Physics AS Bridging Project

Overview

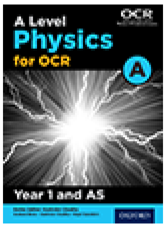
At English Martyrs, you will do AS examinations at the end of year 12.
In year 13 you will do the A2 examinations. The grade you achieve for AS physics has no influence on the A2 grade you might achieve. However, in order to progress from AS to A2, you must achieve a minimum of grade D at AS.

Pass grades at AS range from A – E.
Pass grades at A2 range from A* - E

Physics Syllabus

You will be taught the OCR physics A syllabus.
AS and A2 specifications:
https://www.ocr.org.uk/qualifications/as-and-a-level/physics-a-h156-h556-from-2015/#as-level

Recommended Text Book



A Level Physics A for OCR Year 1 and AS Student Book

Author: Graham Bone,Gurinder Chadha

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Outline of Modules

AS Module 1 – Development of practical skills in physics (taught within modules 2-5)
AS Module 2 – Foundations of physics
AS Module 3 – Mechanics
AS Module 4 – Electrons, Waves and Photons
- -
A2 Module 5 – Newtonian World and Astrophysics
A2 Module 6 – Particle Physics and Medical Physics

Practical Endorsement

The practical endorsement in physics is achieved by successfully completing a series of practical activities over the two years of the course.
You will record all practical activities in a folder which will be marked by your teacher.
All written assessments are at the end of the course. These examine the syllabus contant and the practical skills you have learnt during the course.

The exam board Practical Skills Handbook is essential reading and covers all the various skills you might be examined on.
https://www.ocr.org.uk/images/295483-practical-skills-handbook.pdf

Physics Examinations

AS Paper 1: Breadth in Physics assesses content from modules 1,2 and 3
70 marks – 1hour 30 minutes – 50% of total AS level
AS Paper 2: Depth in Physics assesses content from modules 1,2 and 4
70 marks – 1hour 30 minutes - 50% of total AS level

A2 Paper 1: Modelling Physics (01) assesses content from modules 1,2,3 and 5.
100 marks - 2 hour 15 minutes - 37% of total A level

A2 Paper 2: Exploring Physics (02) assesses content from modules 1,2,4 and 6.
100 marks - 2 hour 15 minutes - 37% of total A level

A2 Paper 3: Unified Physics (03) assesses content from all modules (1-6).
70 marks - 1hour 30 minutes - 26% of total A level

Exercise 1

Using the AS specification document, write down the answers to the following questions:

1. What is the code for the Physics AS specification? ……………
2. What are the 3 sections of the Foundations of Physics module?

   ……………………………………………………….………………………

   ……………………………………………………….………………………

   ……………………………………………………….………………………
3. What are the 5 sections of the Mechanics module?

   ………………………………………………………………………………..

   ………………………………………………………………………………..

   ………………………………………………………………………………..

   ………………………………………………………………………………..

   ………………………………………………………………………………...
4. What are the units of the Stefan Constant? ………………………………….
5. How many metres are there in 1 parsec? …………………………………...
6. Name the constant which has the symbol h, and state its value?

   ………………………

SI units

In Physics, most physical quantities consist of a value and a **unit**. Eg 6.0 kg There are different systems of units, for example, the units of length and distance are metres, or centimetres, or millimetres, or inches or furlongs or miles, etc.

After an agreement between scientists of most nationalities, the *Système International* (known as the SI system, and French for International System, not surprisingly) was drawn up, dictating the standard units for seven fundamental quantities (and also how they would be defined). The standard units adopted by the *Conférence Général des Poids et Mesures* are as follows:

These are known as **Base units.**
Every other unit such a coulombs, newtons, joules, pascals, volts, tesla, ohms etc can be expressed in terms of these base units.

For example, Charge = current x time (Q = I x t)
(coulombs) (amps) x (seconds)

So the coulomb (C) in terms of base units, can be written as A x s or As

Unit	Symbol	Definition	Adopted in...
Metre	m	The metre is the length of the path travelled by light in vacuum in a time interval of 1/299 792 458 of a second.	1983
Kilogram	kg	The **kilogram** is now **defined by defining** the Planck constant to be exactly 6.62607015×10^{-34} **kg**$\cdot m^2\cdot s^{-1}$, effectively **defining** the **kilogram** in terms of the second and the metre.	2018
Second	s	The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom.	1967
Ampere	A	The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed one metre apart in vacuum, would produce between those conductors a force equal to 2×10^{-7} newton per metre of length.	1948
Kelvin	K	The kelvin is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.	1967
Mole	mole	The mole is the amount of substance which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12.	1967
Candela*	cd	The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian. (you won't use this at AS/A2 physics)	1979

Exercise 2

Fill in the gaps as appropriate:

Quantity	Units in words	Symbol
Force	newtons	N
Mass	....	....
Velocity	………………………….	....
Acceleration	....	....
Current	....	....
Voltage	....	....
....	ohms	....
Energy	....	....
Work	....	....
....	hertz	....
Wavelength	....	....
....	coulombs	....

You have probably been used up until now to writing 'metres per second' as m/s. But in A ans AS Level, we use *indices* instead, ie: we write ms^{-1}. Similarly, m/s^2 is written as ms^{-2}. Specific heat capacity, which you have met as J/kg°C should be written as $Jkg^{-1}{}^{\circ}C^{-1}$.

Notice also that all units start with lower case letters: this is to distinguish them from the people they are sometimes named after (eg: newton/Newton). The symbol, however, will always be a capital letter (eg: N).

Exercise 3

Fill in the gaps but using the correct indices notation where appropriate.

Research the other quantites/units as required

Quantity	Units
Velocity	………………..
Acceleration	……………….
Density	………………..
Specific Heat Capacity	……………….
Specific latent Heat	………………...
Intensity	……………….
Pressure	……………….
Stress	………………..
Youngs Modulus	………………..

Quantity	Units
Magnetic Flux	………………..
Magnetic Flux Density	………………
Gravitational field strength	………………
Gravitational potential	…………………
Electric field strength	………………….
Electric potential	………………….

More on converting units into Base units

You have seen on page 3 that units such as coulombs can be written in terms of Base units. To do this, think of an equation which has the unit you want to convert, in it. Eg the newton, which is the unit of force.

$F = ma$; m, the mass, is measured in kg, which is a base unit
a, the acceleration, is measured in ms^{-2}
so we can multiply the units together, and we find that $1N = 1kg \times 1ms^{-2}$
so N is the same as $kgms^{-2}$

Help here! https://www.youtube.com/watch?v=DTv_eI9Hlro

Conversions of this type often come up in the examinations.

Exercise 3

Use the following formula to express the units in terms of base units

	Formulae	Unit	...in terms of base units
1.	Charge = It	coulomb, C	……………………………………………
2.	Force = ma	newton, N	…………………………………….
3.	Work done= force x distance	joule, J	……………………………………
4.	pressure = f / A	pascal, Pa	……………………………………
5.	$K.E. = \frac{1}{2}mv^2$	joule, J	……………………………………………
6.	GPE = mgh	joule, J	…………………………………….
7.	$\text{Power} = \frac{\text{Energy transferred}}{\text{Time taken}}$	watt, W	……………………………………………
8.	$V = \frac{\text{Energy}}{\text{Charge }(Q)}$, $Q = It$ and $V = IR$	ohms, Ω	……………………………………………

Prefixes

Often it is more appropriate to use a multiple or sub multiple of a unit for a given quantity simply because the unit itself is either too big or too small. To save ourselves writing out the powers of ten or even all the zeros, we use **prefixes** in front of the units as a sort of short hand. You will already be familiar with milli (m), which means 'one thousandth' and kilo (k), which means 'one thousand' but there are many more, eg: wavelengths of electromagnetic radiation are often measured in nanometres (nm). The most commonly used prefixes are shaded.

Prefix	Factor	Symbol
exa	10^{18}	E
peta	10^{15}	P
tera	10^{12}	T
giga	10^{9}	G
mega	10^{6}	M
kilo	10^{3}	k
milli	10^{-3}	m
micro	10^{-6}	μ
nano	10^{-9}	n
pico	10^{-12}	p
femto	10^{-15}	f
atto	10^{-18}	a

Exercise 4

1. How many metres in 2.4 km? ....

2. How many joules in 8.1 MJ? ....

3. Convert 326 GW into W. ....

4. Convert 54 600 mm into m. ....

5. How many grams in 240 kg? ....

6. Convert 0.18 nm into cm. ....

7. Convert 632 nm into mm. ....

8. Convert 1002 mV into V. ....

9. How many eV in 0.511 MeV? ....

10. How many m in 11 km? ....

Convert the following quantities into more sensible units. The first one is done for you.

11.	300000m	300km	16.	0.078mm	....
12.	0.007m	....	17.	12300000pA	....
13.	0.00002A	....	18.	75×10^{5} C	....
14.	2100000V	....	19.	8.9×10^{12} nV	....
15.	35700Ω	....	20.	4.23×10^{-7} km	....

Quoting Answers

Nine times out of ten, your calculator will give you an answer to around 8 decimal places. However, you do not need to give this much information as your answer, so you should *truncate* (shorten) your answer. There are two ways of doing this:

Significant Figures

The 'significant figures' of a number are the first non-zero digits, eg: in the number 0.00034, the first significant digit is 3. If you quote an answer to a certain number of significant figures, you start with the first non-zero digit, and list the required number of digits, rounding the last digit.
eg: 0.0030945 to 3 significant figures would be 0.00309 (3 s.f.)
0.0030945 to 2 significant figures would be 0.0031 (2 s.f)
0.0030900 to 4 significant figures would be 0.003090 (4 s.f)

Decimal Places

The 'decimal places' of a number are how many digits are given after the decimal point.
eg: 0.0030945 to 3 decimal places would be 0.003 (3 d.p.)
0.0030945 to 6 decimal places would be 0.003095 (6 d.p.)
Again, the last digit must be rounded. Obviously, if this number was quoted to less than 3 decimal places, the value would be zero, which is wrong. Care must be taken when rounding answers to significant figures or decimal place.

In Physics AS/A2, we take particular account of the **significant figures**. As a general rule, and answer to a calculation should be given to the same number of significant figures as the **minimum** number given in the question. If you give too few sig figs, you will lose a mark. It is acceptable to give one more sig fig than is required.
Never quote and answer to 1 sig fig.

Keep the numbers in your working to a greater accuracy than you are quoting in. It's no good working out a couple of values to 3 s.f. and then using those values to produce an answer which you quote to 4 s.f. Similarly, you cannot claim an answer to be more accurate than the values given to you in a problem. This is something you will quickly pick up with practice.

Exercise 5

Give the following numbers to their required accuracy

	Number	Accuracy	Answer
1.	1.23456	3 d.p.	....
2.	0.0000970003	4 s.f.	....
3.	0.000879912	3 s.f.	....
4.	7689932	3 s.f.	....
5.	0.0030009	4 s.f.	....
6.	7070777	3 s.f.	....

Standard Form

At A level, quantities will be written in standard form, and it is expected that your answers will be given in standard form.
This means answers should be written as ….x 10^y. E.g. for an answer of 1200kg we would write 1.2×10^3kg.

For information see https://www.youtube.com/watch?v=ceneATH5EZ8

Exercise 6

1.Write 2530 in standard form…………

2.Write 280 in standard form…………...

3.Write 0.77 in standard form…………...

4.Write 0.0091 in standard form…………

5.Write 1 872 000 in standard form……..….

6. Write 4.3×10^3 as a normal number………..

7. Write 6.002×10^2 as a normal number………..

8. Write 8.31×10^6 as a normal number…………

9. Write 3.505×10^1 as a normal number……….

10. 2.4×10^2 as a normal number……………

Exercise 7 Carry out the following calcualtions, taking care to show all working out, significant figures, standard form and units where appropriate.

1.Calculate the mean of the following numbers. 6.56, 4.3, 8.765, 1.275×10^1 ………………..

2. Using the equation f=ma, calculate the force needed to give a mass of 2486kg an acceleration of $0.50ms^{-2}$

3. Calculate the work done when a force of 2.5×10^5N moves a distance of 250m.

4. Calculate the kinetic energy of a 2.05 tonne car moving at $34ms^{-1}$.

5.Calculate the gravitational potential energy of a 650kg mass lifted through a height of 6.0m (g = $9.81Nkg^{-1}$)

6.Calculate the acceleration of a lorry whose velocity changes from $3.4ms^{-1}$ to $10ms^{-1}$ in a time of 4.53 s

7. Calculate the density of a rock which has a volume of $10cm^3$ and a mass of 20g.

Rearranging formula

Being able to use formulae correctly is an **essential** skill in A Level Physics. A formula is a mathematical expression which relates various quantities together. eg:

$$F = \frac{\mu_0 I_1 I_2}{2\pi r}$$

Quantities come in two types: *constants,* whose values never change (eg: 2π, μ_0) and *variables,* which can take on any values (eg: I_1, I_2, F). All quantities have their own symbols, which are usually letters of the English or Greek* alphabets. (Sometimes there are more than one symbol in common use for some quantities, sometimes one letter may stand for two or three different quantities.)

It is quite common for an equation to contain two or more quantities of the same type, eg: in the above equation there are two different currents, I_1 and I_2. To show that the difference, each I is given a *subscript* - a small symbol to the right and below, and smaller than the main symbol. Subscripts can be of various types, and they serve to provide extra descriptive information about the quantity. They can be:-

Numbers: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Letters: $Z^2 = (X_L - X_C)^2 + R^2$

Words or abbreviations: v_{escape}, I_{rms}

The more formulas you come across, the better you will become at recognising which symbols stand for what. You are not, under the present rules, expected to know all the formulas by heart: they will be provided for you in a data booklet during the exams. However, it is very important that you attempt to learn as many as you can during the course of your studies. Firstly, if you know a formula you will not have to waste time searching for it in the booklet; secondly, learning a formula will help you to learn the principles behind it, and thirdly, if you start to rely on the booklet as your prime source of information (instead of your brain!) you will soon find yourself staring at a page of meaningless lines and squiggles.

In other words, take the time to learn the formula, and refer to the booklet as a check.

You will be using formulae to use various known quantities to calculate one unknown quantity. eg: if we know the values of μ_0, I_1, I_2, π and r then we can plug these values into the equation on the previous page to calculate a value for F. But what if we want to find out a value for r, and we have values for all the other quantities? We have to *rearrange* the formula into an expression for r; we say that we need to *make r the subject of the equation.*

* A full list of the letters of the Greek alphabet is included at the end

To illustrate this, consider an equation you are much more familiar with:

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

If you are given the speed of an object and the time it is travelling for, to work out the distance it has travelled you rearrange the equation so that distance is the subject:

$$\text{distance} = \text{speed} \times \text{time}$$

And if you know the speed and distance you can work out the time:

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

Exercise 8 Rearrange the following

1. E=m x g x h to find h

2. Q= I x t to find I

3. E = ½ mv² to find m

4. v = u + at to find u

5. v = u + at to find a

There are many equations in Physics which contain squared, cubed and square-rooted quantities,

eg: to make l the subject of the formula $T = 2\pi\sqrt{l/g}$:

Step 1 Square both sides $T^2 =$

Step 2 Multiply both sides by g $gT^2 =$

Step 3 Divide both sides by $4\pi^2$ $l = gT^2/4\pi^2$

Help here! https://www.youtube.com/watch?v=HyH9-5tnS0A

Exercise 9

Make r the subject of the formula $F = \dfrac{\mu_0 I_1 I_2}{2\pi r}$

Make r the subject of the formula $F = \dfrac{Q}{4\pi\varepsilon_0 r^2}$

Exercise 10

There is only one way to get the hang of rearranging formula quickly and accurately, and that's lots and lot's of practice! Rearrange the formulae below, making x the subject. *Write your answers on lined paper and* ***show your working!***

1. $y = 2x - 4$
2. $y = \dfrac{3}{x} + 7$
3. $y = \dfrac{1}{\sqrt{x-2}}$
4. $y = \dfrac{1}{x}$
5. $y = \dfrac{3}{x-1}$
6. $y = \sqrt{(x^2 - 7)}$
7. $y = \dfrac{1}{x^2}$
8. $y = \dfrac{3}{x} + \dfrac{1}{2x}$
9. $y = \dfrac{x-1}{5x}$
10. $y = \sqrt{mx + c}$
11. $y = \dfrac{1}{(2x-5)^2}$
12. $y = \sqrt[3]{6 - 3x}$
13. $y = \dfrac{x-4}{4x}$
14. $y = \sqrt{\dfrac{4-2x}{3x}}$
15. $y = \sqrt{x^3 + 2}$

You may have noticed that there are several *pairs* of *opposite* operations that you use to rearrange formula:

add *is the opposite to* **subtract**
multiply *is the opposite to* **divide**
square *is the opposite to* **square root**
cube *is the opposite to* **cube root**

The golden rule when rearranging is:

Whatever you do to one side of the equation, you must do exactly the same to the other side.

For example if you invert one side (ie: turn a fraction the other way up) you must also invert the other side. eg:

$$\sin c = \frac{1}{n} \xrightarrow{\text{becomes}} \frac{1}{\sin c} = n$$

WARNING: Be **very** careful when turning fractions upside-down. If there is more than one term on either side, then you have to find a common denominator and combine the terms into a single fraction **before** you invert it. eg:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \xrightarrow{\text{becomes}} \frac{1}{R} = \frac{R_2 + R_1}{R_1 R_2} \xrightarrow{\text{becomes}} R = \frac{R_1 R_2}{R_1 + R_2} \quad \text{NOT } R = R_1 + R_2$$

The same goes for squaring and square-rooting:

$$Z^2 = X^2 + R^2 \xrightarrow{\text{becomes}} Z = \sqrt{(X^2 + R^2)} \quad \text{NOT} \quad Z = X + R$$

Exercise 11

Below is a list of formulae and some quantities. For every formula, rearrange it to make each quantity the subject in turn. *Use lined paper and show the stages in your rearrangement*

	Formula	**Make these the subject...**
1.	$T = 2\pi\sqrt{\frac{I}{mgh}}$	g, I
2.	$T = 2\pi\sqrt{\frac{h^2 + k^2}{gh}}$	k
3.	$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$	f, v
4.	$V = \frac{R}{R + r}E$	r
5.	$E = \frac{F/A}{e/l}$	e, A
6.	$v^2 = u^2 + 2as$	u
7.	$Z^2 = (X_L - X_C)^2 + R^2$	X_C, R

Combining Equations

Very often, quantities find themselves involved in more than one equation. For example, consider these two equations, which describe the motion of a body being acted on by a force:

$$F = ma \quad \text{and} \quad v^2 = u^2 + 2as$$

From the first equation we can produce an expression for a:

$$a = \frac{F}{m}$$

Then we **substitute** that expression for a into the second equation:

$$v^2 = u^2 + 2\frac{Fs}{m}$$

In this way, we have **eliminated** a from our equation, so we can solve the problem without knowing what a is. This is something that we often do, when we cannot use one equation on its own because we haven't got values for all the quantities.

Exercise 12

Combine and rearrange the following equations.

Use lined paper and show the stages in your rearrangement

	Formulae		**Eliminate these...**	**Make this the subject...**
1.	$S = (v+u)/2$ $S = d/t$		S	v
2.	$E = mgh$ $E = \frac{1}{2}mv^2$		E	h
3.	$p = mv$ $E = \frac{1}{2}mv^2$	a) b)	v m	m v
4.	$F = ma$ $v = r\omega$ $a = v^2/r$	a) b)	a and v r and a	r ω
5.	$F = \frac{\mu_0 I^2}{2\pi r}$ $V = IR$		I	V

Show your working!

When you are working through a problem, combining and rearranging equations, putting values in and calculating a final answer, it is **ESSENTIAL** that your working is set out tidily and logically. In most exam questions, your working is worth some marks, and even if you get the final answer wrong, you can still pick up some marks if your working is correct. Here are some suggestions:

- Write legibly.
- Work down the page, don't zigzag from left to right.
- Write down each formula as you use it.
- At each stage, explain clearly and briefly what you are doing.
- When you come to put some values in, list them, with their units.
- Underline any intermediate answers, so that you can find them easily at a later point.
- Underline your final answer clearly.
- Don't forget the units and the correct number of significant figures

When you are doing calculations, make sure you are not using your calculator to do trivial sums. It is not uncommon to see intelligent students using their calculators to do 1 plus 1! By doing simple sums and cancellations in your head, you will save time, and you may also reduce the numbers of mistakes you make.

Now work through this package of material

http://fdslive.oup.com/www.oup.com/oxed/secondary/science/Science_A_Level_Transition_Pack_Physics.pdf

Drawing Graphs

Introduction

Another essential skill in Physics is the ability to produce a clear and accurate graph from a set of values from an experiment. We use graphs because the visual information in the line is easier to interpret than a list of values. They can also be used to take errors into account, and to show up possible mistakes.

If you are given a set of data, the best way to obtain values from it is to PLOT A GRAPH.

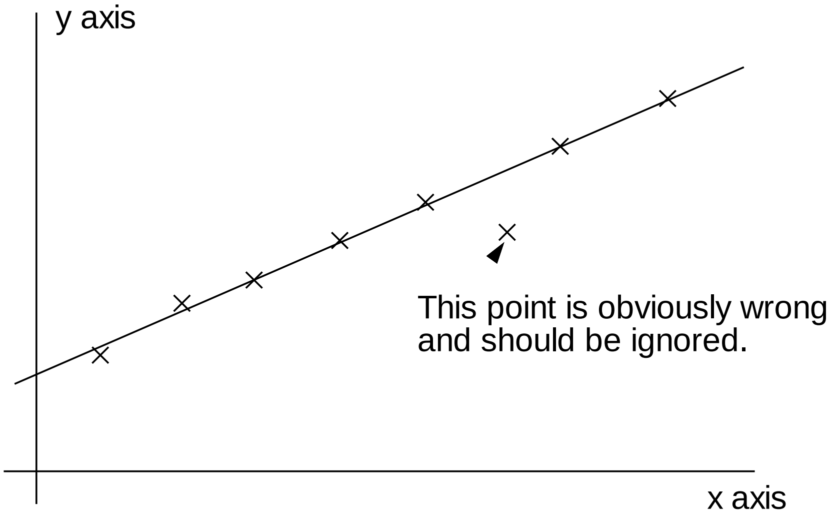
Good Graph Practice

- Use a **sharp** pencil for all lines and points. Preferably, use pencil for everything: if you make a mistake in pen (and *everyone* makes mistakes plotting graphs) you cannot rub it out.
- Plot your points as small crosses (× or +) so it will be easy to draw a line through the centre and still see where the point is. Dots will be obliterated by the line, and large dots are inaccurate.
- Label your axes with the quantity and its units.
- Choose a sensible scale that fills as much of the page as possible.
- Make sure you have a 30cm ruler available.
- Put a title on the graph, explaining what it is showing.
- If you are plotting more than one line on the same axes, either label the lines or use a key.
- NEVER draw a bar chart unless strictly asked to do so.
- Always draw a line or curve of best fit. NEVER do dot-to-dot!

Straight Line Graphs

Most graphs that you plot will be straight lines. When you come to draw the line in, you must draw a *line of best fit*: the line that goes as near as possible to as many points as possible, and has roughly the same number of points below the line as above it. Sometimes it will be easy to draw, other times it will be difficult. You may find that a transparent plastic ruler helps.

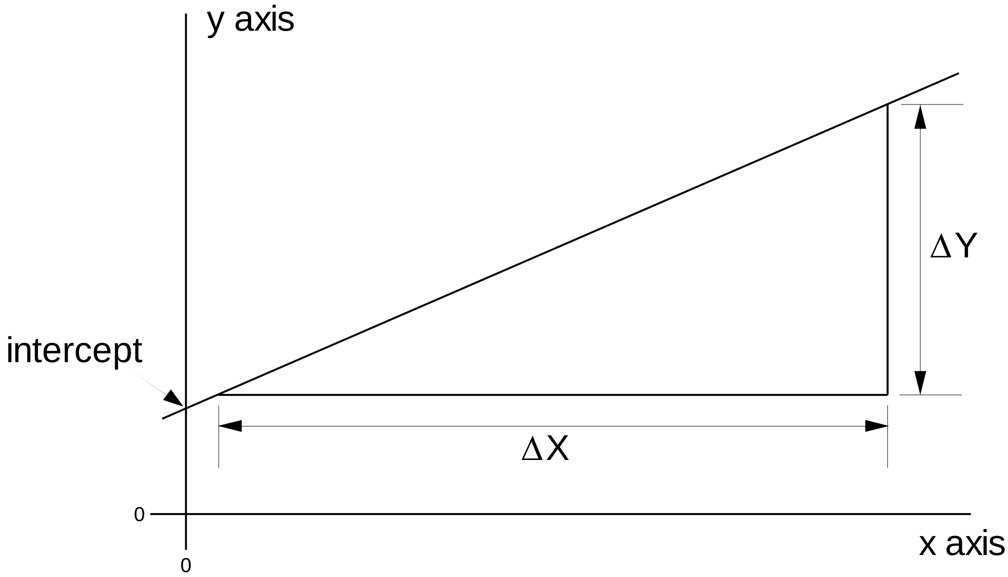
Any points that seem to be way out of line with the rest can be assumed to be the result of an error somewhere, and should not be taken into account when fitting the line. Look at the diagram over the page.



Once you have plotted the graph, you can get some values from it:

Firstly there is the **intercept**. This is where the line crosses the *y* axis.

Secondly, there is the **gradient**, or **slope** of the graph. To work this out, you need to draw a right angled triangle on the line. Make this triangle as big as is possible on the paper, as this will improve the accuracy of your result.



The gradient is calculated by: gradient $= \dfrac{\Delta Y}{\Delta X}$

The units of the gradient come from the units of the axes, eg: if *y* was time in seconds and *x* was distance in metres, then the units of the gradient would be metres ÷ seconds, ie: ms^{-1}.

Note: The intercept can only be read from the x=0 line. If the graph does not have x=0 on it, then the intercept cannot be used. In this situation, use the straight line formula to work out 'c'

Straight Line Formula

Any relationship which produces a straight line graph is said to be **linear**. The equation for a linear graph is always of the form:

$$\boxed{y = mx + c}$$

where: x and y are the two variables
m is the gradient
c is the intercept.

If an equation can be rearranged into this form, then a straight line graph can be produced.

Turning a formula into a straight line graph

Rearranging a formula into straight line form takes a bit of practice. Here is an example: The time period of a pendulum is related to its length by the formula $T = 2\pi\sqrt{l/g}$. We have a set of values of T and l. What graph should we plot?

Firstly, we rearrange the formula slightly:

$$T^2 = 4\pi^2\left(l/g\right)$$

$$T^2 = \frac{4\pi^2}{g}l$$

To make this equivalent to $y = mx + c$:

$$\begin{aligned} T^2 &\leftrightarrow y \\ l &\leftrightarrow x \quad \text{and } c=0 \\ \frac{4\pi^2}{g} &\leftrightarrow m \end{aligned}$$

So we need to plot a graph with T^2 on the y axis and l on the x axis. We can measure the gradient m and can then calculate a value for g using

$$\text{gradient} = \frac{4\pi^2}{g} \quad \text{therefore} \quad g = \frac{4\pi^2}{\text{gradient}}$$

Note: On some graphs, only the gradient can be used, on others only the intercept can be used, and on some both can be used.

Exercise 13

For each of the following relationships, rearrange the formula into a straight line from, and say which quantities to plot on which axes. Then show how to calculate the desired values from the gradient and/or intercept.

1. $W = \frac{1}{2}k(\Delta l)^2$ Data available: W, Δl

   x axis:.. y axis:..

   to calculate k:..

   ....

2. $v = u + at$ Data available: v, t

   x axis:.. y axis:..

   to calculate u: ....

   ....

   to calculate a:..

   ....

3. $I = n\phi - B$ Data available: I, ϕ

   x axis:.. y axis:..

   to calculate n: ....

   ....

   to calculate B:..

   ....

4. $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ Data available: u, v

   x axis:.. y axis:..

   to calculate f: ....

   ....

5. $T = 2\pi\sqrt{\frac{h^2 + k^2}{gh}}$ Data available: h, T

   x axis:.. y axis:..

   to calculate g: ....

   ....

   to calculate k:..

   ....

Exercise 14

In an experiment to investigate how the length of a tube affects its resonant frequency, a set of corresponding values of length, l, and frequency f, were collected. It is known that the relationship between them is governed by the equation

$$l + e = \frac{v}{4f}$$

where: e is a constant of the tube, called the *end correction*, and is measured in the same units as the length.
v is the speed of sound in air.

1. Rearrange the formula into a straight line form.

....

....

....

....

2. The following table lists the values of l and f that were collected. The third column has been left blank; you should need to use it.

l **(m)**	***f*** **(Hz)**	
0.10	720	....
0.20	380	....
0.25	320	....
0.40	205	....
0.45	175	....
0.50	160	....
0.60	135	....
0.70	115	....
0.80	100	....

3. Plot a graph that will produce a straight line, using the rearranged formula from part 1.

4. Measure the gradient ....
and the intercept..

5. Calculate values for v and e, including their units.

....

....

....

....

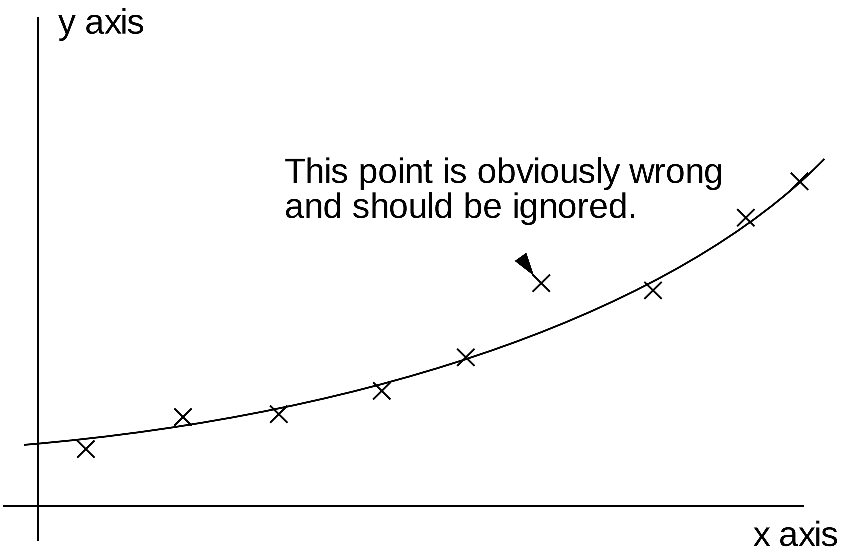
....

....

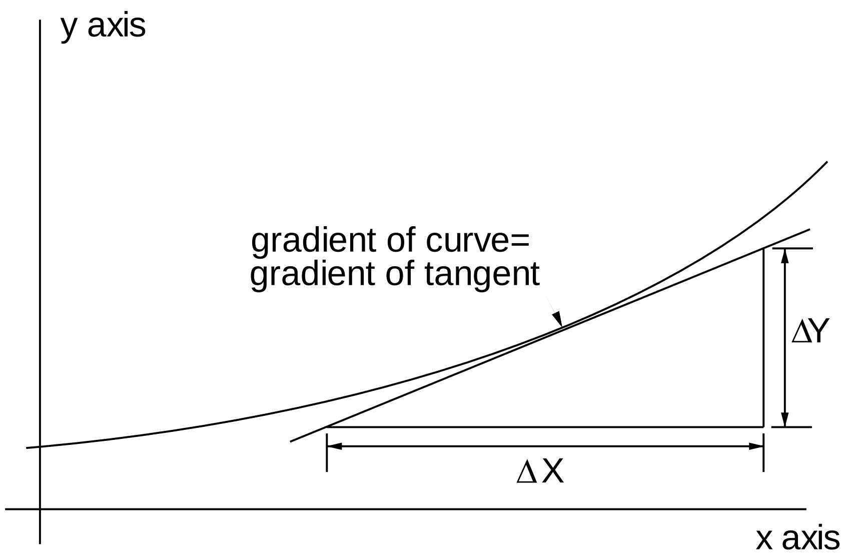
....

Curves

Not all graphs can be put into a straight line form, and sometimes we actually want to produce a curve on a graph. When you are drawing a curve to a set of points, try to draw a smooth curve of best fit, and avoid lines that wobble up and down:



Because it is not a straight line, the curve does not have a gradient. However, you can measure the gradient *at a point* by drawing a line at a tangent to the curve at a particular place, then calculating the gradient of that as before. The gradient of a curve represents the *rate of change* of *y* with respect to *x*.



When you are asked to calculate the gradient of a curve, **always** draw the tangent, and make the triangle nice and big, to reduce errors. It also helps to write the values of ΔX and ΔY on the sides of the relevant triangle.

Exercise 15

Plot the following set of data, with time an the x axis and current on the y axis:

Time (s)	Current (A)
0	0.0
5	1.55
10	2.75
15	3.70
20	4.42
25	5.00
30	5.43
35	5.80
40	6.05
45	6.26
50	6.43

Calculate the gradient (including units) at the following times:

10s: gradient= ....

....

20s: gradient= ....

....

38s: gradient= ....

....

Appendix: Greek Letters

This is a complete list of all 24 Greek letters, which are used widely in Physics. It is unlikely that you will come across all of them during your A Level course - the letters most likely to crop up have been highlighted.

	Uppercase	Lowercase
Alpha	Α	α
Beta	Β	β
Gamma	Γ	γ
Delta	Δ	δ
Epsilon	Ε	ε
Zeta	Ζ	ζ
Eta	Η	η
Theta	Θ	θ
Iota	Ι	ι
Kappa	Κ	κ
Lambda	Λ	λ
Mu	Μ	μ
Nu	Ν	ν
Xi	Ξ	ξ
Omicrom	Ο	ο
Pi	Π	π
Rho	Ρ	ρ
Sigma	Σ	σ
Tau	Τ	τ
Upsilon	Υ	υ
Phi	Φ	φ
Chi	Χ	χ
Psi	Ψ	ψ
Omega	Ω	ω