

Units, prefixes and reliable measurements

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lesson

Quick answer: SI units are the internationally agreed units for measurement: metre for length, kilogram for mass, second for time, ampere for current and kelvin for temperature. Prefixes such as kilo and milli scale them by powers of ten, and significant figures and uncertainty show how reliable a measured value is.

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE WS, IGCSE 1.1

What are SI units and why do scientists use them?

Imagine students in Lagos, Leeds and Lahore each timing a falling ball. Their results can only be compared if they all use the same units. That shared system is the **International System of Units**, or SI. A measurement is always a number followed by a unit: “12” means nothing, but “12 s” does.

Definition

SI units are the internationally agreed units used in science. A small set of **base units** defines the system, and every other unit, such as the newton or the joule, is built from them.

Quantity	Base unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol

Speed is a derived quantity with the unit m/s, and force has the unit newton, where $1 \text{ N} = 1 \text{ kg m/s}^2$. Note that the kilogram is the one base unit that already contains a prefix.

How do prefixes change a unit?

Everyday sizes are rarely one metre or one second, so we attach a prefix that multiplies the unit by a power of ten.

giga G 10^9	mega M 10^6	kilo k 10^3	unit m, g, s 1	milli m 10^{-3}	micro μ 10^{-6}	nano n 10^{-9}
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Each step to the right: the number of units gets 1000 times bigger
(centi, c = 10^{-2} , sits between the unit and milli)

Prefixes move in steps of 1000: 1 km = 1000 m and 1 mm = 0.001 m.

Prefix	Symbol	Factor	Example
giga	G	10^9	2.4 GHz = 2.4×10^9 Hz
mega	M	10^6	3 MW = 3×10^6 W
kilo	k	10^3	5 km = 5000 m
centi	c	10^{-2}	8 cm = 0.08 m
milli	m	10^{-3}	40 ms = 0.040 s
micro	μ	10^{-6}	25 μm = 2.5×10^{-5} m
nano	n	10^{-9}	90 nm = 9.0×10^{-8} m

Key rule

To convert to the base unit, multiply by the prefix factor. To convert back, divide by it.

Worked example 1

Wanjiru weighs 4500 mg of salt for a school lab. Write this in kilograms in standard form.

4500 mg = 4500×10^{-3} g = 4.5 g. Then 4.5 g = 4.5×10^{-3} kg. Answer: **4.5×10^{-3} kg**.

Common mistake

Squared and cubed units do not follow the plain prefix factor. Since 1 m = 100 cm, $1 \text{ m}^2 = 100 \times 100 = 10\,000 \text{ cm}^2$, not 100 cm^2 , and $1 \text{ m}^3 = 1\,000\,000 \text{ cm}^3$.

How do you write very large and very small numbers?

Standard form writes a number as **$a \times 10^n$** , where a is at least 1 and less than 10 and n is a whole number. A positive n moves the decimal point right, a negative n moves it left. For example $3\,400\,000 = 3.4 \times 10^6$ and $0.000\,072 = 7.2 \times 10^{-5}$.

What are significant figures?

Significant figures (s.f.) show how precisely a number is known. Non-zero digits always count, zeros between digits count, zeros at the start never count, and zeros at the end after a decimal point do count.

Number	Significant figures	Reason
4.07	3	zero between digits counts
0.0052	2	leading zeros do not count
0.0520	3	trailing zero after the point counts
1.200	4	trailing zeros after the point count

Key rule

In a multiplication or division, give the answer to the same number of significant figures as the least precise value used.

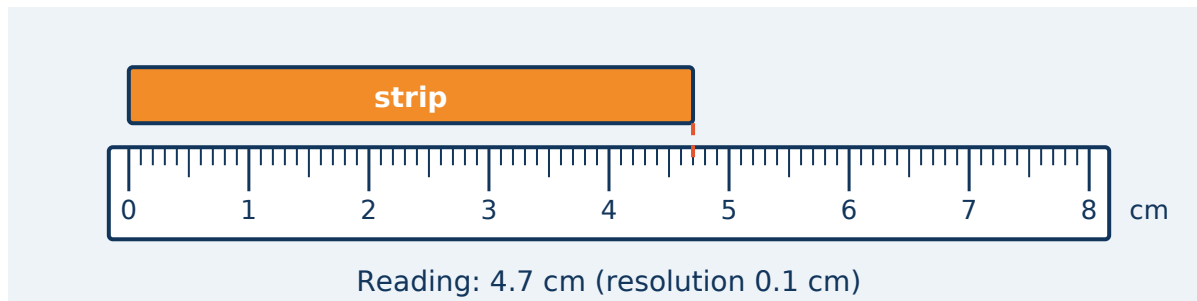
Worked example 2

A tile measures 18.4 cm by 3.2 cm. Calculate its area to a sensible number of significant figures.

$18.4 \times 3.2 = 58.88 \text{ cm}^2$. The width 3.2 cm has only 2 s.f., so the answer has 2 s.f.: **59 cm²**.

How do you read an instrument and describe a measurement?

The **resolution** of an instrument is its smallest division. A ruler with millimetre marks has a resolution of 1 mm, so a reading is quoted to the nearest 0.1 cm, as in the strip below.

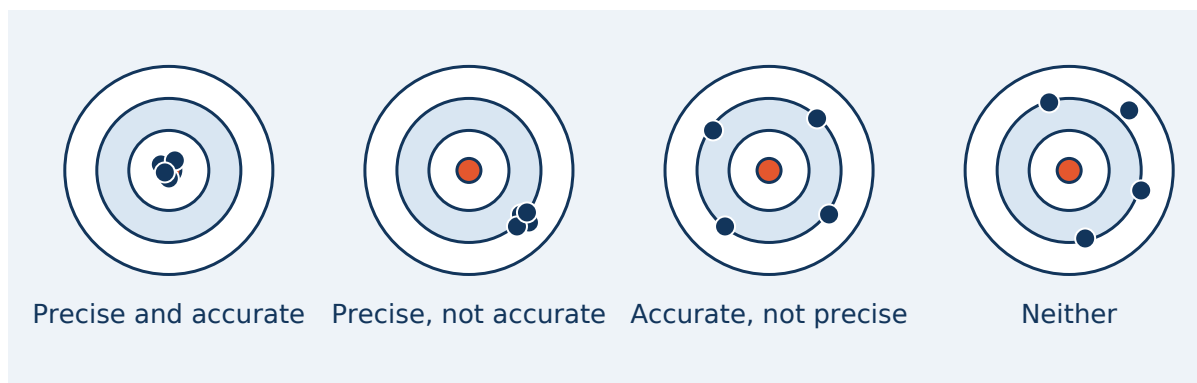


The right-hand end of the strip lines up with the 7th small mark after 4 cm.

What is the difference between precision and accuracy?

Definition

Accuracy means how close a result is to the true value. **Precision** means how close repeated results are to each other. A set of readings can be one without the other.



The centre of each target is the true value; the dots are repeated measurements.

Repeat a measurement and take the **mean**. The spread gives the uncertainty: half the range, (largest – smallest) ÷ 2. The percentage uncertainty is (uncertainty ÷ mean) × 100.

Worked example 3

Emma in Leeds times 10 swings of a pendulum three times: 16.2 s, 16.6 s and 16.4 s. Find the mean and the percentage uncertainty.

Mean = $(16.2 + 16.6 + 16.4) \div 3 = 49.2 \div 3 = 16.4$ s. Uncertainty = $(16.6 - 16.2) \div 2 = 0.2$ s. Percentage = $0.2 \div 16.4 \times 100 = 1.2\%$.

Lina's tip

Keep every digit on your calculator while you work and round only once, at the very end. Write the unit after every line of working so you never lose it.

Key points to remember

- Base units: metre (m), kilogram (kg), second (s), ampere (A), kelvin (K), mole (mol).
- Prefixes: kilo 10^3 , milli 10^{-3} , micro 10^{-6} , nano 10^{-9} , mega 10^6 , giga 10^9 .
- Standard form: $a \times 10^n$ with a from 1 up to (not including) 10.
- Products and quotients keep the fewest significant figures of the data.
- Uncertainty $\approx$ half the range of repeated readings.

Units, prefixes and reliable measurements: frequently asked questions

What are the seven SI base units?

They are the metre (length), kilogram (mass), second (time), ampere (current), kelvin (temperature), mole (amount of substance) and candela (luminous intensity). At grades 9-10 the first five are used most.

How do you convert milli and micro units?

Multiply by the prefix factor to reach the base unit: milli is 10^{-3} and micro is 10^{-6} . For example $350 \text{ mA} = 350 \times 10^{-3} \text{ A} = 0.35 \text{ A}$.

How many significant figures should an answer have?

Use the same number as the least precise piece of data in a multiplication or division. Round only at the last step to avoid building up errors.

Can a measurement be precise but not accurate?

Yes. If a balance has a zero error, repeated readings can agree closely with each other but all be too high. That is precise but not accurate.

Why is standard form useful in physics?

It shows the size of a number at a glance and keeps the significant figures clear. Values such as 3.0×10^8 m/s or 1.6×10^{-19} C are far easier to read this way.