

Checking units, uncertainties and vector components

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

Many physics results are only as good as their weakest measurement. In this lab you find the density of a wooden dowel from three measurements and work out which of them limits the accuracy of the answer. You need only a ruler and a kitchen scale.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 1, IB A

Aim

To find the density of a wooden dowel and to decide which measurement contributes most to the uncertainty in the result.

Equipment

- Wooden dowel or broom handle, about 12 cm long, with square-cut ends
- 30 cm ruler (± 0.1 cm) or vernier callipers
- Kitchen scale reading to 0.1 g
- Calculator

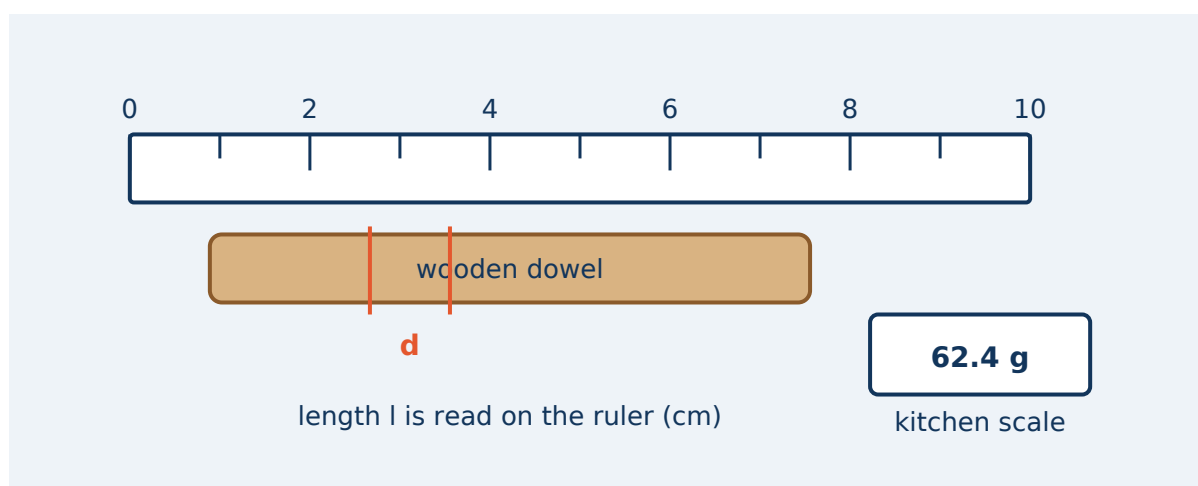
Safety

Safety

Cut the dowel with adult help and sand any splinters. Keep the dowel away from the edge of the bench so that it cannot roll off and drop on a foot.

Method

1. Place the dowel on the scale and record its mass m .
2. Lay the dowel against the ruler and measure its length l , reading both ends carefully.
3. Measure the diameter d at five different places, turning the dowel between readings.
4. Calculate the mean diameter and use half the range as its uncertainty.
5. Calculate the volume $V = \pi d^2 l \div 4$ and the density $\rho = m \div V$.



Set-up for measuring mass, length and diameter.

Results

Sample measurements:

Measurement	Value	Absolute uncertainty
Mass m	62.4 g	± 0.1 g
Length l	12.0 cm	± 0.1 cm
Diameter d , reading 1	3.20 cm	-
Diameter d , reading 2	3.18 cm	-
Diameter d , reading 3	3.22 cm	-
Diameter d , reading 4	3.19 cm	-
Diameter d , reading 5	3.21 cm	-

Analysis questions

Question 1 Mean diameter

Calculate the mean diameter and its absolute uncertainty using half the range.

Question 2 Percentage uncertainties

Calculate the percentage uncertainty in m , l and d .

Question 3 Volume

Calculate the volume of the dowel.

Question 4 Density and uncertainty

Calculate the density and its percentage and absolute uncertainty.

Question 5 Largest contribution

Identify the measurement that contributes most to the uncertainty and explain your choice.

Question 6 Float or sink

Water has a density of 1000 kg/m^3 . Decide whether the dowel floats and estimate the fraction submerged.

Question 7 Unit check

Show that kg m^{-3} is the correct base unit for density and convert your result.

Question 8 Improvement

Suggest one improvement that would reduce the uncertainty most.