Pre-Lab Questions 1

Topic: Measurement

Objective: To enable the students to state and differentiate important concepts and terms that are useful to carry out Experiment 1 meaningfully.

After answering these questions, the students will be able to

1. differentiate between *zero error* and *reading uncertainty* (error) for a meter rule, vernier caliper and a micrometer.
2. state the significant figures of a given number and use the rules for stating the significant figures at the end of a calculation.
3. differentiate between a *systematic* and a *random* uncertainty.
4. calculate the propagation of uncertainty from several combinations of measurement that includes addition, subtraction, multiplication and power formulation.

PRE-LAB QUESTIONS 1

Answer the following questions and submit your group answer to the instructor.

1. Is it possible to get an exact measurement without any uncertainty (error)?

2. What is the *zero error* and the *reading uncertainty* (error) for
   (a) a meter rule,
   (b) a vernier caliper, and
   (b) a micrometer?

3. State the number of significant figures for each of the following numbers
   (a) 17.20 (b) 0.0270 (c) 12000 (d) 3.1400

4. Perform the following calculations and give the answer with the correct significant figures.
   (a) 23.90×3.81 (b) $10.27 \div 2.8$ (c) $4.917 \times 1.5 \times 12.31$

5. State two major differences between a *systematic* and a *random* error?

6. Does the laboratory balance measure weight or mass? Explain.

7. What is the function of the vernier scale on the vernier caliper? Does it extend *accuracy* or *precision*? Explain.

8. If $x = 1.52 \pm 0.01$ cm and $y = 3.36 \pm 0.01$ cm, calculate S, D, M and V and their uncertainty ΔS, ΔD, ΔM and ΔV respectively.
   (a) $S = x + y$
   (b) $D = y - x$
   (c) $M = xy$
   (d) $R = \frac{x}{y}$
   (e) $V = x^3$

9. The length of a plank is measured by using a meter rule and the value obtained is reported as 2.4 m. Why is this reading inappropriately reported?

Experiment 1

Topic: Measurement

Objective: To determine the density of a ball bearing and a glass block.

Learning Outcomes of Experiment 1

After doing the experiment, the students will be able to

1. determine the density of a ball bearing and a glass block.
2. calculate the uncertainty of the density.
3. write a report on the experiment.
4. state the appropriate and reasonable sources of error or factors that contributed to the uncertainties in the readings.

Introduction

Measurement of physical quantities is a very important especially in the sciences. The value given by the measuring instrument can be used to determine the desired physical quantity by substituting this value into an equation that relates the measured value to the desired quantity.

The choice of a measuring instrument depends on

(i) the availability of the measuring instruments,
(ii) how practical is the measurement to be carried out using certain instruments,
(iii) the accuracy needed for the measurement.

Density of a substance is defined as the mass per unit volume ($\rho = \frac{m}{V}$). Density can be determined experimentally by measuring the mass and volume of a sample of substance and calculating the ratio *m/V*.

For example, to determine the density of a cylinder as shown in FIGURE 1, the mass m, diameter, d and height, h of the cylinder can be measured using an electronic balance and a vernier caliper. The volume and uncertainty of the cylinder can be calculated from the following formula.

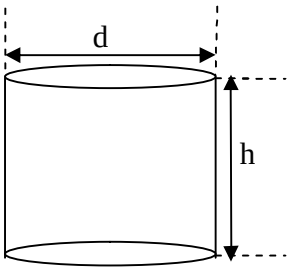
Volume of cylinder: $V = \pi r^2 h$ with $r = \frac{d}{2}$

Uncertainty of the volume: $\Delta V = \left(2\frac{\Delta r}{r} + \frac{\Delta h}{h} \right) V$

Since $\rho = \frac{m}{V}$, the uncertainty of the density is given by:

$$\Delta\rho = \left(\frac{\Delta m}{m} + \frac{\Delta V}{V}\right)\rho$$

FIGURE 1



In reporting the measured value, the uncertainty of the measurement should also be stated. This will give an indication, to what extent is the precision of the measurement and the calculated results. The propagation of uncertainties from the various measurements used in the equations should also be calculated. This will enable us to know the uncertainty involved in the final results.

Objective: To determine the density of a ball bearing and a glass block.

Instructions

1. Discuss the following items with your lab group before taking the reading.

    a. Discuss the quantity to be measured and the appropriate equation to use to determine the density of the ball bearing and the glass block.

    b. Choose an appropriate measuring instrument available in the laboratory for your measurement.

    c. Decide how the measurement is to be carried out and the number of measurements that you need to take.

2. Make your measurements, tabulate the data appropriately and calculate the density of the ball bearing and the glass block and its uncertainty. State your final results in SI units.

3. Hand in your group report at the end of the lab period.

4. All groups will be scheduled to present and defend their procedures and results of certain experiments in class.

Format of the Laboratory Report

1. *Objective* : State the objective of the experiment.
2. *Apparatus* : State the instruments used.
3. *Theory* : State the formula that you used to calculate the density of the ball bearing.
4. *Procedures* : Describe the steps that you take to perform the experiment.
5. *Data* : Present the data appropriately. Organize the data in tables if possible. Use a correct and consistent significant figures. State the units and uncertainties of each quantity.
6. *Results* : Show the calculations of the density of the ball bearing and its uncertainty.
7. *Conclusions* : Indicate what is measured, the uncertainties and the sources of uncertainties.

Post- Lab Questions

1. Why is it better to take many readings for the same measured quantity compared to a single reading?

2. If the volume of the ball bearing was first determined using a micrometer, what difference does it make if a vernier caliper is used instead?

3. Suppose that you were given an irregularly shaped object that floats, describe how you would experimentally determine its volume?