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Practical Skills ·

Both papers ask about experiments in writing: how to measure, which variables to control, how to process results, and how to improve the method. The same handful of skills answers every one of these questions; this handbook works through them on three experiments.

The words the questions use

Independent, dependent and control variables – the one you change, the one you measure, and the ones you keep the same – each control with how it is kept the same

Resolution – the smallest change an instrument can show: 1 mm on a metre rule, 0.01 A on a digital ammeter

Random and systematic error – random errors scatter readings either side of the true value and are reduced by repeating and averaging; a systematic error (a zero error, a meter that reads high) shifts every reading the same way and is not

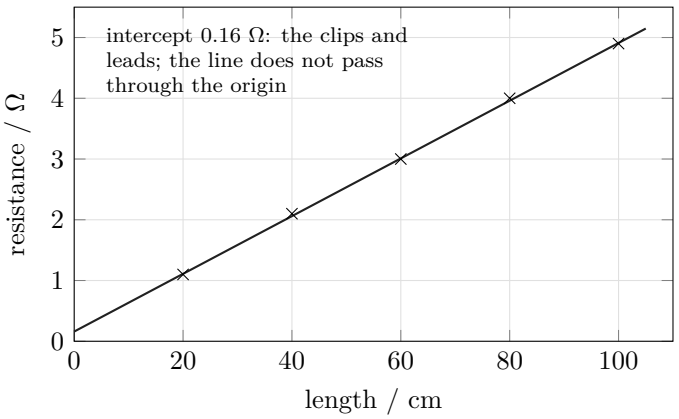
Accurate, precise, repeatable, reproducible – accurate: close to the true value. Precise: repeated readings close together. Repeatable: the same person gets the same results again. Reproducible: another person or method gets the same results

Anomalous result – a reading that does not fit the pattern; circle it, leave it out of the mean, and repeat that measurement

Worked analysis: resistance and the length of a wire

A constantan wire was taped along a metre rule. One crocodile clip stayed at 0 cm; the other was moved to each length L. The current I and potential difference V were recorded, and R = V ÷ I calculated. The power supply was kept at a low voltage and switched off between readings so the wire did not heat up.

length L / cm	**20.0**	**40.0**	**60.0**	**80.0**	**100.0**
V / V	0.45	0.82	1.20	1.58	1.95
I / A	0.40	0.40	0.40	0.40	0.40
R / Ω	1.1	2.1	3.0	4.0	4.9



A straight line: resistance increases by the same amount for each extra 20 cm.

Conclusion: resistance increases linearly with length – about 0.48 Ω for every 10 cm (the gradient, 0.0475 Ω/cm). Doubling the length doubles the resistance of the WIRE; the small intercept is the resistance of the clips and leads, so it is not quite directly proportional as measured.

Errors and improvements: measure L from the inside edge of each clip, not the outside; if the wire warms, its resistance rises, so use a small current and switch off between readings; repeat each length and take a mean.

Worked calculation: density of an irregular object :

A stone's mass was measured on a balance reading to 0.1 g: 54.6 g. Its volume was found by displacement in a measuring cylinder with 2 cm^3 divisions: the water level rose from 40 cm^3 to 60 cm^3.

1. Volume = 60 − 40 = 20 cm^3.

2. Density = mass ÷ volume = 54.6 g ÷ 20 cm^3 = 2.7 g/cm^3 (2700 kg/m^3).

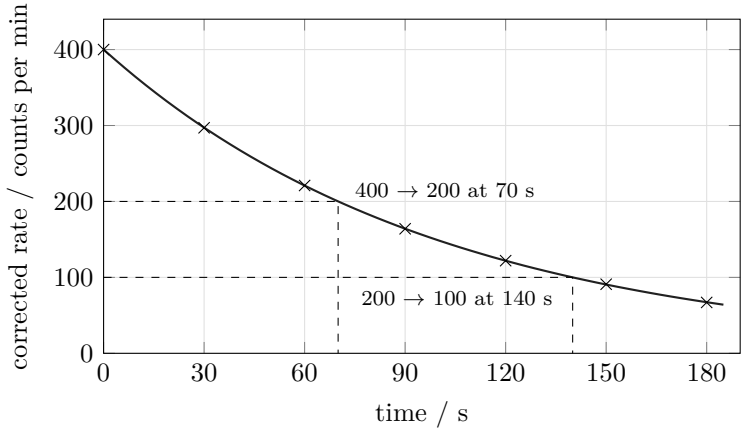
The volume is the least precise measurement: each level can be read only to about 1 cm^3, so the volume could be 18 to 22 cm^3 and the density 2.5 to 3.0 g/cm^3. A narrower cylinder with finer divisions, or a eureka (displacement) can with the overflow caught in a small measuring cylinder, reduces this.

Lower the stone in on a thread so no water splashes out, and read the bottom of the meniscus at eye level. An air bubble stuck to the stone makes the volume too large and the density too small.

Worked analysis: half-life from count-rate data :

The background count rate was measured first, with no source present: 20 counts per minute. The count rate of a short-lived source was then recorded every 30 s, and the background subtracted from each reading.

time / s	**0**	**30**	**60**	**90**	**120**	**150**	**180**
measured / counts per min	420	317	241	184	142	111	87
corrected / counts per min	400	297	221	164	122	91	67



Read the time for the count rate to halve, twice, from different starting points.

Half-life = 70 s: the corrected count rate halves from 400 to 200 counts per minute in 70 s, and from 200 to 100 in a further 70 s. Using two halvings checks the value.

Radioactive decay is random, so each count varies. Counting for longer at each reading makes the random variation a smaller fraction of the count. Without the background correction the curve levels off at 20 counts per minute instead of falling towards zero, and the half-life comes out too long.

Safety: the source is handled with tongs, held away from the body, and returned to its lead-lined box

straight after use.

Planning and improving – what earns the marks

A method in numbered steps that someone else could follow: the equipment, what is measured with what, how the independent variable is changed and over what range (at least five values), and how many repeats.

Match each improvement to a named error: a light gate for reaction time; a set square against parallax; a lid against heat loss. ‘Be more careful’ or ‘use better equipment’ gains nothing.

Name a hazard of THIS experiment and its precaution: a stretched wire can snap, so wear eye protection; a hot wire can burn, so use a low current and switch off between readings.

Say what the graph’s shape shows: a straight line through the origin means directly proportional; a straight line that does not pass through the origin, a linear relationship.