# Measurement and Uncertainty

**Name:** _____ **Date:** _____

Scientists measure quantities using instruments such as rulers, balances, thermometers, measuring cylinders, and stopwatches. Choose equipment with a suitable **range** and **resolution**.

- **Range:** The values an instrument can measure.
- **Resolution:** The smallest change an instrument can show.
- **Measurement uncertainty:** An estimate of the doubt associated with a measurement.

Always record a measurement with its **unit**, such as 24.5 cm, 18.2 g, or 12.6 s.

For this worksheet, estimate the reading uncertainty of an **analogue instrument** as **± half its smallest scale division**. For a **digital instrument**, use **± one unit of its last displayed digit**, unless another uncertainty is provided. These are simple estimates; other effects, such as reaction time, may increase uncertainty.

**Example:** A thermometer has divisions of 2 °C.

Estimated reading uncertainty = ±1 °C
A reading could be recorded as **(24 ± 1) °C**.

This gives an estimated interval from **23 °C to 25 °C**.

## Choose the Equipment

Select the most appropriate equipment from the word bank. Each instrument is used once.

**Word bank:** ruler • balance • thermometer • measuring cylinder • stopwatch

| Quantity to measure | Equipment | Suitable unit |
|---|---|---|
| Length of a pencil | _____ | _____ |
| Mass of a stone | _____ | _____ |
| Temperature of water | _____ | _____ |
| Volume of a liquid | _____ | _____ |
| Time taken for a toy car to travel down a ramp | _____ | _____ |

## Record Measurements Correctly

Rewrite each measurement using the correct scientific unit symbol.

**1.** A pencil is 16 centimetres long.

**2.** A stone has a mass of 42.5 grams.

**3.** Water has a temperature of 28 degrees Celsius.

**4.** A race takes 14.2 seconds.

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# Measurement and Uncertainty

## Estimate Uncertainty

Use the rules in the reading above.

**1.** An analogue thermometer has a smallest scale division of 1 °C. uncertainty: ± _____ °C

**2.** An analogue measuring cylinder has a smallest scale division of 2 mL. uncertainty: ± _____ mL

**3.** A digital balance displays a mass of 25.46 g. uncertainty: ± _____ g

**4.** A temperature is measured as 36 °C using the thermometer in Question 1. Record the result with its uncertainty.

## True or False?

Write **T** or **F**. Correct each false statement.

**1.** Every measurement is perfectly exact. _____

**2.** A digital stopwatch displaying hundredths of a second removes human reaction-time uncertainty. _____

**3.** Measurements should include appropriate units. _____

## Apply Your Understanding

### 1. Choosing equipment

You need to measure approximately 18 mL of water. You can choose:

- A 50 mL measuring cylinder with 1 mL divisions.
- A 250 mL beaker with 50 mL divisions.

Which is more appropriate? Explain.

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### 2. Interpreting uncertainty

A student records a length as **(12.4 ± 0.1) cm**.

a. What is the lower end of the estimated interval? _____ cm

b. What is the upper end of the estimated interval? _____ cm

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# Measurement and Uncertainty

**3. Comparing results**

Two students measure the same object:

- Student A: **(10.2 ± 0.2) cm**
- Student B: **(10.4 ± 0.2) cm**

Do their estimated intervals overlap? Explain why their results may be consistent even though their recorded values differ.

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**4. Improving a measurement**

A student uses a stopwatch to time one swing of a pendulum. Suggest why timing 10 complete swings and dividing the total time by 10 could give a better estimate of the time for one swing.

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# Measurement and Uncertainty

# Measurement and Uncertainty — Answer Key

## Choose the Equipment

| Quantity | Equipment | Suitable unit |
|---|---|---|
| Length of a pencil | Ruler | cm or mm |
| Mass of a stone | Balance | g |
| Temperature of water | Thermometer | °C |
| Volume of a liquid | Measuring cylinder | mL |
| Time taken for a toy car to travel down a ramp | Stopwatch | s |

## Record Measurements Correctly

1. **16 cm**
2. **42.5 g**
3. **28 °C**
4. **14.2 s**

## Estimate Uncertainty

Using the worksheet's estimation rules:

1. **±0.5 °C**
2. **±1 mL**
3. **±0.01 g**
4. **(36 ± 0.5) °C**

## True or False?

1. **False.** Every measurement has some uncertainty.
2. **False.** The stopwatch's display resolution does not remove uncertainty caused by human reaction time when starting and stopping it.
3. **True.**

## Apply Your Understanding

### 1. Choosing equipment

The **50 mL measuring cylinder** is more appropriate. Its 1 mL divisions allow a more precise reading of approximately 18 mL than the beaker's 50 mL divisions.

### 2. Interpreting uncertainty

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# Measurement and Uncertainty

a. Lower end: **12.3 cm**
b. Upper end: **12.5 cm**

**3. Comparing results**

**Yes, the intervals overlap.**

- Student A: **10.0–10.4 cm**
- Student B: **10.2–10.6 cm**

The overlap is **10.2–10.4 cm**. Their results may therefore be consistent when measurement uncertainty is considered.

**4. Improving a measurement**

Timing 10 complete swings produces a longer total measurement. The start-and-stop reaction-time uncertainty is then a smaller fraction of the total time. Dividing by 10 gives an estimate of the average time for one complete swing with a smaller relative timing uncertainty.

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