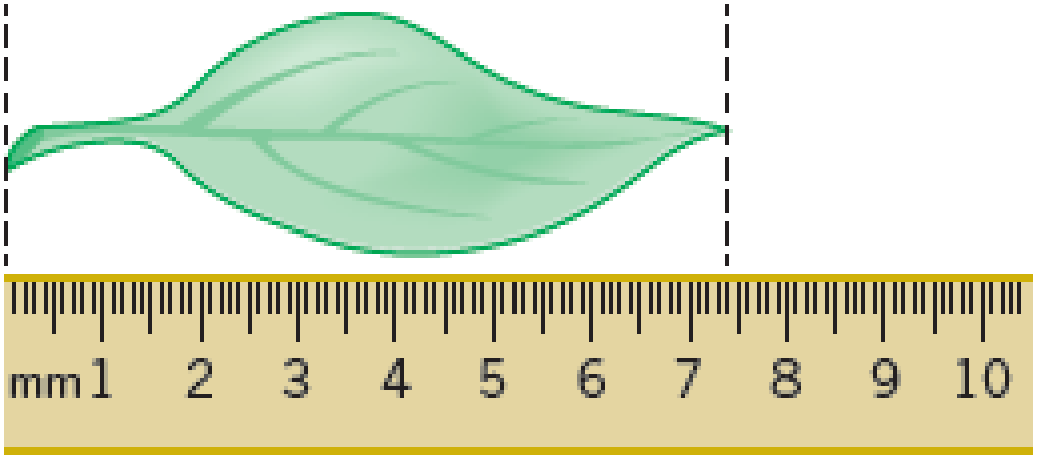
GCSE to A-Level Biology Transition

Lesson 13
Uncertainties

Learning objective

- Identify uncertainties in measurements
- Calculate percentage error where there are uncertainties in measurements.



Uncertainties in apparatus

- When measuring something (height, mass, temperature etc…), there will always be a small difference between the measured value and the true value.
- This is called an **uncertainty** (or absolute error).
- The uncertainty is equal to half the smallest division on the scale being used.

- Examples
  - Thermometer with markings every 2°C- uncertainty would be ± 1°C
  - Measuring cylinder with 5ml markings- uncertainty would be ± 2.5ml

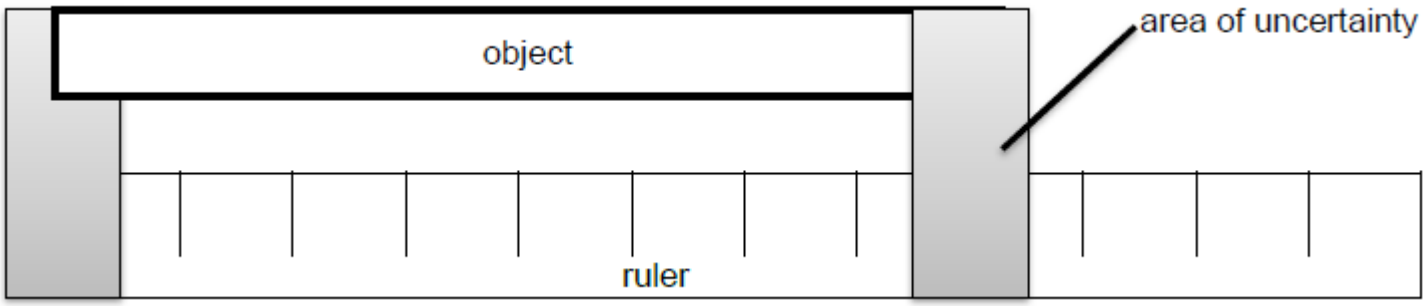
Judgement of uncertainty

- **1 judgement** e.g. using a thermometer, only needs to make one judgement (the height of the liquid). This is a reading. It can be assumed that the zero value has been correctly set.
- **2 judgements** e.g. watches and rulers, both the starting point and the end point of the measurement must be judged, leading to two uncertainties.

Reading (one judgement only)	Measurement (two judgements required)
thermometer	Ruler
pH meter	Protractor
top pan balance	Stopwatch
measuring cylinder	analogue meter
volumetric flask	

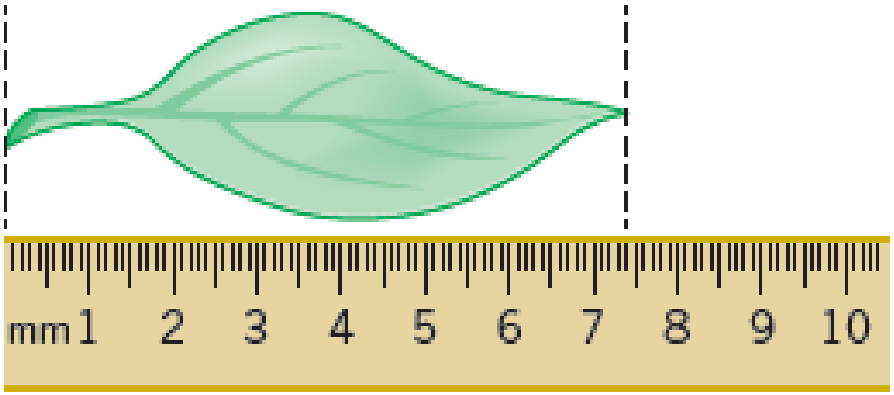
2 Judgements e.g. lengths

- **Two** uncertainties must be included: the uncertainty of the placement of the zero of the ruler and the uncertainty of the point the measurement is taken from.
- As both ends of the ruler have a ±0.5 scale division uncertainty, the measurement will have an uncertainty of ±1 division.



- For most rulers, this will mean that the uncertainty in a measurement of length will be ±1 mm (0.5 + 0.5).

Uncertainty ruler example



- Using a ruler with a mm scale, the length of the leaf seems to be 74 mm. The smallest division is 1 mm, so the uncertainty is 0.5 mm (include the uncertainty on both sides of the measurement) so the absolute error is ±1mm .
- The true length is therefore 74 mm ±1mm (73mm to 75mm)

Practise Questions

Give the uncertainty for the following pieces of equipment:

a) large measuring cylinder with 2 cm^3 divisions

b) digital stopwatch timer measuring to the nearest hundredth of a second

c) thermometer with 0.1 °C divisions

Answers

Give the uncertainty for the following pieces of equipment:

large measuring cylinder with 2 cm^3 divisions

± 1 cm^3

Digital stopwatch timer measuring to the nearest hundredth of a second

± 0.01 s (0.005s + 0.005s, 2 judgements needed here)

Thermometer with 0.1 °C divisions

± 0.05 °C

Percentage Uncertainty

- Difference between the true value and the maximum or minimum value is called the **absolute error** (previous slides)

- Percentage uncertainty calculation (aka relative error)

$$\text{Percentage Uncertainty} = \frac{\text{absolute error}}{\text{measured value}} \times 100\%$$

- Using the leaf example from the previous slides… the absolute error is ± 1 mm.
- The percentage uncertainty is therefore:

  1/74 × 100% = 1.35%

Practise Questions

Complete the table to show the missing values in the last two columns.

Measurement made	Equipment used	Absolute error	Percentage Uncertainty
Fluid column in a measuring cylinder is 6 mm	mm scale		
Volume of a syringe is 12 cm^3 of liquid	0.5 cm^3 divisions		
Mass of an object 3 g	balance with 2 d.p.		
Change in mass of 1.6 g	balance with 2 d.p.		
Time taken for colour to change 4.8s	Stopwatch, 0.1s		

Answers

Measurement made	Equipment used	Absolute error	Percentage Uncertainty
Fluid column in a measuring cylinder is 6 mm	mm scale	±0.5 mm	8.3%
Volume of a syringe is 12 cm^3 of liquid	0.5 cm^3 divisions	±0.25 cm^3	2.1%
Mass of an object 3 g	balance with 2 d.p.	±0.005 g	0.17%
Change in mass of 1.6 g	balance with 2 d.p.	±0.005 g	0.6%
Time taken for colour to change 4.8s	Stopwatch, 0.1 s	±0.1 s	2.1%

2 judgements needed (0.005+0.005)

Initial mass **AND** final mass needed to be measured. So twice the uncertainty.