Determination of the density of wood and steel

Fall 2016

Contents

Equipment

Block of wood; metal sphere; pair of calipers; meter stick.

Goals of the experiment

To find the best estimate of the density, ρ, of a wooden block and a metal sphere at room temperature and to determine how accurately the density can be estimated.

Background

A fundamental property characterizing any material is its density. The average density, ρ, of a material of mass, M, which occupies the volume, V, is defined as:

$$\rho = \frac{M}{V} \tag{1}$$

The volume of the wooden block and the steel ball will be calculated based on repeated measurements of its dimension(s). Statistical methods will be used to estimate uncertainties of the measurements of each dimension (Type A uncertainty). The uncertainty of the single measurement of the mass of the block is a Type B uncertainty. The uncertainty of the single measurement of the mass of the metal sphere is also a Type B uncertainty. The combined standard uncertainty of the density will be determined using the law of propagation of uncertainty.

Prelab exercises

- Find in the internet the Guide to the Expression of Uncertainty in Measurement (you can also see the link to it posted on D2L for your course).
- Define the following terms:uncertainty; error; type A and B of the uncertainty (How is it estimated?); standard uncertainty (What is its symbol?); combined standard uncertainty

The experiment

Measurement of the volume

- Discuss with your group which method(s) to use to find the volume of the block and the sphere.
- Determine the volume of both objects using repeated measurements for the dimension(s). To incorporate into your measurement the likelihood that the object is not perfect, measure the dimension at different points on the object. Hint: In order for the standard deviation to truly represent the uncertainty, the readings must be taken with sufficient accuracy (there will be variations in your readings).
- In order to estimate the uncertainty in the dimension(s) use Type A uncertainty
- Calculate the volume and estimate its uncertainty. Explain how you arrived at that estimate.

Measurement of the mass

Measure the mass of each object on the balance supplied. Make the measurement as accurately as possible and estimate the uncertainty in a single measurement - for a digital balance the uncertainty is usually Âś1 last displayed digit (e.g. for a reading of 254.4 g the uncertainty u(M) is 0.1 g).

Data analysis

Calculate the density with uncertainty. Explain how you arrived at that estimate.

Discussion

Compare your value of the density of wood and steel with the value obtained by two other groups.

How to compare two values within uncertainties

If you measured the area of the rectangle, A, to be 1.3 cm2 and the standard uncertainty u(A) to be 0.6 cm2, and Bob obtained A=1.5 cm2 and u(A)=0.3 cm2, you can say you obtained the same result to within the experimental uncertainties, because the difference between your results, 0.2 cm2, is less than the sum of the uncertainties, 0.9 cm2.

Discussion questions

- Do your values agree within experimental uncertainties with those from the other two groups?
- Find examples of publishes values of density of wood and steel and compare them with your results.
- What factors could have affected the values measured for the density of wood/steel?

The report

Your report should include the following:

- A title; your name, and those of your collaborators;
- Objective of the experiment (a summarizing statement about what you set out to observe); Short description of experimental methods;
- Data: all the measured values with their uncertainties.
- Analysis: Calculation of density of wood and steel and their uncertainties;
- Discussion: a comparison of the calculated values of density with their expected values; comments on possible sources of errors;answers to the three questions
- Your conclusion about whether the two values are equal within the experimental uncertainties.