of, not the shape of that object. For a given substance, (copper, aluminum, water, lead, acrylic) the density stays relatively constant and we have expected values for them in units of g/cm^3.

Material	Accepted Density (g/cm^3)
Al	2.70
Cu	8.85
Brass	8.28
Lead	11.34
Zinc	7.14
Acrylic	1.20
AISI 52100 Chromium Steel	7.81
PVC	1.35

In this lab, you will also, for the first time, be asked to compare an experimental result with an expected value. How does one do this? It is important to remember than any experimental result should be expressed in the form of a Best Estimate $\pm$ Uncertainty. This Best Estimate and corresponding Uncertainty correspond to a range of possible values; the upper limit being the Best Estimate + Uncertainty and the lower limit being the Best Estimate – Uncertainty. Based on the data, the actual value of the calculated quantity is thought to be somewhere within that range. To check for agreement with theory or some accepted value, you just have to see if the theoretical/expected value is within that range, i.e., a value the experimental data would be consistent with. An easy, concise way show this process in a lab report is using what we call a "four line summary". The first line is your **Result** in the form of Best Estimate $\pm$ Uncertainty. The second line is your **Range** written in the form of lower limit -> upper limit. The third line is your **Theory** or **Expected** value. The fourth line is then an explicit statement (Yes or No) of whether the expected value is in **Agreement** with the experimental result. A four line summary would look like this

Result	273 ± 7 Seconds
Range	276 -> 280 Seconds
Theory	275 Seconds
Agreement	Yes

When asked to compare a result with a theoretical or expected value, you should do so using the four line summary format.

3 Part 1: Finding Density

Procedure Part 1

1.) You will be given 4 objects made of materials for which you have expected values for the density. Using a digital mass balance, measure and record the mass of each object. Also record the reading error for these measurements.

2.) Use a Vernier Caliper to measure the physical dimensions of the objects (height, length, width, diameter,… depending on the object's shape). Record these values and the reading error for these measurements.

Calculations Part 1

1.) Calculate and list the best estimate for the volume of each object.

2.) Calculate and list the uncertainty in the volume best estimate by using the upper and lower limit technique.

3.) Calculate and list the density for each object.

4.) Calculate and list the uncertainty in the density for each object using the upper and lower limit technique.

5.) Compare the density Result with the Expected Value for each of the four objects using the four line summary format. (4 four line summaries, one for each object)

4 Part 2: Finding mass

Procedure Part 2

1.) You will be given 3 objects with known densities. You are **not** allowed to measure the mass of the objects directly using a balance.

2.) You are to make measurements and perform calculations to determine the mass of each object. You are also to determine the uncertainty in that calculated best estimate for the mass of each object.

3.) Write down your results for the mass of each object, in the form of best estimate ± uncertainty, in the table provided for each of the three objects.

4.) At this point, bring the objects and your table with calculated values up to the instructor. The instructor will use a balance to measure the mass of each object and check to see if your experimental results are in agreement with the actual measured masses.

5.) In the lab report you turn in, you will need to list all the data you measured and show how you calculated the best estimates for mass and the uncertainties as well.

Lab Questions

1.) In finding the densities of the objects, where does most of the uncertainty in the density come from? Explain why.

2.) How would your uncertainty in the masses have changed if the digital mass balance only read to the nearest 1.0 g? How would your density results have changed?

3.) Did your experimental results tend to agree with the accepted values for density or not? What does this tell you about your measurements?

Volume and Density Lab

Data Sheet / Report

PHYS 104L

Part 1

Object				
Mass (g)				
Reading Error (g)				

Measured Dimensions and Reading Errors:

Object 1 Object 2 Object 3 Object 4

Calculating Volume and Density:

Object 1

Volume Result = _____ Density Result = _____

Calculating Volume and Density:

Object 2

Volume Result = _____ Density Result = _____

Object 3

Volume Result = _____ Density Result = _____

Calculating Volume and Density:

Object 4

Volume Result = _____ Density Result = _____

Part 2

Experimental Results Table

Object Description			
Calc. Mass Result (g)			
Calc. Mass Range (g)			
Actual Mass (g)			
Agreement? (Y/N)			

Show Measurements and Calculations for each object below and on the next page.