Activity 1 Scientific vocabulary: Designing an investigation

Link each term on the left to the correct definition on the right.

Term	Definition
Hypothesis	The maximum and minimum values of the independent or dependent variable
Dependent variable	A variable that is kept constant during an experiment
Independent variable	The quantity between readings, eg a set of 11 readings equally spaced over a distance of 1 metre would give an interval of 10 centimetres
Control variable	A proposal intended to explain certain facts or observations
Range	A variable that is measured as the outcome of an experiment
Interval	A variable selected by the investigator and whose values are changed during the investigation

Activity 2 Scientific vocabulary: Making measurements

Link each term on the left to the correct definition on the right.

True value	The range within which you would expect the true value to lie
Accurate	A measurement that is close to the true value
Resolution	Repeated measurements that are very similar to the calculated mean value
Precise	The value that would be obtained in an ideal measurement where there were no errors of any kind
Uncertainty	The smallest change that can be measured using the measuring instrument that gives a readable change in the reading

Activity 3 Scientific vocabulary: Errors

Link each term on the left to the correct definition on the right.

Random error	Causes readings to differ from the true value by a consistent amount each time a measurement is made
Systematic error	When there is an indication that a measuring system gives a false reading when the true value of a measured quantity is zero
Zero error	Causes readings to be spread about the true value, due to results varying in an unpredictable way from one measurement to the next

Understanding and using SI units

All measurements have a size (eg 2.7) and a unit (eg metres or kilograms). Sometimes, there are different units available for the same type of measurement. For example, milligram, gram, kilogram and tonne are all units used for mass. Some values like strain and refractive index are not followed by a unit.

To reduce confusion, and to help with conversion between different units, there is a standard system of units called the SI units which are used for most scientific purposes.

These units have all been defined by experiment so that the size of, say, a metre in the UK is the same as a metre in China.

There are seven SI base units, which are given in the table.

Physical quantity	Unit	Abbreviation
Mass	kilogram	kg
Length	metre	m
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
luminous intensity	candela	cd

All other units can be derived from the SI base units. For example, area is measured in metres square (written as m^2) and speed is measured in metres per second (written as $m\ s^{-1}$ this is a change from GCSE, where it would be written as m/s).

Some derived units have their own unit names and abbreviations, often when the combination of SI units becomes complicated. Some common derived units are given in the table below.

Physical quantity	Unit	Abbreviation	SI unit
Force	newton	N	$kg\ m\ s^{-2}$
Energy	joule	J	$kg\ m^2\ s^{-2}$
Frequency	hertz	Hz	s^{-1}

Using prefixes and powers of ten

Very large and very small numbers can be complicated to work with if written out in full with their SI unit. For example, measuring the width of a hair or the distance from Manchester to London in metres (the SI unit for length) would give numbers with a lot of zeros before or after the decimal point, which would be difficult to work with.

So, we use prefixes that multiply or divide the numbers by different powers of ten to give numbers that are easier to work with. You will be familiar with the prefixes milli (meaning 1/1000), centi (1/100), and kilo (1 × 1000) from millimetres, centimetres and kilometres.

There is a wide range of prefixes. Most of the quantities in scientific contexts will be quoted using the prefixes that are multiples of 1000. For example, we would quote a distance of 33 000 m as 33 km.

Kg is the only base unit with a prefix.

The most common prefixes you will encounter are given in the table.

Prefix	Symbol	Power of 10	Multiplication factor	
Tera	T	10^{12}	1 000 000 000 000	
Giga	G	10^{9}	1 000 000 000	
Mega	M	10^{6}	1 000 000	
kilo	k	10^{3}	1000	
deci	d	10^{-1}	0.1	1/10
centi	c	10^{-2}	0.01	1/100
milli	m	10^{-3}	0.001	1/1000
micro	μ	10^{-6}	0.000 001	1/1 000 000
nano	n	10^{-9}	0.000 000 001	1/1 000 000 000
pico	p	10^{-12}	0.000 000 000 001	1/1 000 000 000 000
femto	f	10^{-15}	0.000 000 000 000 001	1/1 000 000 000 000 000

Activity 4 SI units and prefixes

1. Re-write the following quantities using the correct SI units.

    a. 1 minute
    b. 1 milliamp
    c. 1 tonne

2. What would be the most appropriate unit to use for the following measurements?

    a. The wavelength of a wave in a ripple tank
    b. The temperature of a thermistor used in hair straighteners
    c. The half-life of a source of radiation used as a tracer in medical imaging
    d. The diameter of an atom
    e. The mass of a metal block used to determine its specific heat capacity
    f. The current in a simple circuit using a 1.5 V battery and bulb

Activity 5 Converting data

Re-write the following quantities.

1. 1.5 kilometres in metres
2. 450 milligrams in kilograms
3. 96.7 megahertz in hertz
4. 5 nanometers in metres
5. 3.9 gigawatts in watts

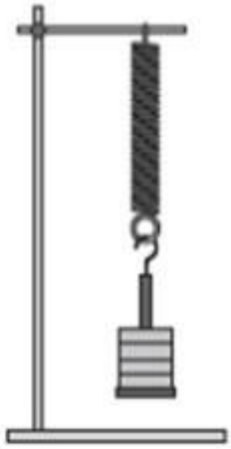
Practical skills

The practical skills you learnt at GCSE will be further developed through the practicals you undertake at A-level. Your teacher will explain in more detail the requirements for practical work in Physics.

There is a practical handbook for AS and A-level Physics, which has lots of very useful information to support you in developing these important skills. You can download a copy here.

Activity 6 Investigating springs

A group of students investigated how the extension of a spring varied with the force applied. They did this by hanging different weights from the end of the spring and measuring the extension of the spring for each weight.



The results are below.

Weight added to the spring / N	Extension of spring / cm			
	Trial 1	Trial 2	Trial 3	Mean
2	3.0	3.1	3.2	
4	6.0	5.9	5.8	
6	9.1	7.9	9.2	
8	12.0	11.9	12.1	
10	15.0	15.1	15.12	

1. What do you predict the result of this investigation will be?
2. What are the independent, dependent and control variables in this investigation?
3. What is the difference between repeatable and reproducible?
4. What would be the most likely resolution of the ruler you would use in this investigation?
5. Suggest how the student could reduce parallax errors when taking her readings.
6. Random errors cause readings to be spread about the true value.

   What else has the student done in order to reduce the effect of random errors and make the results more precise?

7. Another student tries the experiment but uses a ruler which has worn away at the end by 0.5 cm. What type of error would this lead to in his results?

8. Calculate the mean extension for each weight.

9. A graph is plotted with force on the y axis and extension on the x axis. What quantity does the gradient of the graph represent?

Greek letters

Greek letters are used often in science. They can be used:

- as symbols for numbers (such as π = 3.14…)
- as prefixes for units to make them smaller (eg µm = 0.000 000 001 m)
- as symbols for particular quantities.

The Greek alphabet is shown below.

Capital letter	Lower case letter	Name
Α	α	alpha
Β	β	beta
Γ	γ	gamma
Δ	δ	delta
Ε	ε	epsilon
Ζ	ζ	zeta
Η	η	eta
Θ	θ	theta

Capital letter	Lower case letter	Name
Ι	ι	iota
Κ	κ	kappa
Λ	λ	lambda
Μ	μ	mu
Ν	ν	nu
Ξ	ξ	ksi
Ο	ο	omicron
Π	π	pi

Capital letter	Lower case letter	Name
Ρ	ρ	rho
Σ	ς or σ	sigma
Τ	τ	tau
Υ	υ	upsilon
Φ	φ	phi
Χ	χ	chi
Ψ	ψ	psi
Ω	ω	omega

Activity 7 Using Greek letters

Use your knowledge from GCSE to complete the table. The first line has been completed for you.

Object or quantity represented by the Greek letter	Greek letter
Wavelength	λ
Type of ionising radiation which cannot pass through paper and is used in smoke detectors	
	Ω
Type of ionising radiation which is an electron ejected from the nucleus. Can be used to monitor paper thickness	
Very short wavelength electromagnetic wave	

The Physics formula and data sheet

You will need to use the AQA Physics formula and data sheet in your exams.

You can download a copy here.

Activity 8 Using the Physics formula and data sheet

1. Use the sheet to find the symbols used to represent the following particles. (You will learn about these particles when you study particle physics.)

   a. Photon
   b. Neutrino
   c. Muon
   d. Meson (two letters used depending on type of meson)

2. Look through the Electricity and Materials formula sections on the data sheet.

   There is one Greek letter that is used to represent two different quantities. Give the letter and the quantities is it used to represent.

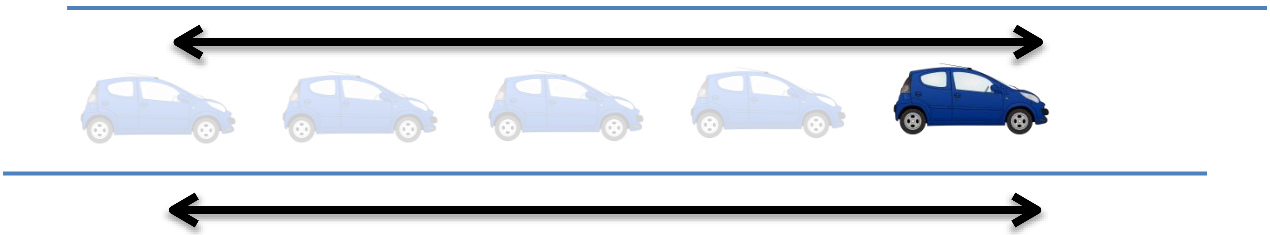
The delta symbol (Δ)

The delta symbol (Δ) is used to mean 'change in'. For example, at GCSE, you would have learned the formula:

$$\text{speed} = \frac{\text{distance}}{\text{time}} \quad \text{which can be written as} \quad s = \frac{d}{t}$$

What you often measure is the **change** in the distance of the car from a particular point, and the **change** in time from the beginning of your measurement to the end of it.

change in distance along road



time at starting point of measurement

change in time

time at end point of measurement

As the distance and the speed are changing, you use the delta symbol to emphasise this. The A-level version of the above formula becomes:

$$\text{velocity} = \frac{\text{displacement}}{\text{time}} \quad \text{which can be written as} \quad v = \frac{\Delta s}{\Delta t}$$

Note: the delta symbol is a property of the quantity it is with, so you treat 'Δs' as one thing when rearranging, and you cannot cancel the delta symbols in the equation above.

Activity 9 Using the delta symbol

1. What is the difference between:

   a. speed and **velocity**
   b. distance and **displacement**

2. Look at the A-level Physics formula sheet (https://filestore.aqa.org.uk/sample- papers-and-mark-schemes/2018/june/AQA-74081-INS-JUN18.PDF) .

   Which equations look similar to ones you used at GCSE, but now include the delta symbol?

3. A coffee machine heats water from 20 °C to

   90 °C. The power output of the coffee

   machine is 2.53 kW. The specific heat capacity

   of water is 4200 J/kg °C

   Calculate the mass of water that the coffee machine can heat in 20 s.

4. An unused pencil has a length of 86.0 mm.

   A student uses the pencil to draw 20 lines on a piece of

   paper. Each line has a length of 25 cm.

   The length of the pencil has changed to 84.5 mm.

   Calculate the length of line that would need to be drawn for the original length to be halved.

Rearranging formulas

Activity 10 Rearranging formulas

1. Rearrange $c = f\lambda$ to make f the subject.
2. Rearrange $\rho = \frac{m}{V}$ to make m the subject.
3. Rearrange $w = \frac{\lambda D}{s}$ to make s the subject
4. Rearrange $P = I^2 R$ to make I the subject
5. Rearrange $E = \frac{1}{2} m v^2$ to make v the subject.
6. Rearrange $h f = \varphi + E_k$ to make φ the subject
7. Rearrange $v = u + a t$ to make a the subject.
8. Rearrange $s = u t + \frac{1}{2} a t^2$ to make a the subject.
9. Rearrange $\varepsilon = I(R + r)$ to make r the subject.
10. Rearrange $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ to make T the subject.

Using maths skills

Physics uses the language of mathematics to make sense of the world. It is important that you are able to apply maths skills in Physics. The maths skills you learnt and applied at GCSE are used and developed further at A-level.

Activity 11 Standard form

1. Write the following numbers in standard

   form. a. 379 4
   b. 0.0712

2. Use the data sheet to write the following as ordinary numbers.

   a. The speed of light
   b. The charge on an electron

3. Write one quarter of a million in standard form.

4. Write these constants in ascending order (ignoring units).

   Permeability of free space The Avogadro constant Proton rest mass Acceleration due to gravity Mass of the Sun

Activity 12 Significant figures and rounding

1. A rocket can hold 7 tonnes of material.

   Calculate how many rockets would be needed to deliver 30 tonnes of material to a space station.

2. A power station has an output of 3.5 MW.

   The coal used had a potential output of 9.8

   MW. Calculate the efficiency of the power

   station.

   Give your answer as a percentage to an appropriate number of significant figures.

3. A radioactive source produces 17 804 beta particles in 1 hour.

   Calculate the mean number of beta particles produced in 1

   minute. Give your answer to one significant figure.

Activity 13 Fractions, ratios and percentages

1. The ratio of turns of wire on a transformer is 350 : 7000 (input : output) What

   fraction of the turns are on the input side?

2. A bag of electrical components contains resistors, capacitors and diodes.

   $^{2}/_{5}$ of the components are resistors.

   The ratio of capacitors to diodes in a bag is 1 : 5. There are 100 components in total.

   How many components are diodes?

3. The number of coins in two piles are in the ratio 5 : 3. The coins in the first pile are all 50p coins. The coins in the second pile are all £1 coins.

   Which pile has the most money?

4. A rectangle measures 3.2 cm by 6.8 cm. It is cut into four equal sized smaller rectangles.

   Work out the area of a small rectangle.

5. Small cubes of edge length 1 cm are put into a box. The box is a cuboid of length 5 cm, width 4 cm and height 2 cm.

   How many cubes are in the box if it is half full?

6. In a circuit there are 600 resistors and 50 capacitors. 1.5% of the resistors are faulty. 2% of the capacitors are faulty.

   How many faulty components are there altogether?

7. How far would you have to drill in order to drill down 2% of the radius of the Earth?

8. Power station A was online 94% of the 7500 days it worked for. Power

   station B was online $^{8}/_{9}$ of the 9720 days it worked for. Which power

   station was offline for longer?