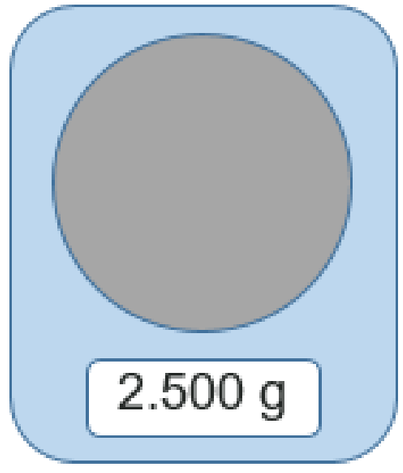
Precision of Measurements

A **precise** measure is the exact quantity asked for.

Example

If measuring 2.5g **precisely**, the amount should be accurate for that exact amount. (✗ measuring 2.352 g would be accurate but not precise)

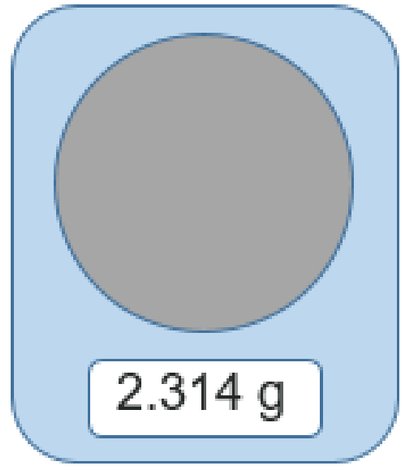


Accuracy of Measurements

Recording measurements to the correct number of decimal places based on the instrument being used.

Example

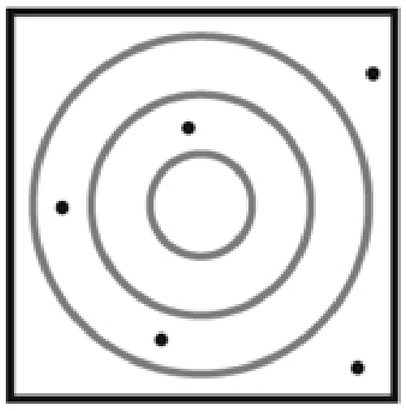
Recording a reading of 2.314 g on a 3-point balance is **accurate**.
(✖ Recording 2.3 g for this balance is inaccurate).



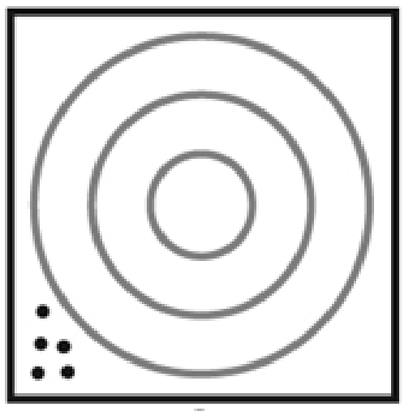
Precision of Results

Precision is how close a series of results are to each other

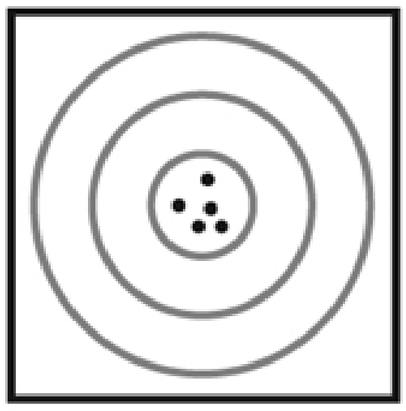
Example



Inaccurate ✗ & Imprecise ✗



Precise ✓ but Inaccurate ✗



Precise ✓ and **Accurate** ✓

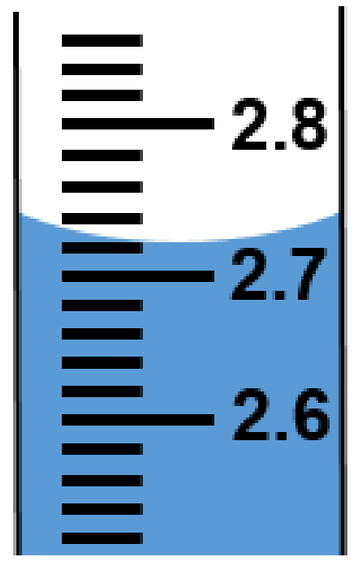
Accuracy of Results

The accuracy of results is how close they are to the true value.

Example

If your expected results are 2.7 mL

Inaccurate	Accurate
2.42 mL ✗	2.72 mL ✓
2.10 mL ✗	2.68 mL ✓
4.03 mL ✗	2.71 mL ✓

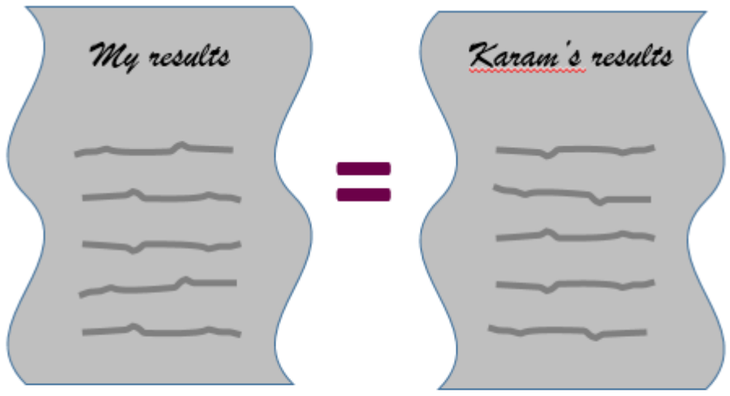


Repeatability & Reproducibility

…are both measures of how well results agree with independent results.

REPEATABLE results are obtained using the same method and test materials, and under identical conditions

REPROCUCIBLE results are obtained using the same method and test materials but under different conditions (e.g. different operator, apparatus or laboratory



reproducible

Random Errors

Random errors can be identified by repeating the experiment and dealt with by removing obviously erroneous results (**outliers**) from the data set. The cause of the random error is often impossible to identify.

Example

The following set of masses was recorded: 22.72 g, 22.69 g, 18.73 g, 22.71 g.

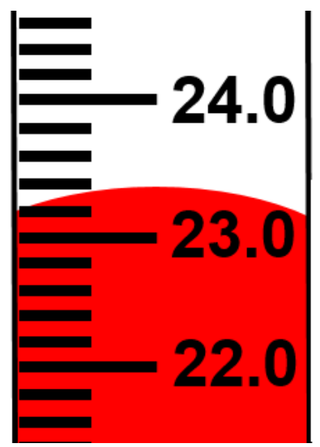
From this data set, 18.73 g is an **outlier**. A **random error** such as the balance display moving around could have caused this reading to occur.

Personal Errors

Personal Errors are mistakes or miscalculations that lead to the wrong value being recorded.
These lead to errors and not uncertainties. They can be eliminated by careful repetition of data collection and treatment.

Examples:

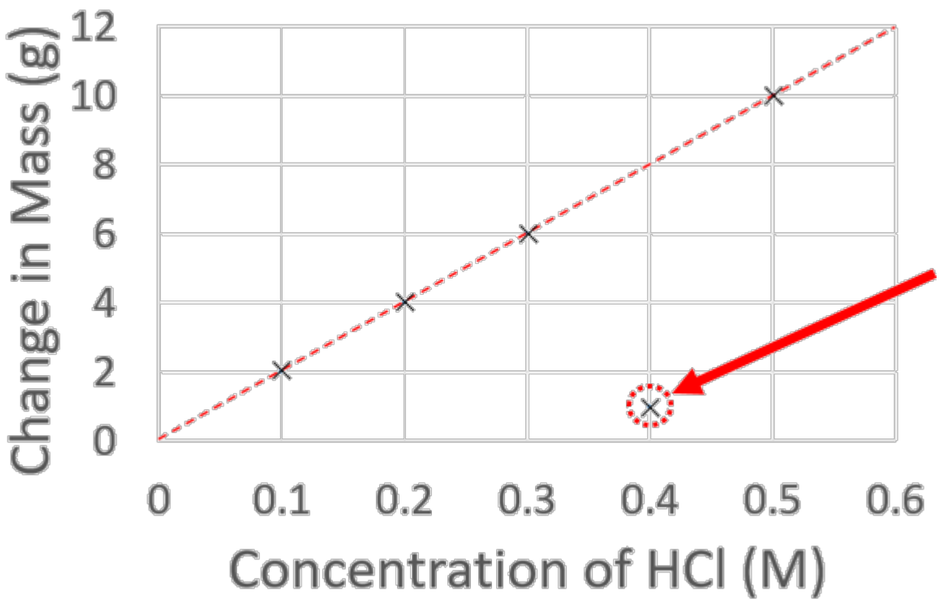
- Misreading the scale on a thermometer
- Measuring the voltage across the wrong section of a circuit
- Forgetting to divide the diameter by 2 before calculating the area of a circle using πr^2



Outliers

Outliers are results that lie a long way from other results. **Outliers** should be analysed and explained, not simply dismissed. Extra readings are often necessary.

Example



This result is an **outlier**. It was obtained because the volume of acid used was too small.

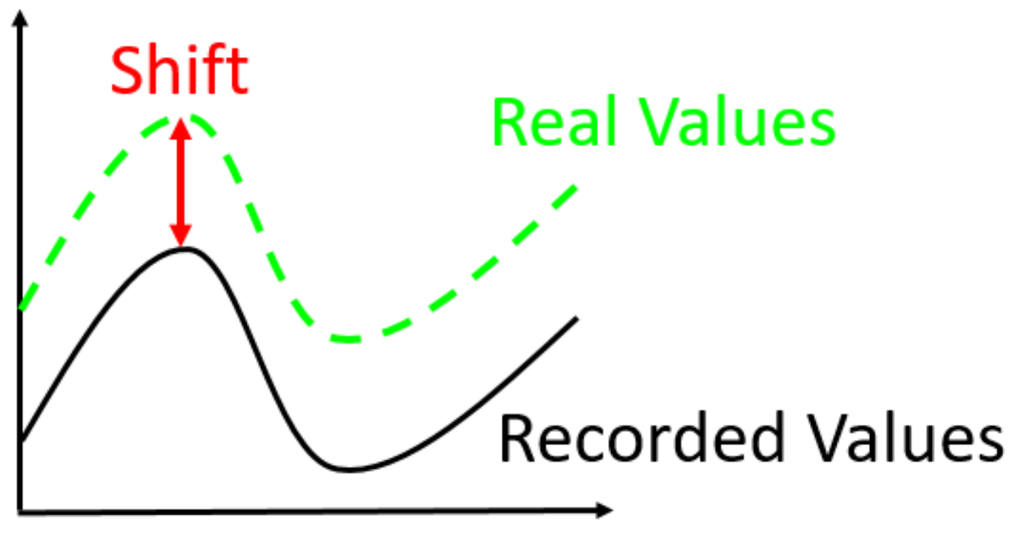
This test will need to be repeated to obtain an accurate value

Systematic Errors

Systematic errors could be due to faulty or incorrectly calibrated equipment. These errors can be eliminated through repetition with different equipment or careful calibration of instruments.

Example

An incorrectly calibrated spectrometer could produce a spectrum that has been shifted above or below the ‘real’ value



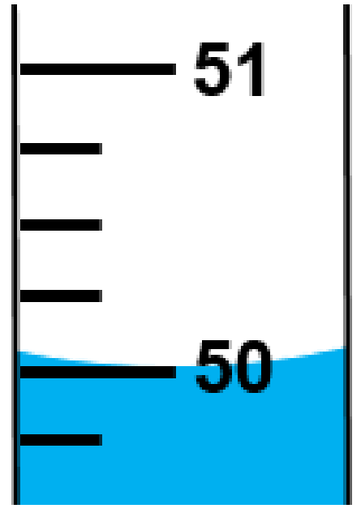
Evaluation of Uncertainty

Uncertainties arise from **systematic** and **random** errors. They are due to the level of accuracy in the equipment and random factors.

Uncertainties cannot be eliminated by repetition.

Example

A 100 mL measuring cylinder has an uncertainty of ± 1 mL. A reading of 50 mL means we can only be certain the actual value lies from 49 – 51 mL



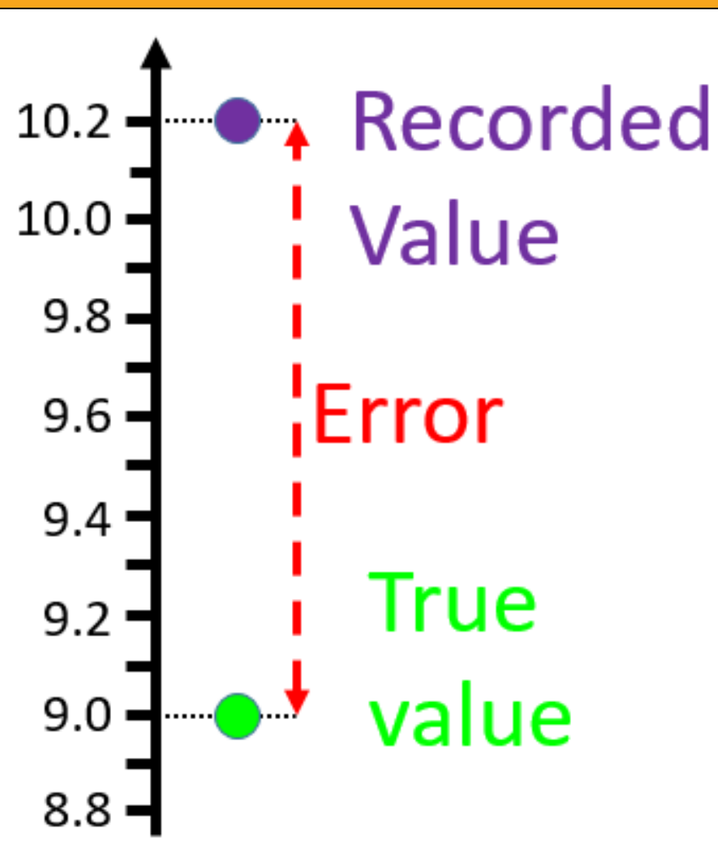
Errors and Uncertainties in Results

An **error** describes how far a value (recorded or calculated) is from the true value

Example

E.g. a recorded value of 10.2 when the true value is 9.0 has an **error** of 1.2

[10.2 – 9.0 = 1.2]

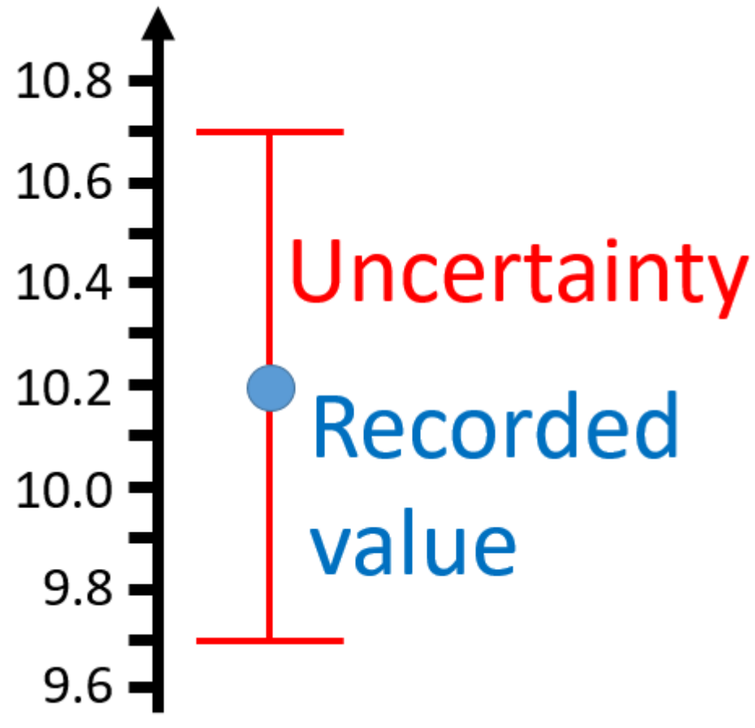


Errors and Uncertainties in Results

Uncertainty describes the level of accuracy that can be obtained from a particular experiment, piece of equipment or data collected.

Example

A value of 10.2 with an **uncertainty** of ±0.5 means our answer lies somewhere from 9.7 – 10.7 and we are **uncertain** which value it is.



Uncertainty in Instruments

Laboratory instruments are manufactured to deliver accurate results to a specified level of **uncertainty.**

Example

Instrument	Uncertainty
pipette	± 0.02 mL
burette	± 0.02 mL
3-point balance	± 0.005 g
10 mL measuring cylinder	± 0.1
100 mL measuring cylinder	± 1 mL
250 mL volumetric flasks	± 0.2 mL

Validity

Validity describes whether a result measure what it is claiming to measure.

If a measurement is only affected by the independent variable it is **valid**. If other variables have affected the measurement it is likely to be **invalid**

Example

In an experiment testing how high a ball will bounce when dropped from different heights, the test would be **invalid** if, for example, you used a different ball for each test or if you bounced them on a different surface.