PCS 211 Lab 1 : Uncertainity

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1 Introduction

We shall in the due process of the laboratory experiment, aim to calculate the density of some unknown given metal mass (metal block) through measuring mass and volume through various method.

We then shall use the information from the experiment to estimate the substance type of the metal block by comparing the densitiy of the given metal block to the densities of some known metals.

We shall futher aim to calculate the uncertainities in measurments of the mass and volume through subsequent different methods and find the most optimal method for the purposes of evaluating the densities of any substance.

2 Theory

Before beginning this investigation we must know the methods and the theory behind the investigation and the due course of action.

2.1 Mass Measurment

We shall be measuring the mass of the unknown metal block by the use of a triple beam mechanical balance scale

2.2 Volume Measurement

The volume of the metal block can be measured by various ways:

- Vernier Caliper
- Ruler
- Archimedes Principle

2.2.1 Volume Measurement by Vernier Caliper

The volume can be measured by induvidually measuring the dimensions of the meatal block and then simply multiyplying those dimensions to obtain the volume of the metal block.

$$V = l \times b \times h$$

Where V is the volume, l is the length, b is the breadth and h is the height of the metal block.

2.2.2 Volume Measurement by Ruler

The measurement process of the volume of the metal block by ruler is the same as the one done using the vernier caliper.

The difference these both instruments have is the accuracy in measurement of volume.

2.2.3 Volume Measurement by Archimedes Principle

The volume can be measured by using the archimedes principle by immersing the metal block in a beaker filled with fluid (water) and calculating the difference of the fluid levels before and after immersion.

2.3 Density

Once we find out the **mass** and **volume** of the metal block with its subsequent uncertainities, we can finally find the **density** (the aim of the experiment) of the metal block.

Density is a function that is mathematically defined as,

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

Where, m is the **mass** of the metal block and V is the **volume** of the metal block.

Note: After measuring the mass and the volume of the metal block, we can find the density of the metal block, by dividing both the quantities.

3 Materials Required

- Unknown Metal Mass
- Triple Beam Mechanical Balace Scale
- Vernier Caliper

- Ruler with 1cm least count
- Beaker with 150 cm^3 water

4 Experimental Data

4.1 Mass Measurement

Trials	Mass (g)	Uncertainity
1	88.0	±0.1
2	88.1	±0.1
3	88.2	±0.1
4	88.2	±0.1
5	88.0	±0.1

4.2 Volume Measurement by Vernier Caliper

Trails	Length (cm)	Breadth (cm)	Height (cm)	Volume (cm^3)	Uncertainity
1	3.16	3.17	1.13	11.3	±0.1
2	3.17	3.15	1.12	11.2	±0.1
3	3.15	3.16	1.13	11.2	±0.1
4	3.16	3.17	1.12	11.2	±0.1
5	3.17	3.16	1.13	11.3	±0.1

4.3 Volume Measurement by Ruler

Trails	Length (cm)	Breadth (cm)	Height (cm)	Volume (cm^3)	Uncertainity
1	3.1	3.0	1.0	9.3	±1.1
2	3.1	3.1	1.1	10	±1.1
3	3.0	3.1	1.0	9.3	±1.1
4	3.0	3.0	1.1	9.9	±1.1
5	3.1	3.1	1.1	10	±1.1

4.4 Volume Measurement by Archimedes Principle

Trails	Volume (cm^3)	Uncertainity
1	10	± 1
2	9	± 1
3	9	± 1
4	10	± 1
5	10	± 1

5 Analysis

As discussed above there are 3 cases/methods to find the density of the metal block as there are 3 ways to find the volume of the metal block and there is only one way to find the mass of the metal block.

5.1 Case 1: Density by Vernier Caliper

Upon observation we have ρ_{c1} and $\Delta\rho_{c1}$ as,

$$\rho_{c1} = \overline{\rho_{c1_n}} = \frac{\sum_{n=1}^{n} \rho_{c1_n}}{n} = \frac{\rho_{c1_1} + \rho_{c1_2} + \rho_{c1_3} + \rho_{c1_4} + \rho_{c1_5}}{5}$$

$$\Delta\rho_{c1} = \overline{\Delta\rho_{c1_n}} = \frac{\sum_{n=1}^{n} \Delta\rho_{c1_n}}{n} = \frac{\Delta\rho_{c1_1} + \Delta\rho_{c1_2} + \Delta\rho_{c1_3} + \Delta\rho_{c1_4} + \Delta\rho_{c1_5}}{5}$$

Therfore we have,

$\rho_{c1} = 7.838258534$ g/cm^3

$\Delta\rho_{c1} = 0.070303566$ g/cm^3

$\therefore \rho_1 = 7.83 \pm 0.07$ g/cm^3

5.2 Case 2: Density by Ruler

Upon observation we have ρ_{c2} and $\Delta\rho_{c2}$ as,

$$\rho_{c2} = \overline{\rho_{c2_n}} = \frac{\sum_{n=1}^{n} \rho_{c2_n}}{n} = \frac{\rho_{c2_1} + \rho_{c2_2} + \rho_{c2_3} + \rho_{c2_4} + \rho_{c2_5}}{5}$$

$$\Delta\rho_{c2} = \overline{\Delta\rho_{c2_n}} = \frac{\sum_{n=1}^{n} \Delta\rho_{c2_n}}{n} = \frac{\Delta\rho_{c2_1} + \Delta\rho_{c2_2} + \Delta\rho_{c2_3} + \Delta\rho_{c2_4} + \Delta\rho_{c2_5}}{5}$$

Therfore we have,

$\rho_{c2} = 9.093065494$ g/cm^3

$\Delta\rho_{c2} = 1.033641933$ g/cm^3

$\therefore \rho_2 = 9.09 \pm 1.03$ g/cm^3

5.3 Case 3: Density by Archimedes Principle

Upon observation we have ρ_{c3} and $\Delta\rho_{c3}$ as,

$$\rho_{c3} = \overline{\rho_{c3_n}} = \frac{\sum_{n=1}^{n} \rho_{c3_n}}{n} = \frac{\rho_{c3_1} + \rho_{c3_2} + \rho_{c3_3} + \rho_{c3_4} + \rho_{c3_5}}{5}$$

$$\Delta\rho_{c3} = \overline{\Delta\rho_{c3_n}} = \frac{\sum_{n=1}^{n} \Delta\rho_{c3_n}}{n} = \frac{\Delta\rho_{c3_1} + \Delta\rho_{c3_2} + \Delta\rho_{c3_3} + \Delta\rho_{c3_4} + \Delta\rho_{c3_5}}{5}$$

Therfore we have,

$\rho_{c3} = 9.201777778$ g/cm^3

$\Delta\rho_{c1} = 0.963765394$ g/cm^3

$\therefore \rho_3 = 9.20 \pm 0.96$ g/cm^3

6 Evaluation

It is safe to assume that we can consider the density found out by using the **vernier caliper** method as the actual density because this is the method that produced the lowest amount of uncertainity relative to other methods.

If we are to compare our findings with the desities of known metals, we would come to the conclusion that, the **given metal block is made up of iron**.

$\therefore$ percentage uncertanity in measurement by ruler $= \left(1 - \frac{\rho_{c2}}{\rho_{c1}}\right) \cdot 100 \approx 16\%$

percentage uncertanity in measurement by archimedes principle $= \left(1 - \frac{\rho_{c3}}{\rho_{c1}}\right) \cdot 100 \approx 15\%$

7 Conclusion

In this lab report, we have investigated an unknown given metal mass (rectangular block) and estimated the metal type by examining the densitiy of the metal block by various methods.

We had further analysed the uncertainties in measurement of the various different methods that were utilized in the above lab report. In this dure process we had come to a conclusion that the method of using a **vernier caliper** is the **best way of approach** as it presents us with least amount of uncertainities in measurement, implying a **higher level accuracy** in the density measurement.

We had finally come to a conclusion that the unknown mass presented upon us was made up of iron. We had come upon this conclusion by comparing the relative densities found in the due course of this investigation to a set of known metals and their densities

Bibliography

[1] Serway, R. A., Jewett, J. W. (2018). Physics for Scientists and Engineers. Cengage Learning.