HAMPSTEAD SCHOOL
Learning together Achieving together

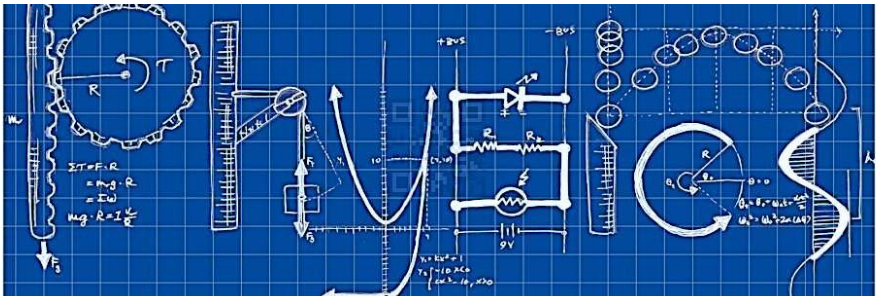
Y11-12
Summer Bridging Tasks
2023

Physics A Level

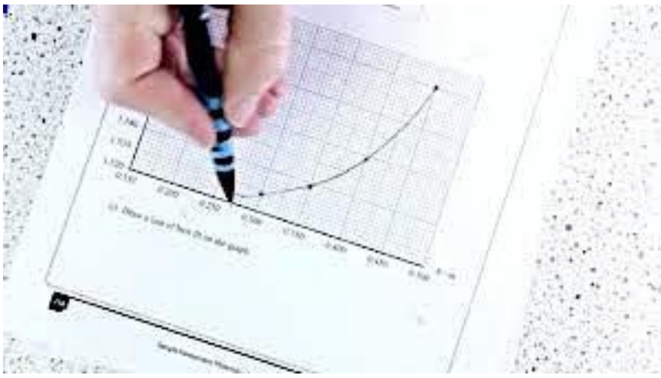
Name: ____

- You should spend some time during the summer holidays working on the activities in this booklet.
- You will be required to hand in this booklet in your first lesson at the start of Year 12 and the content will be used to form the basis of your first assessments.
- You should try your best and show commitment to your studies.

- We are really looking forward to you coming to Hampstead School Sixth Form and studying A Level Physics



AS Physics at Hampstead School



Transition Booklet from GCSE Physics to AS Physics

Introduction

This booklet will assist you in getting better prepared to study AS Physics at Hampstead School. You must work through the booklet and self assess to identify the topics/areas for improvement. Write a brief comment on your progress in the comments box as you complete each topic. This help will inform you with what you must revise prior to beginning the AS Physics course. Bring your copy of the completed booklet to your first AS Physics lesson.

AS Physics
Skills

Contents

AS Physics	# 1. Prefixes and units
Skills	

In Physics we have to deal with quantities from the very large to the very small. A prefix is something that goes in front of a unit and acts as a multiplier. This sheet will give you practice at converting figures between prefixes.

Symbol	**Name**	**What it means**		**How to convert**	
P	peta	10^{15}	1000000000000000		↓ x1000
T	tera	10^{12}	1000000000000	↑ ÷ 1000	↓ x1000
G	giga	10^{9}	1000000000	↑ ÷ 1000	↓ x1000
M	mega	10^{6}	1000000	↑ ÷ 1000	↓ x1000
k	kilo	10^{3}	1000	↑ ÷ 1000	↓ x1000
			1	↑ ÷ 1000	↓ x1000
m	milli	10^{-3}	0.001	↑ ÷ 1000	↓ x1000
μ	micro	10^{-6}	0.000001	↑ ÷ 1000	↓ x1000
n	nano	10^{-9}	0.000000001	↑ ÷ 1000	↓ x1000
p	pico	10^{-12}	0.000000000001	↑ ÷ 1000	↓ x1000
f	femto	10^{-15}	0.000000000000001	↑ ÷ 1000	

Convert the figures into the units required.

6 km	=	6×10^{3}	m
54 MN	=		N
0.086 μV	=		V
753 GPa	=		Pa
23.87 mm/s	=		m/s

Convert these figures to suitable prefixed units.

640	GV	=	640×10^{9}	V
		=	0.5×10^{-6}	A
		=	93.09×10^{9}	m
	kN	=	32×10^{5}	N
	nm	=	0.024×10^{-7}	m

Convert the figures into the prefixes required.

s	**ms**	**μs**	**ns**	**ps**
0.00045	0.45	450	450 000 or 450×10^{3}	450×10^{6}
0.000000789				
0.000 000 000 64				

mm	**m**	**km**	**μm**	**Mm**
1287360				
295				

The equation for wave speed is:

$$wave\ speed = frequency\ \times wavelength$$

$$(m/s) \qquad\qquad (Hz) \qquad\qquad (m)$$

Whenever this equation is used, the quantities must be in the units stated above. At GCSE we accepted m/s but at AS/A Level we use the index notation. m/s becomes m s^{-1} and m/s^2 becomes m s^{-2}.

By convention we should also leave one space between values and units. 10m should be 10 m.

We also leave a space between different units but no space between a prefix and units.

This is to remove ambiguity when reading values.

Example ms^{-1} means 1/millisecond because the ms means millisecond, 10^{-3} s

but m s^{-1} means metre per second the SI unit for speed.

or mms^{-1} could mean mm s^{-1} compared with m ms^{-1}

millimeters per second compared with meters per millisecond - quite a difference!!!

Calculate the following quantities using the above equation, giving answers in the required units.

1) Calculate the speed in m s^{-1} of a wave with a frequency of 75 THz and a wavelength 4.0 µm.

   $v = f\lambda = 75 \times 10^{12} \times 4.0 \times 10^{-6} = 3.0 \times 10^{8}$ m s^{-1} (300 Mm s^{-1})

2) Calculate the speed of a wave in m s^{-1} which has a wavelength of 5.6 mm and frequency of 0.25 MHz.

3) Calculate the wavelength in metres of a wave travelling at 0.33 km s^{-1} with a frequency of 3.0 GHz.

4) Calculate the frequency in Hz of a wave travelling at 300 x 10^3 km s^{-1} with a wavelength of 0.050 mm.

5) Calculate the frequency in GHz of a wave travelling at 300 Mm s^{-1} that has a wavelength of 6.0 cm.

AS Physics	# 2. Significant Figures
Skills	

1. **All non-zero numbers ARE significant.** The number 33.2 has THREE significant figures because all of the digits present are non-zero.

2. **Zeros between two non-zero digits ARE significant.** 2051 has FOUR significant figures. The zero is between 2 and 5

3. **Leading zeros are NOT significant.** They're nothing more than "place holders." The number 0.54 has only TWO significant figures. 0.0032 also has TWO significant figures. All of the zeros are leading.

4. **Trailing zeros when a decimal is shown ARE significant.** There are FOUR significant figures in 92.00 and there are FOUR significant figures in 230.0.

5. **Trailing zeros in a whole number with no decimal shown are NOT significant.** Writing just "540" indicates that the zero is NOT significant, and there are only TWO significant figures in this value.

(THIS CAN CAUSE PROBLEMS!!! WE SHOULD USE POINT 8 FOR CLARITY, BUT OFTEN DON'T - 2/3 significant figures is accepted in IAL final answers - eg 500/260 = 1.9 to 2 sf. Better 5.0 x 10^2 / 2.6 x 10^2 = 1.9)

8. **For a number in scientific notation: N x 10^x, all digits comprising N ARE significant by the first 5 rules; "10" and "x" are NOT significant.** 5.02 x 10^4 has THREE significant figures.

For each value state how many significant figures it is stated to.

Value	Sig Figs	Value	Sig Figs	Value	Sig Figs	Value	Sig Figs
2		1066		1800.45		0.070	
2.0		82.42		2.483 x 10^4		69324.8	
500		750000		0.0006		0.0063	
0.136		310		5906.4291		9.81 x 10^4	
0.0300		3.10 x 10^4		200000		40000.00	
54.1		3.1 x 10^2		12.711		0.0004 x 10^4	

When adding or subtracting numbers

Round the final answer to the **least precise** number of decimal places in the original values.

Eg. 0.88 + 10.2 – 5.776 (= 5.304) = **5.3** (to 1d.p. , since 10.2 only contains 1 decimal place)

(Khan Academy- Addition/ subtraction with sig fig excellent video- make sure you watch .)

Add the values below then write the answer to the appropriate number of significant figures

Value 1	Value 2	Value 3	Total Value	Total to correct sig figs
51.4	1.67	3.23		
7146	–32.54	12.8		
20.8	18.72	0.851		
1.4693	10.18	–1.062		
9.07	0.56	3.14		
739762	26017	2.058		
8.15	0.002	106		
152	0.8	0.55		

When multiplying or dividing numbers

Round the final answer to the **least** number of significant figures found in the initial values.

E.g. 4.02 x 3.1 | 0.114 = (109.315…) = **110** (to 2s.f. as 3.1 only has 2 significant figures.

Multiply the values below then write the answer to the appropriate number of significant figures

Value 1	Value 2	Total Value	Total to correct sig figs
0.91	1.23		
8.764	7.63		
2.6	31.7		
937	40.01		
0.722	634.23		

Divide value 1 by value 2 then write the answer to the appropriate number of significant figures

Value 1	Value 2	Total Value	Total to correct sig figs
5.3	748		
3781	6.50		
91×10^{2}	180		
5.56	22×10^{-3}		
3.142	8.314		

When calculating a mean

1) Remove any **obvious** anomalies (circle these in the table)
2) Calculate the mean with the remaining values, and record this to the **least** number of decimal places in the included values

E.g. Average 8.0, 10.00 and 145.60:

1) Remove 145.60

2) The average of 8.0 and 10.00 is **9.0** (to 1 d.p.)

Calculate the mean of the values below then write the answer to the appropriate number of significant figures

Value 1	Value 2	Value 3	Mean Value	Mean to correct sig figs
1	1	2		
435	299	437		
5.00	6.0	29.50		
5.038	4.925	4.900		
720.00	728.0	725		
0.00040	0.00039	0.000380		
31	30.314	29.7		

AS Physics	# 3. Converting length, area and volume
Skills	

Whenever substituting quantities into an equation, you must always do this in SI units – such as time in seconds, mass in kilograms, distance in metres…

If the question doesn't give you the quantity in the correct units, you should always convert the units **first**, rather than at the end. Sometimes the question may give you an area in mm^2 or a volume in cm^3, and you will need to convert these into m^2 and m^3 respectively before using an equation.

To do this, you first need to know your length conversions:

1m = 100 cm = 1000 mm   (1 cm = 10 mm)

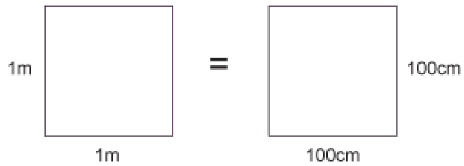
m ⍰ cm	x 100	cm ⍰ m	÷ 100
m ⍰ mm	x 1000	m ⍰ mm	÷ 1000

Always think –

"Should my number be getting larger or smaller?" This will make it easier to decide whether to multiply or divide.

Converting Areas

A 1m x 1m square is equivalent to a 100 cm x 100 cm square.



Therefore,   1 m^2 = 10 000 cm^2

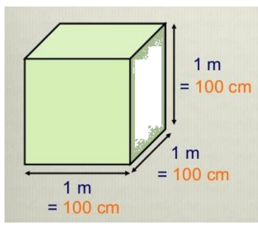
Similarly, this is equivalent to a 1000 mm x 1000 mm square;

So,   1 m^2 = 1 000 000 mm^2

m^2 ⍰ cm^2	x 10 000	cm^2 ⍰ m^2	÷ 10 000
m^2 ⍰ mm^2	x 1 000 000	m^2 ⍰ mm^2	÷ 1 000 000

Converting Volumes

A 1m x 1m x 1m cube is equivalent to a 100 cm x 100 cm x 100 cm cube.



Therefore,   1 m^3 = 1 000 000 cm^3

Similarly, this is equivalent to a 1000 mm x 1000 mm x 1000 mm cube;

So,   1 m^3 = 10^9 mm^3

m^3 ⍰ cm^3	x 1 000 000	cm^3 ⍰ m^3	÷ 1 000 000
m^3 ⍰ mm^3	x 10^9	m^3 ⍰ mm^3	÷ 10^9

6 m^2	=		cm^2
0.002 m^2	=		mm^2
24 000 cm^2	=		m^2
46 000 000 mm^3	=		m^3
0.56 m^3	=		cm^3

750 mm^2	=		m^2
5 x 10^{-4} cm^3	=		m^3
8.3 x 10^{-6} m^3	=		mm^3
3.5 x 10^2 m^2	=		cm^2
152000 mm^2	=		m^2

Now use the technique shown on the previous page to work out the following conversions:

31 x 10^8 m^2	=		km^2
59 cm^2	=		mm^2
24 dm^3	=		cm^3
4 500 mm^2	=		cm^2
5 x 10^{-4} km^3	=		m^3

(*Hint: There are 10 cm in 1 dm)*

A 2.0 m long solid copper cylinder has a cross-sectional area of 3.0 x10^2 mm^2. What is its volume in cm^3?

Volume = _____ cm^3

For the following, think about whether you should be writing a smaller or a larger number down to help decide whether you multiply or divide.

Eg. *To convert 5 m ms^{-1} into m s^{-1} – you will travel more metres in 1 second than in 1 millisecond, therefore you should multiply by 1000 to get 5000 m s^{-1}.*

5 N cm^{-2}	=		N m^{-2}
1150 kg m^{-3}	=		g cm^{-3}
3.0 m s^{-1}	=		km h^{-1}
65 kN cm^{-2}	=		N mm^{-2}
7.86 g cm^{-3}	=		kg m^{-3}

AS Physics	# 4. Rearranging Equations
Skills	

Rearrange each equation into the subject shown in the middle column.

Equation		Rearrange Equation
$V = IR$	R	
$I = \frac{Q}{t}$	t	
$\rho = \frac{RA}{l}$	A	
$\varepsilon = V + Ir$	r	
$s = \frac{(u+v)}{2}t$	u	

Equation		Rearrange Equation
$hf = \phi + E_K$	f	
$E_P = mgh$	g	
$E = \frac{1}{2}Fe$	F	
$v^2 = u^2 + 2as$	u	
$T = 2\pi\sqrt{\frac{m}{k}}$	m	

AS Physics	# 5. Variables
Skills	

A variable is a quantity that takes place in an experiment. There are three types of variables:

Independent variable – *this is the quantity that you* ***change***

Dependent variable – *this is the quantity that you* ***measure***

Control variable – *this is a quantity that you* ***keep the same*** *so that it does not affect the results*

You can only have one independent variable and one dependent variable, but the more control variables you have the more accurate your results will be.

Further to these, you can also split the independent variable category – this can be continuous or discrete.

A continuous variable can take *any* numerical value, including decimals. You will construct line graphs for continuous variables.

A discrete variable can only take *specific* values or labels (eg. integers or categories). You will construct bar charts for discrete variables.

For each case study below, state the independent variable, dependent variable, and any control variables described. ***Add further control variables****, and state what type the independent variable is and what type of graph you will present the results with (if required).*

Case study 1 – *Measuring the effect of gravity*

The aim of this experiment is to find out how fast objects of different masses take to fall from height. To conduct this experiment we used a number of spheres of the same diameter, which had different masses. Each sphere had its mass measured on electronic scales, before being dropped from a marker exactly 2.000 m from the floor. The time the sphere took to drop was timed on a stopwatch, and repeated 3 times for each sphere to gain an average time.

Independent variable: ____

Dependent variable: ____

Control variables:____

____

Type of independent variable: ____

Graph: ____

Case study 2 – *The number of children involved in different after school activities.*

The aim of this study is to discover which activities are most popular so the correct resources can be supplied to the correct member of staff. On a certain day after school the number of children were recorded for the different activities they took.

Independent variable: ____

Dependent variable: ____

Control variables: ____

Type of independent variable: ______________________________________

Graph: ____

Case study 3 – *How far does the spring stretch?*

The aim of this experiment is to find how far different masses stretch a spring. A spring was hung from a clamp stand, and its length end to end measured. A 10g mass was then added and the length of the spring measured and recorded. This was repeated adding 10g between 0g and 100g.

Independent variable: ____

Dependent variable: ____

Control variables: ____

Type of independent variable: ______________________________________

Graph: ____

Case study 4 - *What is the best design for a turbine?*

A wind turbine is connected to a voltmeter and is placed 1.0 m from a desk fan. The potential difference produced for different number of blades attached to the turbine is measured. The aim is to see what design produces the largest potential difference.

Independent variable: ____

Dependent variable: ____

Control variables: ____

____

Type of independent variable: ______________________________________

Graph: ____

AS Physics	
Skills	

6. Constructing tables

The **left hand column** is for your **independent variable**.

The **right hand column** is for your **dependent variable**. You may split this up into further columns if repeats are carried out, and make sure you include an average column. Each sub column must come under the main heading (including the average column).

Place results in the table in order of independent variable, usually starting with the smallest value first.

Ensure each column contains a heading with units in brackets. No units should be placed in the table.

All measured values in one column should be to the same decimal place – don't forget to add zeros if necessary!

Any averages should be given to the same number of decimal places as the measured values. Remember to remove any anomalies by circling the results and do not include them in calculating your average.

Any calculated values should be given to a suitable number of significant figures/ precision.

At AS/A Level we don't use brackets to separate the quantity heading from the units but use a / .

Example: **mass (kg)** should be written as **mass / kg.**

speed of car (m/s) should be written as **speed of car / m s^{-1}**

Independent Variable Heading /unit	Dependent Variable Heading /unit			
	1	2	3	Average

A student forgot his exercise book when doing a practical on electrical resistance for a resistor. Below are his readings in the practical. He measured the current in the circuit three times for five different voltages. He has made many errors.

V : 0.11A, 0.1A, 0.12A
2.0V : 0.21A, 0.18A, 0.24

5V : 0.5, 5.1, 0.48   4.0V : 0.35A, 0.40A, 0.45

3.0V: 0.33A, 0.6
0.30

Construct a suitable table for his results.

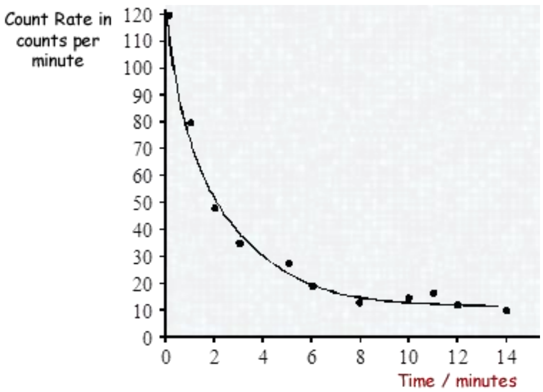
AS Physics	# 7. Drawing Lines of Best Fit
Skills	

When drawing lines of best fit, draw a *smooth* straight or curved line that passes through the majority of the points. If you can, try to have an even number of points above and below the line if it can't go through all points.

When describing the trend, use the phrase….

"As 'X' increases, 'Y' *increases/decreases* in a *linear/non-linear* fashion."

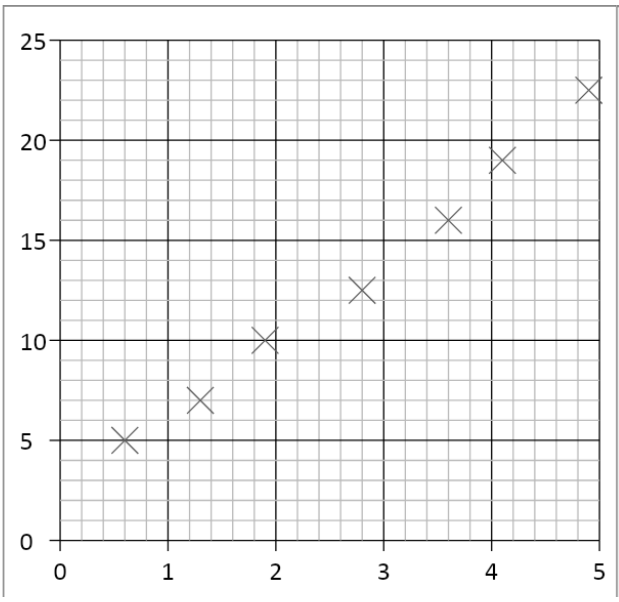
Substitute the quantities into X and Y, and choose either of the two options to describe the graph.

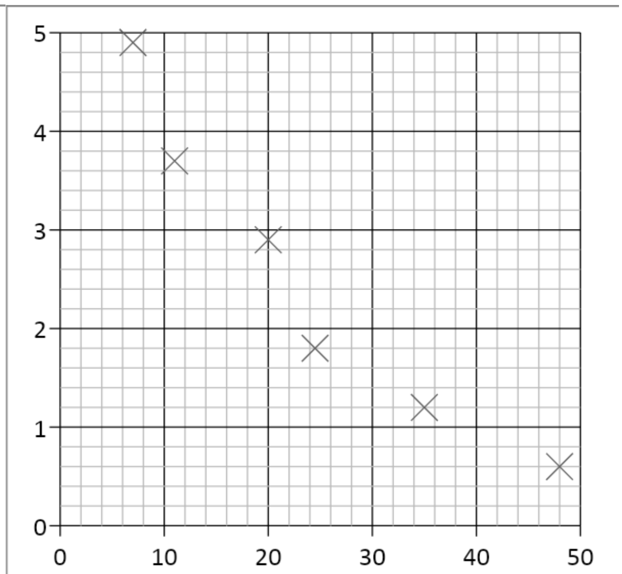


Eg.

As time increases, the count rate decreases in a non-linear fashion.

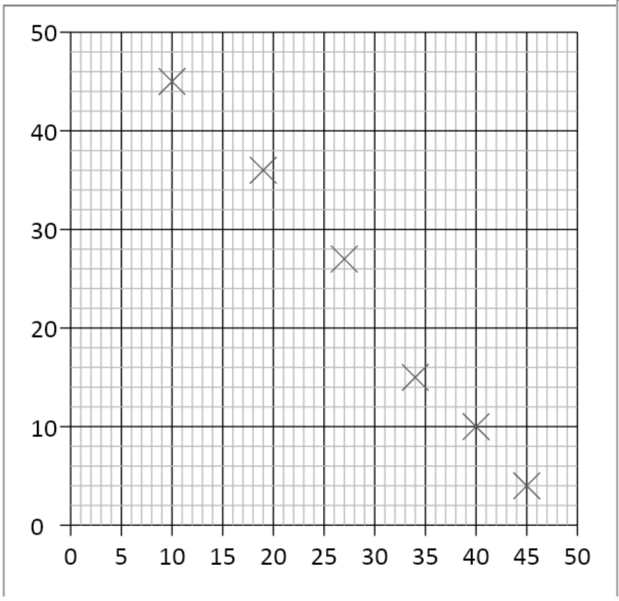
Draw a line of best fit for each of the graphs and describe the trend shown by each (call the quantities X and Y).

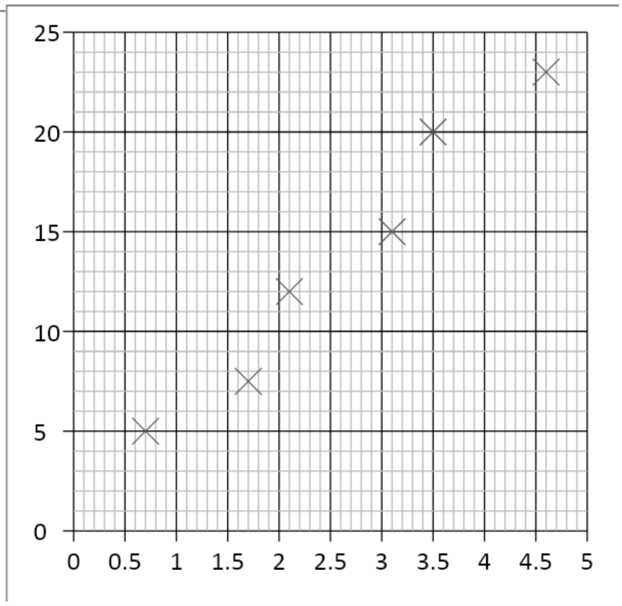




1.

2.


50
40
30
20
10
0
0 5 10 15 20 25 30 35 40 45 50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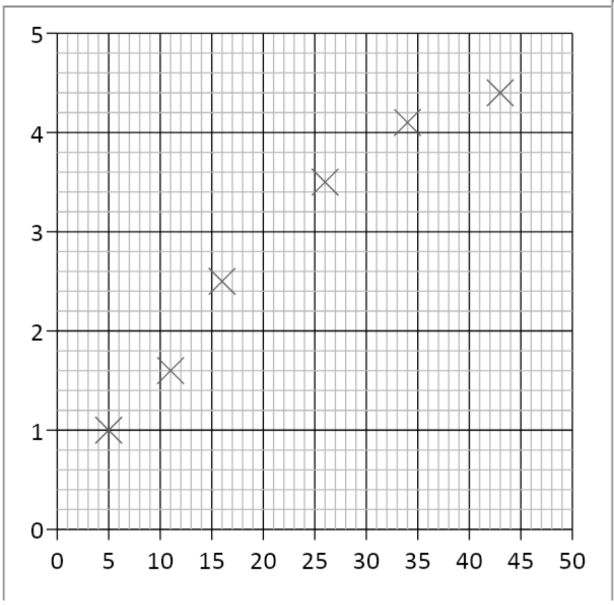
3.

4.


5
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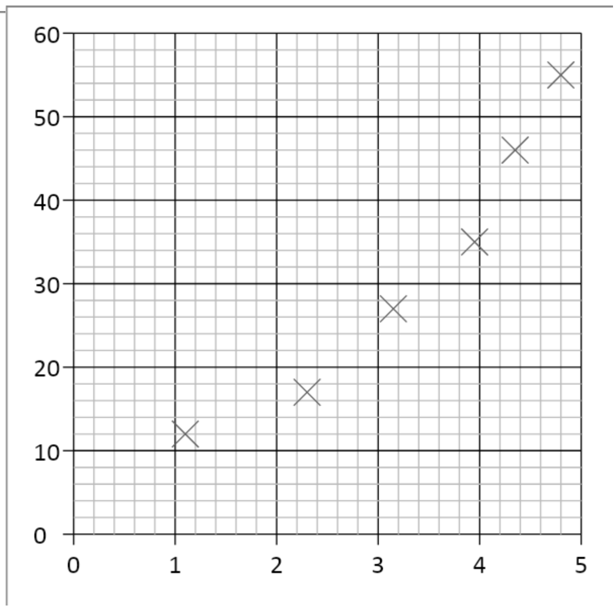
0 5 10 15 20 25 30 35 40 45 50


60
50
40
30
20
10
0
0 1 2 3 4 5

5.

6.

AS Physics	# 8. Constructing Graphs
Skills	

When drawing graphs, you will be marked on the following criteria:

1) Axes – Your independent variable is on the x axis, and your dependent variable is on the y axis. Both axes need to be labelled.
2) Units – Add units to your axes when labelling.
3) Scale – Make your scale as large as possible so that your data fills most of the page. **You don't have to start your axes at the origin**. *Make sure you have a regular scale that goes up in nice numbers – 1, 2, 5, 10 etc…*
4) Points – mark each point with a cross using a sharp pencil. Don't use circles or dots as points.
5) Line of best fit – draw a smooth line of best fit – straight or curved depending on what pattern your data follows.

An easy way to remember these points is….. **S** cale

L ine

A xes

P oints

U nits

Plot graphs for the following sets of data, including a line of best fit for each.

Surface area of pendulum / cm²	**Time taken for pendulum to stop/ s**
5.0	170
6.2	127
7.4	99
8.0	86
8.8	70
9.9	56
Current / A	**Voltage / V**
0.07	1.46
0.14	1.44
0.21	1.42
0.30	1.40
0.41	1.38
0.57	1.33
0.81	1.29

AS Physics	# 9. Calculating Gradients – Straight Lines
Skills	

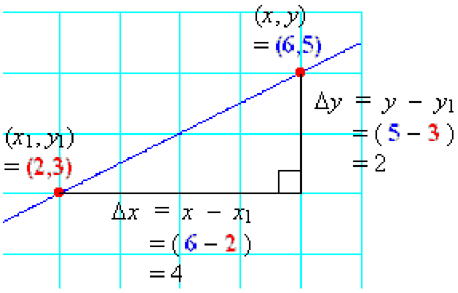
Gradients are a useful tool that show how fast or slow quantities change – eg speed tells us how fast distance is changing, or how quickly energy is being lost over time.

To calculate the gradient, pick any two points on the line as far away as possible and draw a large triangle between them.

The gradient is given by:

$$gradient = \frac{diffference\ in\ y\ values}{difference\ in\ x\ values}$$

But make sure the you subtract the values in the same order! Remember – if the line slopes up, the gradient should be positive; if the line slopes down, then the gradient should be negative.

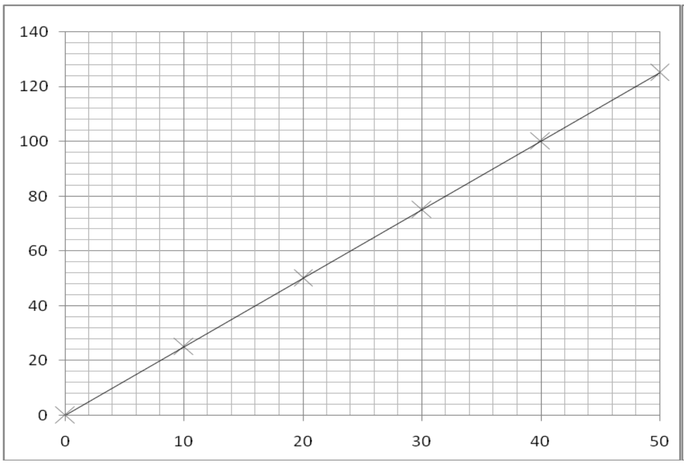


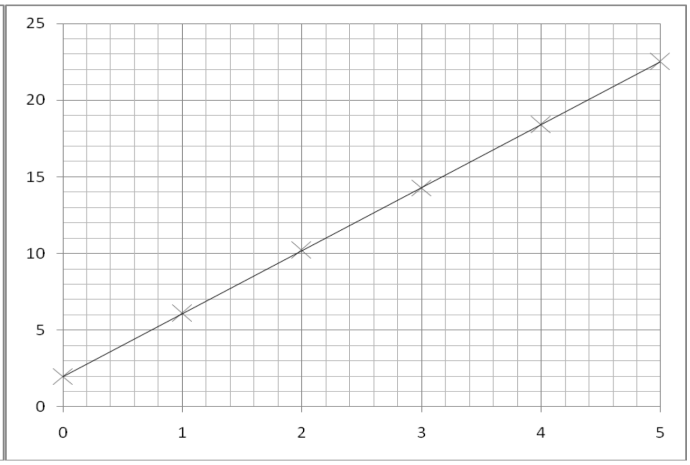
$$Gradient = \frac{difference\ in\ y}{difference\ in\ x}$$

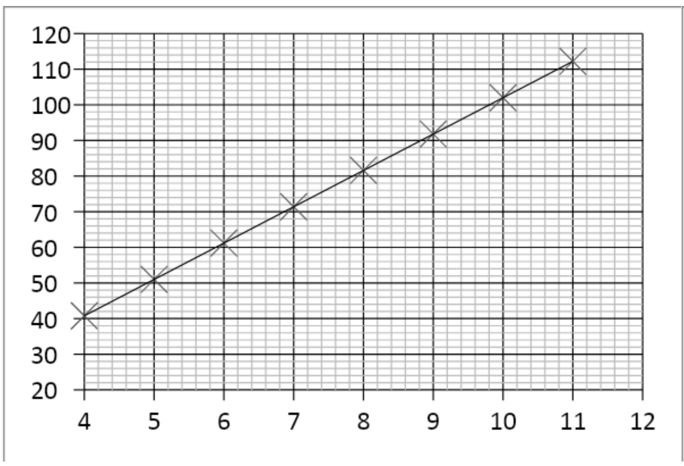
$$= \frac{2}{4}$$

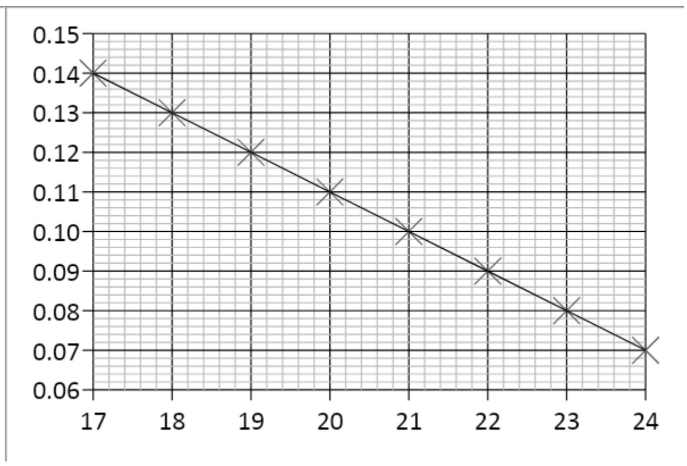
$$\underline{\mathbf{= 0.5}}$$

Calculate the gradients of the graphs below









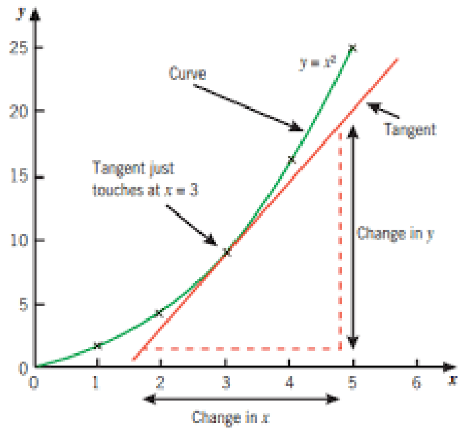
AS Physics	# 10. Calculating Gradients – Curved Lines
Skills	

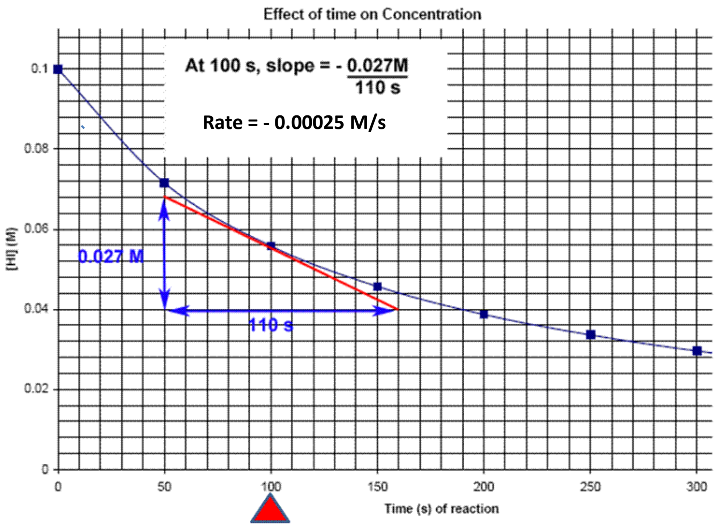
Most graphs in real life are not straight lines, but curves; however it is still useful to know how the quantity changes over time, hence we still need to calculate gradients.

If we want to know the gradient at a particular point, firstly we need to draw a *tangent* to the curve at that point. A tangent is a straight line that follows the gradient at the required point. Once we have drawn the straight line tangent, its gradient can be calculated in exactly the same way as the previous page showed.

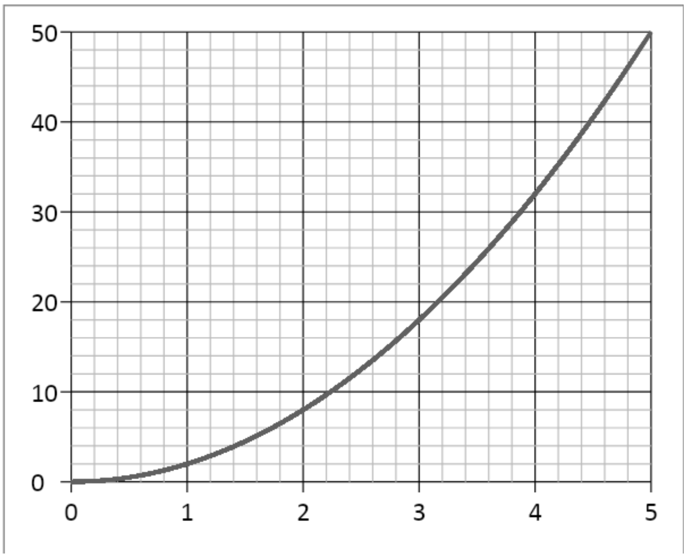
Tip – make sure your tangents and gradient triangles are as big as possible to be as accurate as you can!

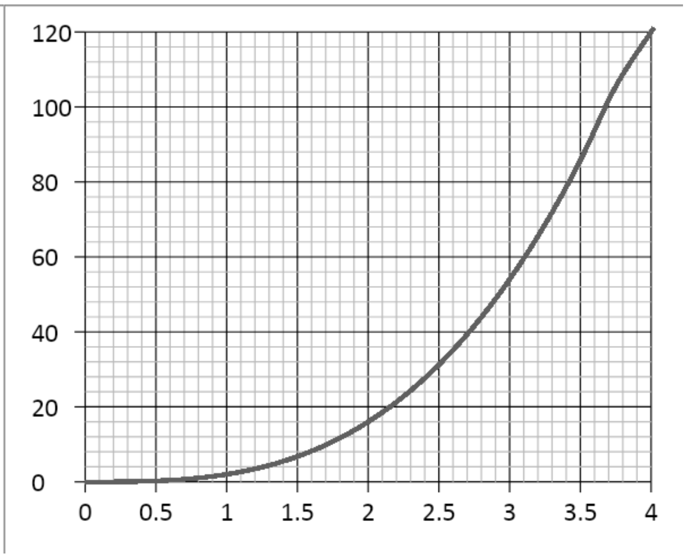
Examples of drawing tangents and calculating the gradient of a tangent:





Draw a tangent to the line and calculate its gradient at the following x-axis values:





2.0 and 4.0

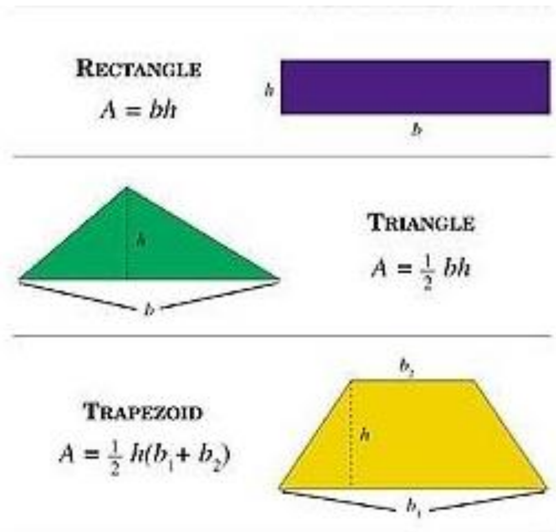
1.5 and 3.5

(Note - gradients in Physics often have units, this is something we will consider as we progress in the course)

AS Physics	# 11. Calculating Areas – Straight line Graphs
Skills	

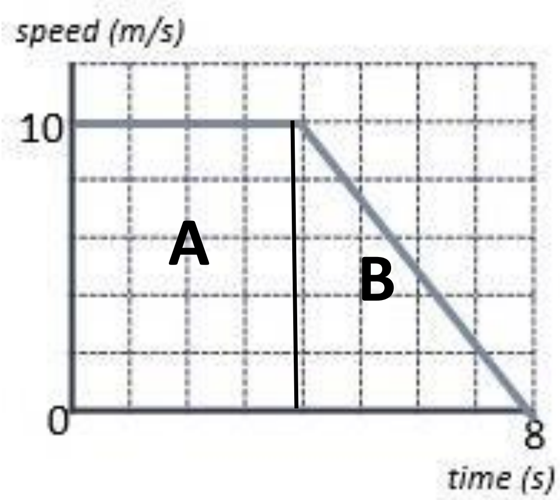
Often other quantities can be found by multiplying the two quantities represented on a graph together (for example, multiplying velocity and time gives distance travelled). The exact quantity can be found by calculating the area under the graph.

If the graph is made of straight lines, the total area can be found by splitting the graph into segments of rectangles and triangles (or into a trapezium) and adding those areas together.



Important – the heights that you use should always be the perpendicular height from the base.

Calculate the distance travelled by determining the area under the graph:



Area A = 10 x 4 = 40 m

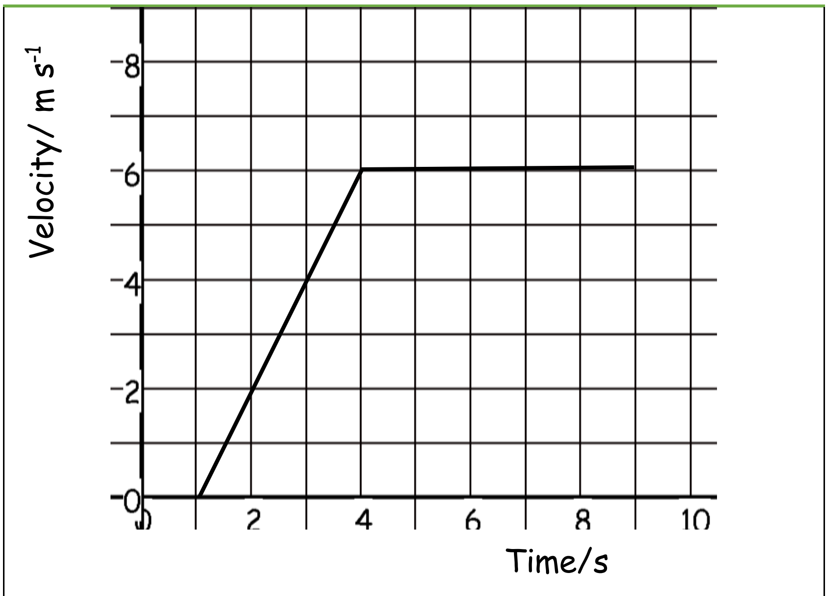
Area B = ½ x 4 x 10 = 20 m

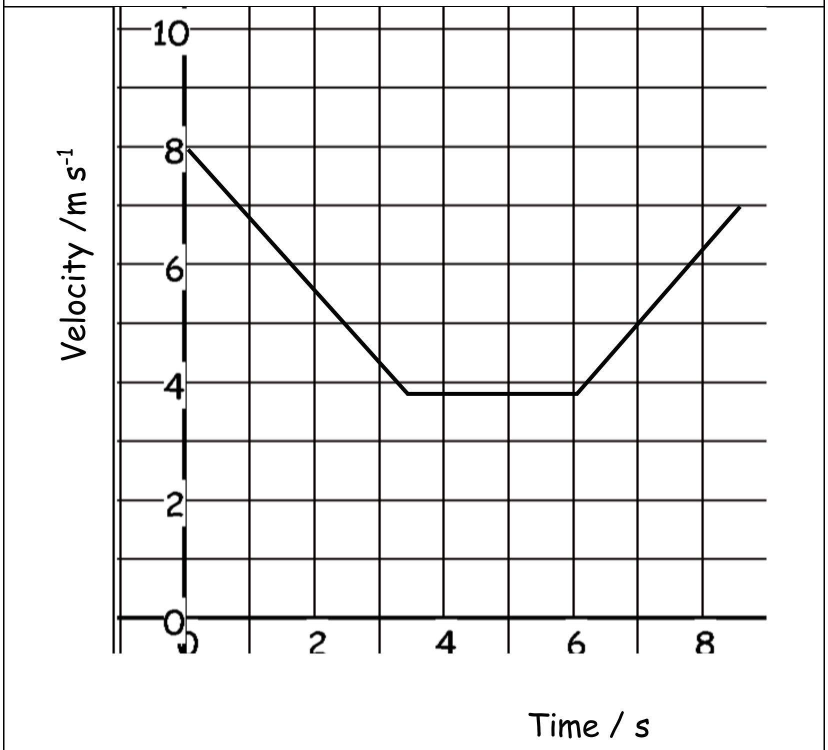
Total Area = A + B = 40 + 20 = **60 m**

Or

Area of trapezium = ½ (4 + 8) x 10 = **60 m**

Calculate the area of the below graphs and the correct unit for that area.



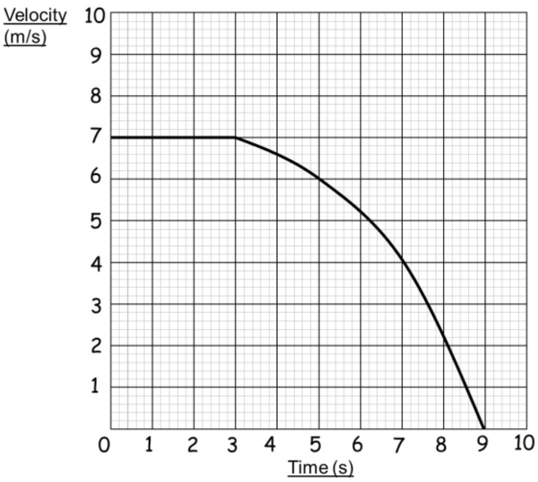


AS Physics	12. Calculating Areas – Curved line Graphs
Skills	

When graphs have curved lines we use a simple process of counting squares and estimating.

1) Calculate the area of 1 small (but the not smallest!) square on the graph
2) Count the number of whole squares under the line
3) Estimate the whole number of squares that have been segmented by the line.
4) Multiply the total number of squares by the area of one square to estimate the area.

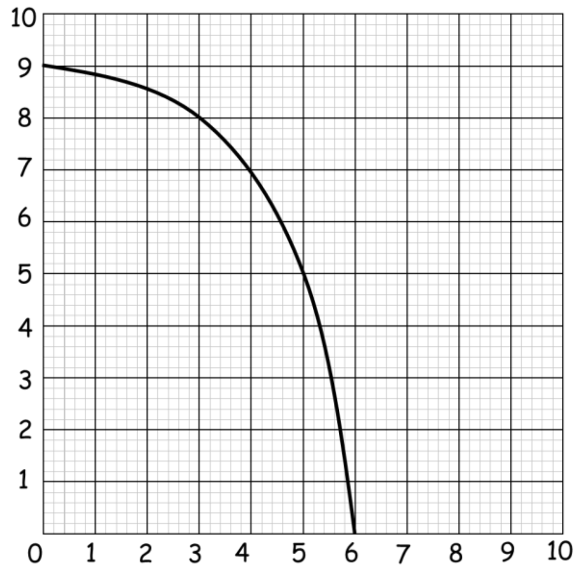
Eg. Work out the distance travelled by calculating the area under the graph.



1) 1 square = 1 m s^{-1} x 1 s = 1 m
2) Whole Squares = 44
3) Segmented squares = 4
4) 48 squares x 1 m = **<u>48 m</u>**

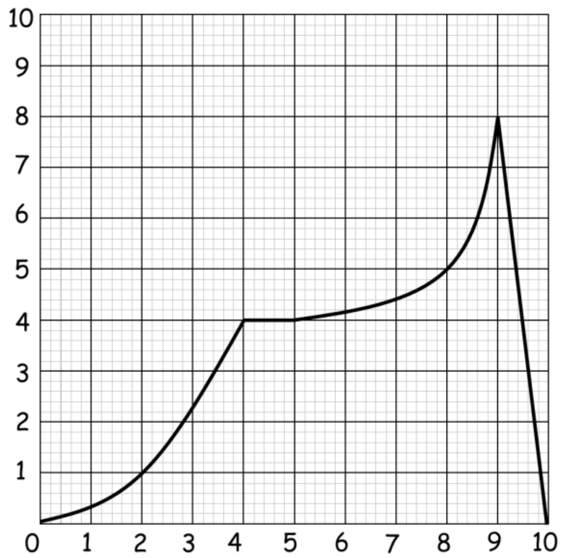
Calculate the area under the following graphs.

velocity/m s^{-1}



time /s

velocity/ km s^{-1}

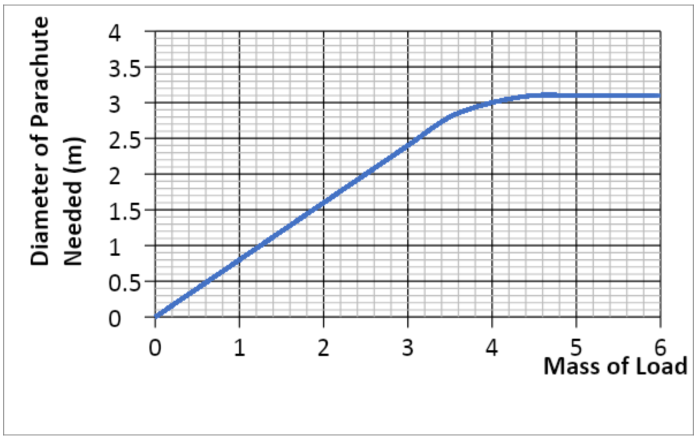


time /min

AS Physics	# 13. Interpreting Graphs
Skills	

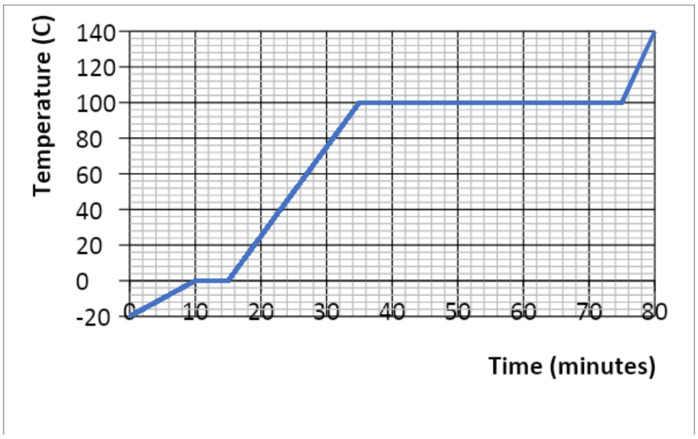
When interpreting graphs that are worth more than 2 marks, you need to go into more detail describing how the gradient changes over time and pick specific values to help support your answer.

Tips:
Use the quantities on the axes to support your answer.
Are there any points where the y value doesn't change? What is this value? When does this happen on the x axis?
Are there any maximum or minimum values? What are they? When do they occur?
The gradient increases/decreases at a constant/increasing/decreasing rate….
Does the gradient represent anything (eg. velocity or acceleration)?
Are there multiple gradients? Are some steeper than others?



As the mass of the load increases, the diameter of the parachute needed also increases at a constant rate. This occurs to a mass of 3.4kg (which gives a diameter of 2.8m), where the gradient increases at a decreasing rate until the diameter remains constant at 3.1m for any load beyond 4.4kg.

Describe in detail each graph. Write your answer at the side of each graph. Include the points mentioned under 'tips' in your answers.



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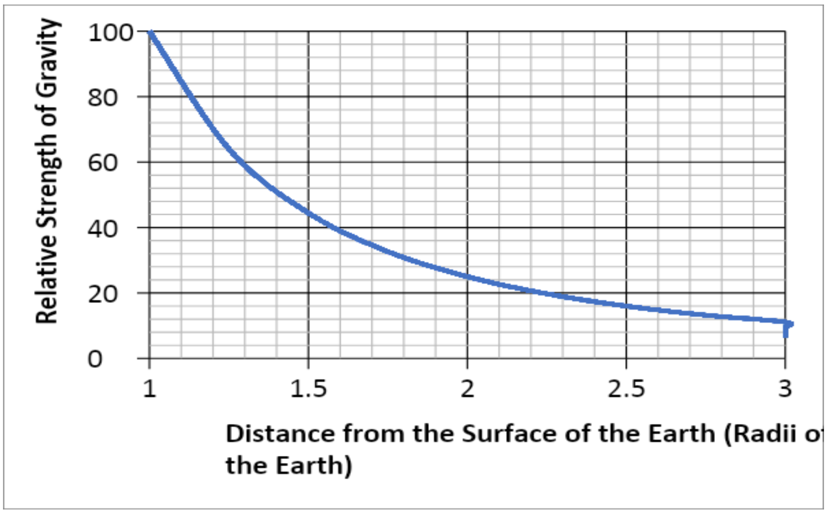
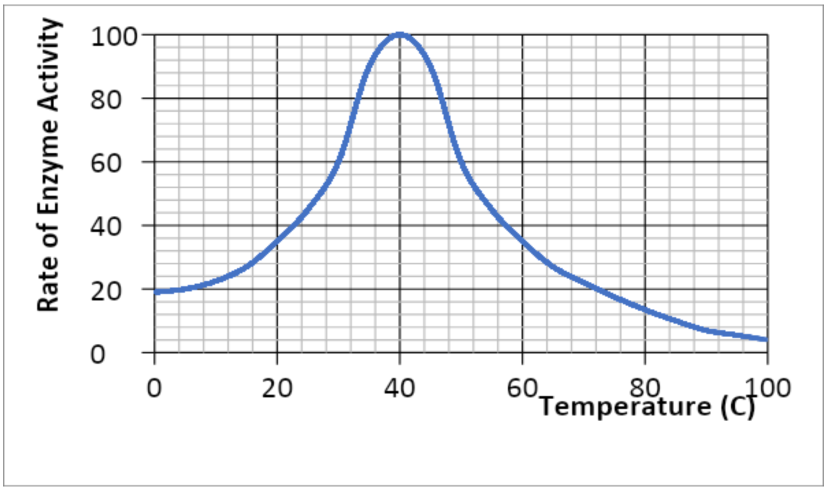
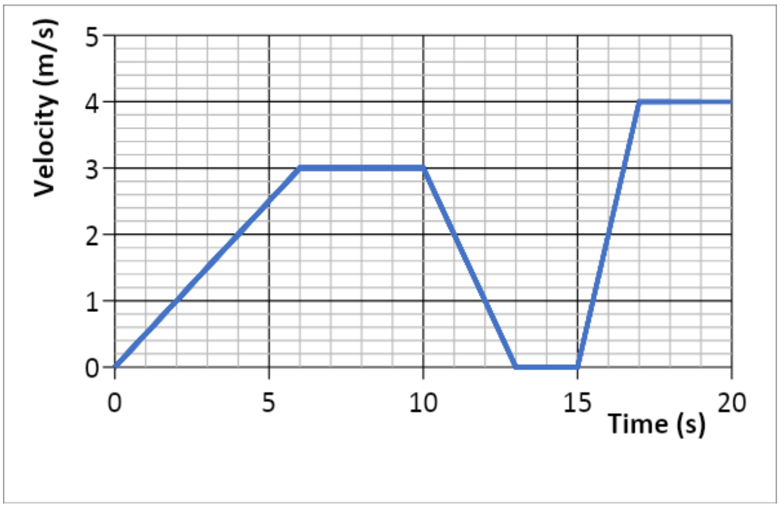

Relative Strength of Gravity
100
80
60
40
20
0
1
1.5
2
2.5
3
Distance from the Surface of the Earth (Radii of the Earth)


Rate of Enzyme Activity
100
80
60
40
20
0
0
20
40
60
80
100
Temperature (C)


Velocity (m/s)
5
4
3
2
1
0
0
5
10
15
20
Time (s)

AS Physics	# 14. Accuracy, Precision, Resolution
Skills	

An ***accurate*** result is one that is judged to be close to the true value. It is influenced by random and systematic errors.

The true value is the value that would be obtained in an ideal measurement.

A ***precise*** measurement is described when the values 'cluster' close together. We describe measurements as precise when repeated values are close together (consistent). It is influenced by random effects.

Resolution is the smallest change in the quantity being measured that causes a perceptible change in the output of the measuring device. This is usually the smallest measuring interval. It does not mean a value is accurate.

Uncertainty is variation in measured data and is due to random and systematic effects. We usually assume the uncertainty is the same as the resolution of the measuring instrument.
example ruler, resolution +/- 1 mm so uncertainty is also +/- 1 mm
Stop watch used by a pupil, resolution +/- 0.01 s but uncertainty estimated as +/- 0.2 s due to human reaction time.
For our exam we estimate uncertainty and as long as you have a sensible justification your answer will be ok.

Eg. The true temperature of the room is 22.4 ℃. One thermometer gives a reading of 22 ℃ and another gives a reading of 23.4 ℃ . Which is most accurate and estimate its uncertainty?

23.4 ℃ has the best resolution but is not close to the correct value.
22 ℃ has less resolution but is more accurate as it is closer to the correct result.
The uncertainty in this reading is 22 +/– 1 ℃

Example
Isabelle is finding the mass of an insect, but the insect moves while on the electronic balance.

She records a set of readings as 5.00 mg , 5.01 mg, 4.98 mg, 5.02 mg.
The true value of the insect's mass is 4.5 mg.
Calculate an average value with estimated uncertainty for her results and compare this value with the true value using the terms above.

15. Identifying Errors

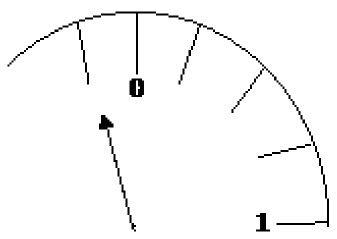
There are two main types of error in Science:

1) Random error
2) Systematic error

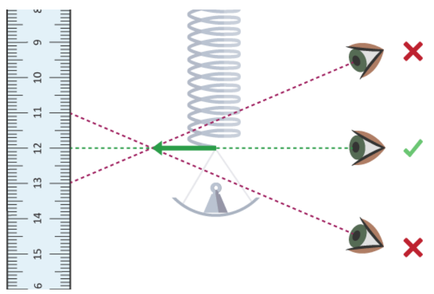
Random errors can be caused by changes in the environment that causes readings to alter slightly, measurements to be in between divisions on a scale or observations being perceived differently by other observers. These errors can vary in size and can give readings both smaller and larger than the true value.
The best way to reduce random error is to use as large values as possible (eg. Large distances) and repeat and average readings, as well as taking precaution when carrying out the experiment.

Systematic errors have occurred when all readings are shifted by the same amount away from the true value.
The two main types of systematic error are:

i) *Zero error* – this is where the instrument does not read zero initially and therefore will always produce a shifted result (eg. A mass balance that reads 0.01g before an object is placed on it). Always check instruments are zeroed before using.
ii) *Parallax error* – this is where a measurement is not observed from eye level so the measurement is always read at an angle producing an incorrect reading. Always read from eye level to avoid parallax.



Zero Error



Parallax Error

Repeat and averaging experiments will not reduce systematic errors as correct experimental procedure is not being followed.

There are occasions where readings are just measured incorrectly or an odd result is far away from other readings – these results are called **anomalies**. Anomalies should be removed and repeated before used in any averaging.

For each of the measurements listed below identify the most likely source of error what type of error this is and one method of reducing it.

Measurement	Source of error	Type of error
A range of values are obtained for the length of a copper wire		
The reading for the current through a wire is 0.74 A higher for one group in the class		
A range of values are obtained for the rebound height of a ball dropped from the same start point onto the same surface.		
A few groups obtain different graphs of resistance vs light intensity for an LDR. A light bulb placed at different distances from the LDR was used to vary the light intensity.		
The time period (time of one oscillation) of a pendulum showing a range of values		

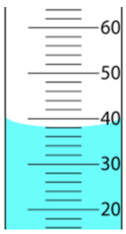
AS Physics	16. Improving Experiments – Accuracy, Resolution and Reliability
Skills	

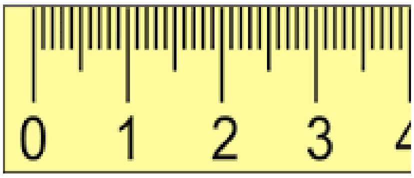
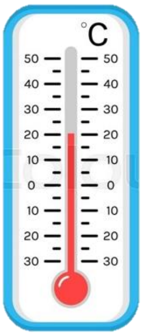
When improving **accuracy**, you must describe how to make sure your *method* obtains the best results possible. You should also try to *use as large quantities as possible as this reduces the percentage error in your results*. Also make your range as large as possible, with small intervals between each reading.

Resolution refers to the smallest scale division provided by your measuring instrument, or what is the smallest non-zero reading you can obtain from that instrument.

Reliability refers to how 'trustworthy' your results are. You can improve reliability by repeating and averaging your experiment, as well as removing anomalies.

Complete the table below to state how to use the measuring instruments as accurately as possible, as well as stating the precision (smallest scale division) of each instrument.

Measuring Instrument	**Accuracy** What procedures should you use to ensure you gain accurate results?	**Resolution** State the resolution of the instruments shown in the diagram.
Measuring Cylinder 		
Top Pan Electronic (Mass) Balance 		

Measuring Instrument	Accuracy What procedures should you use to ensure you gain accurate results?	Precision State the precision of the instruments shown in the diagram.
Ruler 		
Thermometer 		

Research and describe a method to determine the thickness of one sheet of A4 paper accurately. You may only use a mm ruler. You should also refer to the precision and reliability of your result.

AS Physics	# 17. Describing Experiments
Skills	

Variables *– Which variables will you keep the same and which will you change?*
Instruments *– What measuring instruments will you use and how will you take the measurements?*
Range *– Give specific values for the range and intervals you will use. Make sure your range is large with small intervals.*
Analyse *– State any equations you will use and what graph you will plot including the axes.*
Accuracy *– State ways you are being accurate with your measuring instruments.*
Reliability *– State "Repeat and average" to improve reliability*

Using the steps above, describe how to carry out the following experiments below:

e.g.
Water is placed in a plastic tray, one end it raised, dropped and the speed of the water wave is measured. A student suggests that the speed of the wave depends on the height of the water in the tray. How could you prove this?

Change the depth of water by filling the tray to different heights. The height of the water will be measured by placing a ruler into the tray. Depths from 1.0 to 5.0 cm, at 1.0 cm intervals should be used.
The tray should be lifted to the same height each time and dropped without pushing it down. The height the tray is lifted to should also be measured with a ruler that is vertical using a set square.
When the tray hits the table, the time should be measured for the wave to pass end to end 4 times, then divided by 4 to make the reading more accurate to reduce reaction time. The time should be measured using a stopwatch.
The length of the tray should be measured using a ruler, overhead and measured at eye level for accuracy.
The equation speed = distance / time should be used to calculate the speed of the wave.
Repeat each height and average to improve reliability.
Plot a graph of speed (y axis) vs depth of water (x axis) to see if there is a relationship between the two variables.

Question. A student suggests that if an egg was dropped from different heights the area of splatter would increase as the height increases but only until a certain point. How could you investigate this?

18. Appendix 1- Solutions

Topic 1

54×10^6 0.086×10^{-6} 753×10^9 23.87×10^{-3}

0.5 µm 93.09 Gm 3 200 kN 2.4 nm

s	ms	µs	ns	ps
0.00045	0.45	450	450 000 or 450 x10^3	450 x 10^6
0.000000789	0.000789	0.789	789	789 x 10^3
0.000 000 000 64	0.000 000 64	0.000 64	0.64	640

mm	m	km	µm	Mm
1287360	1 287.360	1.28 7360	1 287 360 000	0. 001 287 360
295	0.295	0.000 295	295 000	0 .000 000 295

2. $v = f\lambda = 0.25 \times 10^6 \times 5.6 \times 10^{-6} = 1400 \text{ m s}^{-1}$

3. $\lambda = v/f = 330 / 3.0 \times 10^9 = 1.1 \times 10^{-7}$ m

4. $f = v/\lambda = 300 \times 10^6 / 0.050 \times 10^{-3} = 6.0 \times 10^{12}$ Hz = 6.0 THz

5. $f = v/\lambda = 300 \times 10^6 / 6.0 \times 10^{-2} = 5.0 \times 10^9$ Hz = 5.0 GHz

Topic 2

Value	Sig Figs	Value	Sig Figs	Value	Sig Figs	Value	Sig Figs
2	1	1066	4	1800.45	7	0.070	2
2.0	2	82.42	4	2.483 x 10^4	4	69324.8	6
500	1	750000	2	0.0006	1	0.0063	2
0.136	3	310	2	5906.4291	8	9.81 x 10^4	3
0.0300	3	3.10 x 10^4	3	200000	1	40000.00	7
54.1	3	3.1 x 10^2	2	12.711	5	0.0004 x 10^4	1

Value 1	Value 2	Value 3	Total Value	Total to correct sig figs
51.4	1.67	3.23	56.3	56.3
7146	–32.54	12.8	7126.26	7126
20.8	18.72	0.851	40.371	40.4
1.4693	10.18	–1.062	10.5873	10.59
9.07	0.56	3.14	12.77	12.77
739762	26017	2.058	765781.058	765781
8.15	0.002	106	114.152	114
152	0.8	0.55	153.35	153

Value 1	Value 2	Total Value	Total to correct sig figs
0.91	1.23	1.1193	1.1
8.764	7.63	66.86932	66.9
2.6	31.7	82.42	82
937	40.01	37489.37	37 500
0.722	634.23	457.91406	458

Value 1	Value 2	Total Value	Total to correct sig figs
5.3	748	7.085561×10^{-3}	7.1×10^{-3}
3781	6.50	581.6923077	582
91×10^{2}	180	50.55555555556	51
5.56	22×10^{-3}	252.727272727	250
3.142	8.314	0.37791677	0.3779

Value 1	Value 2	Value 3	Mean Value	Mean to correct sig figs
1	1	2	1.3333	1
435	299	437	436	436
5.00	6.0	29.50	5.50	5.5
5.038	4.925	4.900	4.9543333333	4.954
720.00	728.0	725	724.3333333333	724
0.00040	0.00039	0.000380	0.000380	0.00038
31	30.314	29.7	30.338	30

Topic 3

6 m^2	=	60 000 cm^2
0.002 m^2	=	2000 mm^2
24 000 cm^2	=	2.4 m^2
46 000 000 mm^3	=	0.046 m^3
0.56 m^3	=	560 000 cm^3

750 mm^2	=	0.00075 m^2
5 x 10^{-4} cm^3	=	5.0 x10^{-10} m^3
8.3 x 10^{-6} m^3	=	8300 mm^3
3.5 x 10^2 m^2	=	3.5 x 10^6 cm^2
152000 mm^2	=	0.152 m^2

31 x 10^8 m^2	=	3100 km^2
59 cm^2	=	5900 mm^2
24 dm^3	=	24000 cm^3
4 500 mm^2	=	45 cm^2
5 x 10^{-4} km^3	=	500 000 m^3

A 2.0 m long solid copper cylinder has a cross-sectional area of 3.0 x10^2 mm^2. What is its volume in cm^3?

h= 2.0 m = 2.0 x 10^2 cm   csa = 3.0 cm^2

V = cross-section area x height = 2.0 x 10^2 x 3.0= 600

Volume = ______600 cm^3

5 N cm^{-2}	=	50 000 N m^{-2}
1150 kg m^{-3}	=	(1150 x1000 / 100x100x100) = 1.15 g cm^{-3}
3.0 m s^{-1}	=	(3.0 /1000) x (60x60) = 10.8 km h^{-1}
65 kN cm^{-2}	=	650 N mm^{-2}
7.86 g cm^{-3}	=	7860 kg m^{-3}

Topic 4

$R = V/I$ $t = Q/I$ $A = \rho L/A$ $r = (\varepsilon - V)/I$

$u = 2s/t - v$ $f = (\Phi + E_K)/h$ $g = E_{P,}/mh$ $F = 2E/e$

$u = \sqrt{(v^2 - 2as)}$ $m = T^2 k/4\pi^2$

Topic 5

Case study 1

IV Mass of sphere DV time to fall a set distance CV drop distance, diameter of sphere

IV continuous graph - line graph

Case Study 2

IV types of activities DV number of children CV time of day and day of the week

IV categoric / discrete graph bar chart

Case study 3

IV Value of mass (g) DV length of spring CV same spring, spring stationary when measured

IV continuous graph line

Case study 4

IV number of blades DV output potential difference

CV same dist from fan, constant fan output, same blade design

IV discrete graph bar chart

Topic 6.

Pd across resistor/V	Current through the resistor/A			
	I_1	I_2	I_3	$I_{average}$
1.0	0.11	0.10	0.12	0.11
2.0	0.21	0.18	0.24	0.21
3.0	0.33	0.60	0.30	0.32
4.0	0.35	0.40	0.45	0.40
5.0	0.50	5.10	0.48	0.49

Topic 7

1. Straight line positive gradient , constant
2. Curve, negative gradient, steep then getting shallower
3. Straight line, negative gradient, constant
4. Straight line positive gradient, constant
5. Curve , positive gradient, decreasing
6. Curve, positive gradient, increasing.

Topic 8

Use S L A P U (5 mark) criteria. Graphs will be reviewed in the new term.

Topic 9

Show construction lines on your graphs.

1. m = 124-0/50-0 = 2.5
2. m = 22.5 -2.0/5.0-0 = 4.1
3. m= 112 - 42/11-4 = 10
4. m = 0.07-0.14/24-17 = -0.01

Topic 10.

Construction lInes need to be drawn on graphs for the full method.

1. Gradient at point 2.0 m= 22-0/4-0 = 5.5 gradient at point 4.0 m= 46-0/5.0-1.8 = 14.4
2. Gradient at point 1.5 m= 424-0/4-1 = 14.7 gradient at point 3.5 m= 116-0/4-2 = 58

Topic 11- always show a full method with your solutions.

Top graph area = 39 m Bottom graph area = 33 +/- 1 m (to 2 sig fig)

Topic 12. All values approximate, your estimate should be within quoted error.
Left hand graph- 41 squares each square 1 m s^{-1} x 1 s = 1 m area = 41 m +/- 1 m

Right hand graph 31 squares each square 1 km s^{-1} x 60 s = 60 km area = 1860 km +/- 60 km

Topic 13.

Graph 1- 0-10 minutes temperature rises at a constant rate from -20 ^{0}C to 0 ^{0}C of 2 ^{0}C min^{-1}.
Ice gaining thermal energy.
10-15 minutes temp is constant at 0 ^{0}C as a change of state occurs; solid to liquid.
15- 35 minutes temp rises at 5 ^{0}C min^{-1}, constant rate because gradient is constant.
35-75 minutes temp constant at 100 ^{0}C, change of state ; liquid to gas.
75-80 minutes rapid increase in temp, gradient steepest 8 ^{0} min^{-1}, gas phase.
(values are expected from the graph as is suitable theory; you are expected to recognise graphs).

Graph 2.
As the distance increases from Earth the (relative) value of g decreases. Large decrease initially seen by steep gradient with gradient decreasing as distance increases.
Taking values from graph:
relative dist 1.0, relative g =100   relative dist 2.0, relative g =25,   double d , g drops by 4
relative dist 1.5, relative g = 44   relative dist 3.0, relative g =11,   double d, g drops by 4
We are always looking for patterns in data, gradients, areas or values such as above.

In this case doubling the distance drops g by a factor of 4; called the inverse square law.
This is a very important law in Physics

Graph 3.
Section 1 At 0 ^{0}C activity low at 20 units (no units given so we use **units** as a term) rising to a max activity of 100 units at 40 ^{0}C.

Section 2 From peak at 40 ^{0}C activity rapidly drops to a low of 4 units at 100 ^{0}C.

Optimum activity is at 40 +/- 4 ^{0}C

Graph 4. 6- sections (only 2 described you need to write a description for all sections)

Section 1 - Constant acceleration of 3/6=0.5 m s^{-2} for 6 seconds, covering a displacement from the start point of (3 x 6)/2 = 9m
Section 2 - constant velocity of 3 m s^{-1} for 4 seconds covering a displacement of 3 x 4 = 12m

<u>Topic 14.</u>

Average mass = 20.01/4 = 5.00 +/- 0.01g   (uncertainty is +/- the resolution of instrument)

Recorded values are precise as the repeat readings are close together but they are not accurate because the average value does not equal the true value. Do not confuse resolution with precise.

There is possibly a zero error on the balance as all the recorded values are above the true value by a similar amount.

Topic 15

<table>
<tr><th>Measurement</th><th>Source of error</th><th>Type of error</th></tr>
<tr><td>A range of values are obtained for the length of a copper wire</td><td>RULER measuring length of wire</td><td>RANDOM</td></tr>
<tr><td colspan="3">Reduce this error by ensuring the wire is laid out straight, place the rules directly next to the wire, take repeat readings, remove anomalous readings and calculate an average length for the wire</td></tr>
<tr><td>The reading for the current through a wire is 0.74 A higher for one group in the class</td><td>Ammeter</td><td>SYSTEMATIC</td></tr>
<tr><td colspan="3">Zero error in the ammeter. Check reading before any current flows in the circuit. Subtract zero error reading from each value or calibrate/adjust ammeter to read zero.</td></tr>
<tr><td>A range of values are obtained for the rebound height of a ball dropped from the same start point onto the same surface.</td><td>Ruler / person measuring rebound height</td><td>RANDOM
SYSTEMATIC</td></tr>
<tr><td colspan="3">RANDOM because person recording the height looks at the rule from different positions and or doesn’t use same part of ball to record max height.
SYSTEMATIC because rule might have a zero error.
Solution- put graph paper scale on a screen behind the ball. Drop the ball close to the screen and record the fall in slo-mo using a camera (smart phone). Analyse the play back to get accurate values.</td></tr>
<tr><td>A few groups obtain different graphs of resistance vs light intensity for an LDR. A light bulb placed at different distances from the LDR was used to vary the light intensity.</td><td>Additional light sources in the room</td><td>SYSTEMATIC</td></tr>
<tr><td colspan="3">Some groups may be near a window which will allow extra light onto the measuring equipment beyond that from the light bulb used in the initial experiment. Reduce error by using proper black out curtains and switch off additional light sources while taking readings or cover the apparatus with blackout material.</td></tr>
<tr><td>The time period (time of one oscillation) of a pendulum showing a range of values</td><td>Timing the oscillation</td><td>Random</td></tr>
<tr><td colspan="3">Time 20 oscillations and divide by 20. Use a fiducial mark (pin as a point of reference) to help determine the point of one complete oscillation while counting the 20 oscillations. Release the pendulum at the same amplitude- should be a small angle of about 15^0 from vertical.</td></tr>
</table>

Topic 16

Measuring cylinder - Read the volume of water from the bottom of the meniscus and perpendicular to the scale to reduce parallax error. resolution/error +/- 2 ml

Top pan electronic balance - Ensure balance is zeroed before any reading are taken.
Make sure paper is not touch surfaces either side of the active top pan measuring surface.

Ensure no breeze or external forces are acting on the top pan.

resolution/error +/- 0.01g

Ruler - Place the ruler adjacent to the object being measured to reduce parallax error.
Make sure zero is placed at the start of the object being measured.

Ensure ruler is parallel to the measured surface.

resolution/error +/- 1 mm

Thermometer - Read the top of the active liquid and perpendicular to the scale to reduce parallax error.
resolution/error +/- 2^0C (estimate, we should be better than +/- 5^0C increments shown on the scale) .

Topic 17.

Some pointers.
Produce an equipment list; think of key/essential equipment .
IV height egg dropped from, m
DV diameter of splatter, m (area, m^2 , calculated from this value, we don't calculate the area directly)
CV size of egg, type of surface the egg is dropped onto.
Range of IV 0.50 to 4.00 m in 0.50 m increments.
Give a suitable table with heading /units
Graph plotted of height egg dropped (m) on x-axis v area of splatter (m^2)
Add more detail to your method and hand in with the rest of the notes.
Your method should be detailed enough to be followed and the experiment carried out.

AS Physics	18. Appendix 2- It's all Greek
Skills	

You are expected to know most of these letters.
The letters we will not use at A level are zeta, chi, psi, iota, kappa, xi, omicron.

Greek alphabet list

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

<u>Note.</u>

The second lower case symbol for sigma is used at the end of Greek words and not in our equations.

<u>TASK.</u> Write out the Greek letters that you have used in physics and mathematics.
Can you find other letter you have not used yet? If so write them out.
We often use the upper and lower case letters so learn both.

Transition from GCSE to A Level

Moving from GCSE Science to A Level can be a daunting leap. You'll be expected to remember a lot more facts, equations, and definitions, and you will need to learn new maths skills and develop confidence in applying what you already know to unfamiliar situations.

This worksheet aims to give you a head start by helping you:

- to pre-learn some useful knowledge from the first chapters of your A Level course
- understand and practise of some of the maths skills you'll need.

Learning objectives

After completing the worksheet you should be able to:

- define practical science key terms
- recall the answers to the retrieval questions
- perform maths skills including:
    - unit conversions
    - uncertainties
    - using standard form and significant figures
    - resolving vectors
    - rearranging equations
    - equations of work, power, and efficiency.

Retrieval questions

You need to be confident about the definitions of terms that describe measurements and results in A Level Physics.

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

Practical science key terms

When is a measurement valid?	when it measures what it is supposed to be measuring
When is a result accurate?	when it is close to the true value
What are precise results?	when repeat measurements are consistent/agree closely with each other
What is repeatability?	how precise repeated measurements are when they are taken by the *same* person, using the *same* equipment, under the *same* conditions
What is reproducibility?	how precise repeated measurements are when they are taken by *different* people, using *different* equipment
What is the uncertainty of a measurement?	the interval within which the true value is expected to lie
Define measurement error	the difference between a measured value and the true value
What type of error is caused by results varying around the true value in an unpredictable way?	random error
What is a systematic error?	a consistent difference between the measured values and true values
What does zero error mean?	a measuring instrument gives a false reading when the true value should be zero
Which variable is changed or selected by the investigator?	independent variable
What is a dependent variable?	a variable that is measured every time the independent variable is changed
Define a fair test	a test in which only the independent variable is allowed to affect the dependent variable
What are control variables?	variables that should be kept constant to avoid them affecting the dependent variable

Foundations of Physics

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

What is a physical quantity?	a property of an object or of a phenomenon that can be measured
What are the S.I. units of mass, length, and time?	kilogram (kg), metre (m), second (s)
What base quantities do the S.I. units A, K, and mol represent?	current, temperature, amount of substance
List the prefixes, their symbols and their multiplication factors from pico to tera (in order of increasing magnitude)	pico (p) 10^{-12}, nano (n) 10^{-9}, micro (μ) 10^{-6}, milli (m) 10^{-3}, centi (c) 10^{-2}, deci (d) 10^{-1}, kilo (k) 10^{3}, mega (M) 10^{6}, giga (G) 10^{9}, tera (T) 10^{12}
What is a scalar quantity?	a quantity that has magnitude (size) but *no* direction
What is a vector quantity?	a quantity that has magnitude (size) *and* direction
What are the equations to resolve a force, F, into two perpendicular components, F_x and F_y?	$F_x = F\cos\theta$ $F_y = F\sin\theta$
What is the difference between distance and displacement?	distance is a scalar quantity displacement is a vector quantity
What does the Greek capital letter Δ (delta) mean?	'change in'
What is the equation for average speed in algebraic form?	$v = \frac{\Delta x}{\Delta t}$
What is instantaneous speed?	the speed of an object over a very short period of time
What does the gradient of a displacement–time graph tell you?	velocity
How can you calculate acceleration and displacement from a velocity–time graph?	acceleration is the gradient displacement is the area under the graph
Write the equation for acceleration in algebraic form	$a = \frac{\Delta v}{\Delta t}$
What do the letters *suvat* stand for in the equations of motion?	s = displacement, u = initial velocity, v = final velocity, a = acceleration, t = time taken
Write the four *suvat* equations.	$v = u + at$ $\quad s = ut + \frac{1}{2}at^2$ $s = \frac{1}{2}(u+v)t$ $\quad v^2 = u^2 + 2as$
Define *stopping distance*	the total distance travelled from when the driver first sees a reason to stop, to when the vehicle stops
Define *thinking distance*	the distance travelled between the moment when you first see a reason to stop to the moment when you use the brake
Define *braking distance*	the distance travelled from the time the brake is applied until the vehicle stops
What does *free fall* mean?	when an object is accelerating under gravity with no other force acting on it

Matter and radiation

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

What is an atom made up of?	a positively charged nucleus containing protons and neutrons, surrounded by electrons
Define a *nucleon*	a proton or a neutron in the nucleus
What are the absolute charges of protons, neutrons, and electrons?	$+1.60\times10^{-19}$, 0, and -1.60×10^{-19} coulombs (C) respectively
What are the relative charges of protons, neutrons, and electrons?	1, 0, and – 1 respectively (charge relative to proton)
What is the mass, in kilograms, of a proton, a neutron, and an electron?	1.67×10^{-27}, 1.67×10^{-27}, and 9.11×10^{-31} kg respectively
What are the relative masses of protons, neutrons, and electrons?	1, 1, and 0.0005 respectively (mass relative to proton)
What is the atomic number of an element?	the number of protons
Define an isotope	isotopes are atoms with the same number of protons and different numbers of neutrons
Write what *A*, *Z* and X stand for in isotope notation ($^{A}_{Z}\mathrm{X}$)?	*A*: the number of nucleons (protons + neutrons) *Z*: the number of protons X: the chemical symbol
Which term is used for each type of nucleus?	nuclide
How do you calculate specific charge?	charge divided by mass (for a charged particle)
What is the specific charge of a proton and an electron?	9.58×10^{7} and 1.76×10^{11} C kg^{-1} respectively
Name the force that holds nuclei together	strong nuclear force
What is the range of the strong nuclear force?	from 0.5 to 3–4 femtometres (fm)
Name the three kinds of radiation	alpha, beta, and gamma
What particle is released in alpha radiation?	an alpha particle, which comprises two protons and two neutrons
Write the symbol of an alpha particle	$^{4}_{2}\alpha$
What particle is released in beta radiation?	a fast-moving electron (a beta particle)
Write the symbol for a beta particle	$^{0}_{-1}\beta$
Define *gamma radiation*	electromagnetic radiation emitted by an unstable nucleus
What particles make up everything in the universe?	matter and antimatter
Name the antimatter particles for electrons, protons, neutrons, and neutrinos	positron, antiproton, antineutron, and antineutrino respectively
What happens when corresponding matter and antimatter particles meet?	they annihilate (destroy each other)
List the seven main parts of the electromagnetic spectrum from longest wavelength to shortest	radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays
Write the equation for calculating the wavelength of electromagnetic radiation	wavelength $(\lambda) = \dfrac{\text{speed of light } (c)}{\text{frequency } (f)}$
Define a *photon*	a packet of electromagnetic waves
What is the speed of light?	3.00×10^{8} m s^{-1}
Write the equation for calculating photon energy	photon energy (*E*) = Planck constant (*h*) × frequency (*f*)
Name the four fundamental interactions	gravity, electromagnetic, weak nuclear, strong nuclear

Maths skills

1 Measurements

1.1 Base and derived SI units

Units are defined so that, for example, every scientist who measures a mass in kilograms uses the same size for the kilogram and gets the same value for the mass. Scientific measurement depends on standard units – most are *Système International* (SI) units. Every measurement must give the unit to have any meaning. You should know the correct unit for physical quantities.

Base units

Physical quantity	Unit	Symbol
length	metre	m
mass	kilogram	kg
time	second	s

Physical quantity	Unit	Symbol
electric current	ampere	A
temperature difference	Kelvin	K
amount of substance	mole	mol

Derived units

Example:

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

If a car travels 2 metres in 2 seconds:

$$\text{speed} = \frac{2\,\text{metres}}{2\,\text{seconds}} = 1\frac{\text{m}}{\text{s}} = 1\,\text{m/s}$$

This defines the SI unit of speed to be 1 metre per second (m/s), or 1 m s^{-1} ($s^{-1} = \frac{1}{s}$).

Practice questions

1 Complete this table by filling in the missing units and symbols.

Physical quantity	Equation used to derive unit	Unit	Symbol and name (if there is one)
frequency	period^{-1}	s^{-1}	Hz, hertz
volume	length^3		–
density	mass ÷ volume		–
acceleration	velocity ÷ time		–
force	mass × acceleration		
work and energy	force × distance		

1.2 Significant figures

When you use a calculator to work out a numerical answer, you know that this often results in a large number of decimal places and, in most cases, the final few digits are 'not significant'. It is important to record your data and your answers to calculations to a reasonable number of significant figures. Too many and your answer is claiming an accuracy that it does not have, too few and you are not showing the precision and care required in scientific analysis.

Numbers to 3 significant figures (3 s.f.):

3.62 25.4 271 0.0147 0.245 39 400

(notice that the zeros before the figures and after the figures are *not* significant – they just show you how large the number is by the position of the decimal point).

Numbers to 3 significant figures where the zeros *are* significant:

207 4050 1.01 (any zeros between the other significant figures *are* significant).

Standard form numbers with 3 significant figures:

9.42×10^{-5} 1.56×10^{8}

If the value you wanted to write to 3.s.f. was 590, then to show the zero was significant you would have to write:

590 (to 3.s.f.) or 5.90×10^2

Practice questions

2 Give these measurements to 2 significant figures:

a 19.47 m **b** 21.0 s **c** 1.673×10^{-27} kg **d** 5 s

3 Use the equation:

$$\text{resistance} = \frac{\text{potential difference}}{\text{current}}$$

to calculate the resistance of a circuit when the potential difference is 12 V and the current is 1.8 mA. Write your answer in kΩ to 3 s.f.

1.3 Uncertainties

When a physical quantity is measured there will always be a small difference between the measured value and the true value. How important the difference is depends on the size of the measurement and the size of the uncertainty, so it is important to know this information when using data.

There are several possible reasons for uncertainty in measurements, including the difficulty of taking the measurement and the resolution of the measuring instrument (i.e. the size of the scale divisions).

For example, a length of 6.5 m measured with great care using a 10 m tape measure marked in mm would have an uncertainty of 2 mm and would be recorded as 6.500 ± 0.002 m.

It is useful to quote these uncertainties as percentages.

For the above length, for example,

$$\text{percentage uncertainty} = \frac{\text{uncertainty}}{\text{measurement}} \times 100$$

$$\text{percentage uncertainty} = \frac{0.002}{6.500} \times 100\% = 0.03\%.$$ The measurement is 6.500 m ± 0.03%.

Values may also be quoted with absolute error rather than percentage uncertainty, for example, if the 6.5 m length is measured with a 5% error,

the absolute error = 5/100 × 6.5 m = ±0.325 m.

Practice questions

4 Give these measurements with the uncertainty shown as a percentage (to 1 significant figure):

a 5.7 ± 0.1 cm **b** 450 ± 2 kg **c** 10.60 ± 0.05 s **d** 366 000 ± 1000 J

5 Give these measurements with the error shown as an absolute value:

a 1200 W ± 10% **b** 330 000 Ω ± 0.5%

6 Identify the measurement with the smallest percentage error. Show your working.

A 9 ± 5 mm **B** 26 ± 5 mm **C** 516 ± 5 mm **D** 1400 ± 5 mm

2 Standard form and prefixes

When describing the structure of the Universe you have to use very large numbers. There are billions of galaxies and their average separation is about a million light years (ly). The Big Bang theory says that the Universe began expanding about 14 billion years ago. The Sun formed about 5 billion years ago. These numbers and larger numbers can be expressed in standard form and by using prefixes.

2.1 Standard form for large numbers

In standard form, the number is written with one digit in front of the decimal point and multiplied by the appropriate power of 10. For example:

- The diameter of the Earth, for example, is 13 000 km.
  13 000 km = 1.3 × 10 000 km = 1.3×10^4 km.
- The distance to the Andromeda galaxy is 2 200 000 light years = 2.2 × 1 000 000 ly = 2.2×10^6 ly.

2.2 Prefixes for large numbers

Prefixes are used with SI units (see Topic 1.1) when the value is very large or very small. They can be used instead of writing the number in standard form. For example:

- A kilowatt (1 kW) is a thousand watts, that is 1000 W or 10^3 W.
- A megawatt (1 MW) is a million watts, that is 1 000 000 W or 10^6 W.
- A gigawatt (1 GW) is a billion watts, that is 1 000 000 000 W or 10^9 W.

Prefix	Symbol	Value
kilo	k	10^3
mega	M	10^6

Prefix	Symbol	Value
giga	G	10^9
tera	T	10^{12}

For example, Gansu Wind Farm in China has an output of 6.8×10^9 W. This can be written as 6800 MW or 6.8 GW.

Practice questions

1 Give these measurements in standard form:

a 1350 W **b** 130 000 Pa **c** 696×10^6 s **d** 0.176×10^{12} C kg^{-1}

2 The latent heat of vaporisation of water is 2 260 000 J/kg. Write this in:

a J/g **b** kJ/kg **c** MJ/kg

2.3 Standard form and prefixes for small numbers

At the other end of the scale, the diameter of an atom is about a tenth of a billionth of a metre. The particles that make up an atomic nucleus are much smaller. These measurements are represented using negative powers of ten and more prefixes. For example:

- The charge on an electron = 1.6×10^{-19} C.
- The mass of a neutron = $0.016\,75 \times 10^{-25}$ kg = 1.675×10^{-27} kg (the decimal point has moved 2 places to the right).
- There are a billion nanometres in a metre, that is 1 000 000 000 nm = 1 m.
- There are a million micrometres in a metre, that is 1 000 000 μm = 1 m.

Prefix	Symbol	Value
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}

Prefix	Symbol	Value
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

Practice questions

3 Give these measurements in standard form:

a 0.0025 m **b** 160×10^{-17} m **c** 0.01×10^{-6} J **d** 0.005×10^6 m **e** 0.00062×10^3 N

4 Write the measurements for question 3a, c, and d above using suitable prefixes.

5 Write the following measurements using suitable prefixes.

a a microwave wavelength = 0.009 m

b a wavelength of infrared = 1×10^{-5} m

c a wavelength of blue light = 4.7×10^{-7} m

2.4 Powers of ten

When multiplying powers of ten, you must *add* the indices.

So 100 × 1000 = 100 000 is the same as $10^2 \times 10^3 = 10^{2+3} = 10^5$

When dividing powers of ten, you must *subtract* the indices.

So $\frac{100}{1000} = \frac{1}{10} = 10^{-1}$ is the same as $\frac{10^2}{10^3} = 10^{2-3} = 10^{-1}$

But you can only do this when the numbers with the indices are the same.

So $10^2 \times 2^3 = 100 \times 8 = 800$

And you can't do this when adding or subtracting.

$10^2 + 10^3 = 100 + 1000 = 1100$

$10^2 - 10^3 = 100 - 1000 = -900$

Remember: You can only add and subtract the indices when you are multiplying or dividing the numbers, not adding or subtracting them.

Practice questions

6 Calculate the following values – read the questions very carefully!

a $20^6 + 10^{-3}$

b $10^2 - 10^{-2}$

c $2^3 \times 10^2$

d $10^5 \div 10^2$

7 The speed of light is 3.0×10^8 m s^{-1}. Use the equation $v = f\lambda$ (where λ is wavelength) to calculate the frequency of:

a ultraviolet, wavelength 3.0×10^{-7} m

b radio waves, wavelength 1000 m

c X-rays, wavelength 1.0×10^{-10} m.

3 Resolving vectors

3.1 Vectors and scalars

Vectors have a magnitude (size) and a direction. Directions can be given as points of the compass, angles or words such as forwards, left or right. For example, 30 mph east and 50 km/h north-west are velocities.

Scalars have a magnitude, but no direction. For example, 10 m/s is a speed.

Practice questions

1 State whether each of these terms is a vector quantity or a scalar quantity: density, temperature, electrical resistance, energy, field strength, force, friction, frequency, mass, momentum, power, voltage, volume, weight, work done.

2 For the following data, state whether each is a vector or a scalar: 3 ms^{-1}, +20 ms^{-1}, 100 m NE, 50 km, −5 cm, 10 km S 30° W, 3×10^8 ms^{-1} upwards, 273 °C, 50 kg, 3 A.

3.2 Drawing vectors

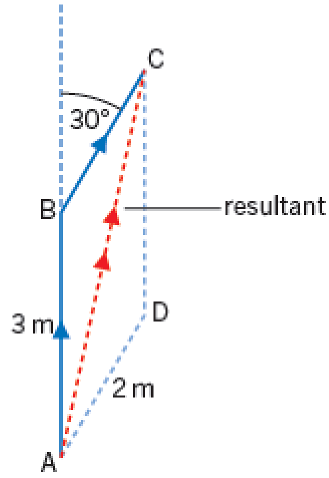
Vectors are shown on drawings by a straight arrow. The arrow starts from the point where the vector is acting and shows its direction. The length of the vector represents the magnitude.

When you add vectors, for example two velocities or three forces, you must take the direction into account.

The combined effect of the vectors is called the resultant.

This diagram shows that walking 3 m from A to B and then turning through 30° and walking 2 m to C has the same effect as walking directly from A to C. AC is the resultant vector, denoted by the double arrowhead.

A careful drawing of a scale diagram allows us to measure these. Notice that if the vectors are combined by drawing them in the opposite order, AD and DC, these are the other two sides of the parallelogram and give the same resultant.



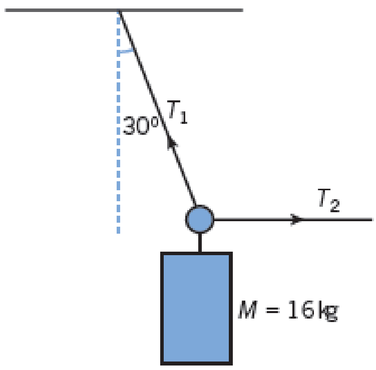
Practice questions

3 Two tractors are pulling a log across a field. Tractor 1 is pulling north with force 1 = 5 kN and tractor 2 is pulling east with force 2 = 12 kN. By scale drawing, determine the resultant force.

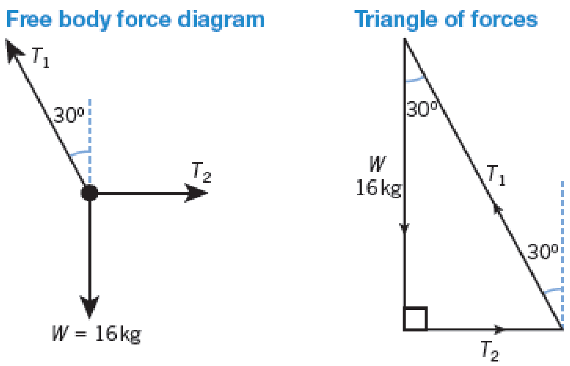
3.3 Free body force diagrams

To combine forces, you can draw a similar diagram to the one above, where the lengths of the sides represent the magnitude of the force (e.g., 30 N and 20 N). The third side of the triangle shows us the magnitude and direction of the resultant force.

When solving problems, start by drawing a free body force diagram. The object is a small dot and the forces are shown as arrows that start on the dot and are drawn in the direction of the force. They don't have to be to scale, but it helps if the larger forces are shown to be larger. Look at this example.



A 16 kg mass is suspended from a hook in the ceiling and pulled to one side with a rope, as shown on the right. Sketch a free body force diagram for the mass and draw a triangle of forces.



Notice that each force starts from where the previous one ended and they join up to form a triangle with no resultant because the mass is in equilibrium (balanced).

Practice questions

4 Sketch a free body force diagram for the lamp (**Figure 1**, below) and draw a triangle of forces.

5 There are three forces on the jib of a tower crane (**Figure 2**, below). The tension in the cable T, the weight W, and a third force P acting at X.

The crane is in equilibrium. Sketch the triangle of forces.

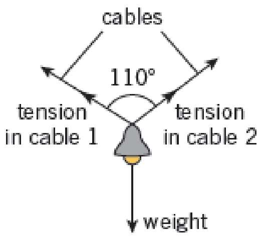


Figure 1

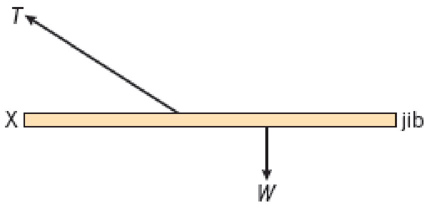


Figure 2

3.4 Calculating resultants

When two forces are acting at right angles, the resultant can be calculated using Pythagoras's theorem and the trig functions: sine, cosine, and tangent.

For a right-angled triangle as shown:

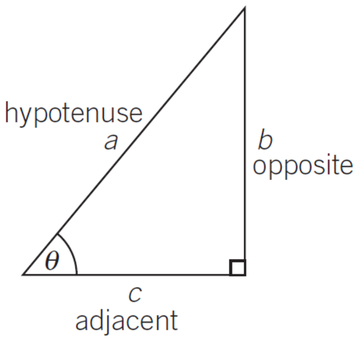
$h^2 = o^2 + a^2$

$\sin\theta = \frac{o}{h}$

$\cos\theta = \frac{a}{h}$

$\tan\theta = \frac{o}{a}$

(soh-cah-toa).



Practice questions

6 **Figure 3** shows three forces in equilibrium.
Draw a triangle of forces to find T and α.

7 Find the resultant force for the following pairs of forces at right angles to each other:

a 3.0 N and 4.0 N **b** 5.0 N and 12.0 N

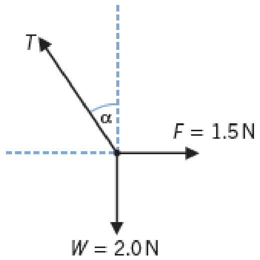


Figure 3

4 Rearranging equations

Sometimes you will need to rearrange an equation to calculate the answer to a question. For example, if you want to calculate the resistance R, the equation:

potential difference (V) = current (A) × resistance (Ω) or $V = I R$

must be rearranged to make R the subject of the equation:

$$R = \frac{V}{I}$$

When you are solving a problem:

- Write down the values you know and the ones you want to calculate.
- you can rearrange the equation first, and then substitute the values

  or
- substitute the values and then rearrange the equation

4.1 Substitute and rearrange

A student throws a ball vertically upwards at 5 m s^{-1}. When it comes down, she catches it at the same point. Calculate how high it goes.

Step 1: Known values are:

- initial velocity u = 5.0 m s^{-1}
- final velocity v = 0 (you know this because as it rises it will slow down, until it comes to a stop, and then it will start falling downwards)
- acceleration $a = g = -9.81$ m s^{-2}
- distance s = ?

Step 2: Equation:

(final velocity)^2 − (initial velocity)^2 = 2 × acceleration × distance

or $v^2 - u^2 = 2 \times g \times s$

Substituting: $(0)^2 - (5.0 \text{ m s}^{-1})^2 = 2 \times -9.81 \text{ m s}^{-2} \times s$

$0 - 25 = 2 \times -9.81 \times s$

Step 3: Rearranging:

$-19.62\, s = -25$

$s = \frac{-25}{-19.62}$ = 1.27 m = 1.3 m (2 s.f.)

Practice questions

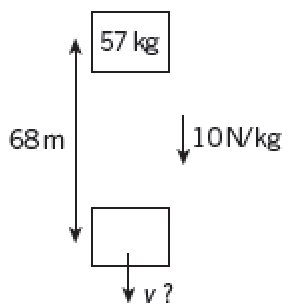
1 The potential difference across a resistor is 12 V and the current through it is 0.25 A. Calculate its resistance.

2 Red light has a wavelength of 650 nm. Calculate its frequency. Write your answer in standard form.
(Speed of light = 3.0×10^8 m s^{-1})

4.2 Rearrange and substitute

A 57 kg block falls from a height of 68 m. By considering the energy transferred, calculate its speed when it reaches the ground.

(Gravitational field strength = 10 N kg^{-1})



Step 1: m = 57 kg h = 68 m g = 10 N kg^{-1} v = ?

Step 2: There are three equations:

PE = $m\,g\,h$ KE gained = PE lost KE = $0.5\,m\,v^2$

Step 3: Rearrange the equations before substituting into it.

As KE gained = PE lost, $m\,g\,h = 0.5\,m\,v^2$

You want to find v. Divide both sides of the equation by 0.5 m:

$$\frac{mgh}{0.5m} = \frac{0.5mv^2}{0.5m}$$

$2\,g\,h = v^2$

 http://www.oxfordsecondary.co.uk/acknowledgements

To get v, take the square root of both sides: $v = \sqrt{2gh}$

Step 4: Substitute into the equation:

$$v = \sqrt{2 \times 10 \times 68}$$

$$v = \sqrt{1360} = 37 \text{ m s}^{-1}$$

Practice questions

3 Calculate the specific latent heat of fusion for water from this data:
4.03×10^4 J of energy melted 120 g of ice.
Use the equation:
thermal energy for a change in state (J) = mass (kg) × specific latent heat (J kg^{-1})
Give your answer in J kg^{-1} in standard form.

5 Work done, power, and efficiency

5.1 Work done

Work is done when energy is transferred. Work is done when a force makes something move. If work is done *by* an object its energy decreases and if work is done *on* an object its energy increases.

work done = energy transferred = force × distance

Work and energy are measured in joules (J) and are scalar quantities (see Topic 3.1).

Practice questions

1 Calculate the work done when the resultant force on a car is 22 kN and it travels 2.0 km.

2 Calculate the distance travelled when 62.5 kJ of work is done applying a force of 500 N to an object.

5.2 Power

Power is the rate of work done.

It is measured in watts (W) where 1 watt = 1 joule per second.

$$\text{power} = \frac{\text{energy transferred}}{\text{time taken}} \quad \textit{or} \quad \text{power} = \frac{\text{work done}}{\text{time taken}}$$

$P = \Delta W / \Delta t$ *Δ is the symbol 'delta' and is used to mean a 'change in'*

Look at this worked example, which uses the equation for potential energy gained.

A motor lifts a mass m of 12 kg through a height Δh of 25 m in 6.0 s.

Gravitational potential energy gained:

$\Delta PE = mg\Delta h = (12 \text{ kg}) \times (9.81 \text{ m s}^{-2}) \times (25 \text{ m}) = 2943 \text{ J}$

Power = $\dfrac{2943\text{ J}}{6.0\text{ s}}$ = 490 W (2 s.f.)

Practice questions

3 Calculate the power of a crane motor that lifts a weight of 260 000 N through 25 m in 48 s.

4 A motor rated at 8.0 kW lifts a 2500 N load 15 m in 5.0 s. Calculate the output power.

5.3 Efficiency

Whenever work is done, energy is transferred and some energy is transferred to other forms, for example, heat or sound. The efficiency is a measure of how much of the energy is transferred usefully.

Efficiency is a ratio and is given as a decimal fraction between 0 (all the energy is wasted) and 1 (all the energy is usefully transferred) or as a percentage between 0 and 100%. It is not possible for anything to be 100% efficient: some energy is always lost to the surroundings.

Efficiency = $\dfrac{\text{useful energy output}}{\text{total energy input}}$ or Efficiency = $\dfrac{\text{useful power output}}{\text{total power input}}$

(multiply by 100% for a percentage)

Look at this worked example.

A thermal power station uses 11 600 kWh of energy from fuel to generate electricity. A total of 4500 kWh of energy is output as electricity. Calculate the percentage of energy 'wasted' (dissipated in heating the surroundings).

You must calculate the energy wasted using the value for useful energy output:

percentage energy wasted = $\dfrac{(\text{total energy input - energy output as electricity})}{\text{total energy input}} \times 100$

percentage energy wasted = $\dfrac{(11600 - 4500)}{11600} \times 100$ = 61.2% = 61% (2 s.f.)

Practice questions

5 Calculate the percentage efficiency of a motor that does 8400 J of work to lift a load.
The electrical energy supplied is 11 200 J.

6 An 850 W microwave oven has a power consumption of 1.2 kW.
Calculate the efficiency, as a percentage.

7 Use your answer to question 4 above to calculate the percentage efficiency of the motor. (The motor, rated at 8.0 kW, lifts a 2500 N load 15 m in 5.0 s.)

8 Determine the time it takes for a 92% efficient 55 W electric motor take to lift a 15 N weight 2.5 m.

Answers to maths skills practice questions

1 Measurements

1

Physical quantity	Equation used to derive unit	Unit	Symbol and name (if there is one)
frequency	period^{-1}	s^{-1}	Hz, hertz
volume	length^3	m^3	–
density	mass ÷ volume	$kg\ m^{-3}$	–
acceleration	velocity ÷ time	$m\ s^{-2}$	–
force	mass × acceleration	$kg\ m\ s^{-2}$	N newton
work and energy	force × distance	N m (or $kg\ m^2\ s^{-2}$)	J joule

2 **a** 19 m **b** 21 s
c 1.7×10^{-27} kg **d** 5.0 s

3 Resistance $= \dfrac{12\text{ V}}{1.8\text{ mA}} = \dfrac{12\text{ V}}{0.0018\text{ A}} = 6666.666...\Omega = 6.66666...\text{k}\Omega = 6.67\Omega$

4 **a** 5.7 cm ± 2% **b** 450 kg ± 0.4%
c 10.6 s ± 0.5% **d** 366 000 J ± 0.3%

5 **a** 1200 ± 120 W **b** 330 000 ± 1650 Ω

6 **D** 1400 ± 5 mm (Did you calculate them all? The same absolute error means the percentage error will be smallest in the largest measurement, so no need to calculate.)

2 Standard form and prefixes

1 **a** 1.35×10^3 W (or 1.350×10^3 W to 4 s.f.) **b** 1.3×10^5 Pa
c 6.96×10^8 s **d** 1.76×10^{11} C kg^{-1}

2 **a** 2 260 000 J in 1 kg, so there will be 1000 times fewer J in 1 g: $\dfrac{2\,260\,000}{1000} = 2260$ J/g

b 1 kJ = 1000 J, $2\,260\,000\text{ J/kg} = \dfrac{2\,260\,000}{1000}\text{kJ/kg} = 2260\text{ kJ/kg}$

c 1 MJ = 1000 kJ, so $2260\text{ kJ/kg} = \dfrac{2260}{1000}\text{MJ/kg} = 2.26\text{ MJ/kg}$

3 **a** 2.5×10^{-3} m **b** 1.60×10^{-15} m
c 1×10^{-8} J **d** 5×10^3 m
e 6.2×10^{-1} N

4 **a** 2.5 µm **b** 1.60 f m
c 10 nJ **or** 0.01 µJ **d** 5 km
e 0.62 N **or** 62 cN

5 **a** 0.009 m = 9×10^{-3} m = 9 mm
b 1×10^{-5} m = $1 \times 10 \times 10^{-6}$ m = 10×10^{-6} m = 10 µm
c 4.7×10^{-7} m = $4.7 \times 100 \times 10^{-9}$ m = 470×10^{-9} m = 470 nm

6 **a** 64000000 **or** 6.4×10^7 **b** 99.99

c 800 **d** 10^3

7 **a** 3.0×10^8 m s^{-1} ÷ 3.03×10^{-7} m = 1.0×10^{15} Hz

b 3.0×10^8 m s^{-1} ÷ 1000 m = 3.0×10^5 Hz

c 3.0×10^8 m s^{-1} ÷ 1.0×10^{-10} m = 3.0×10^{18} Hz

3 Resolving vectors

1 **Scalars:** density, electric charge, electrical resistance, energy, frequency, mass, power, temperature, voltage, volume, work done

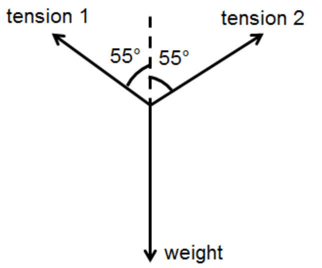
Vectors: field strength, force, friction, momentum, weight

2 **Scalars:** 3 ms^{-1}, 50 km, 273 °C, 50 kg, 3 A

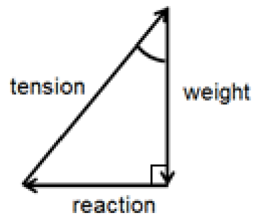
Vectors: **+**20 ms^{-1}, 100 m NE, −5 cm, 10 km S 30°W, 3 × 10^8 m/s upwards

3 13 kN

4 **Free body force diagram:**



Triangle of forces:



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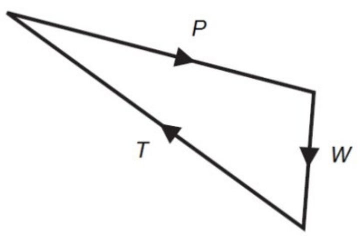

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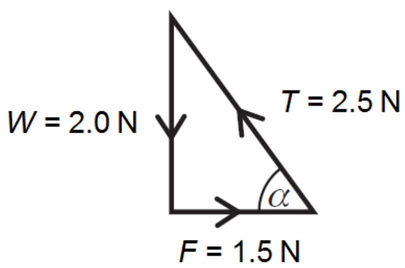


7 **a** 5.0 N at 37° to the 4.0 N force **b** 13 N at 23° to the 12.0 N force

4 Rearranging equations

1 V = 12 V and I = 0.25 A

$V = I\,R$ so $12 = 0.25 \times R$

$$R = \frac{V}{I} = \frac{12}{0.25} = 48\ \Omega$$

2 λ = 650 nm = 650×10^{-9} m and v = 3.0×10^8 m/s

$v = f\lambda$ so $3.0\times10^8 = f \times 650\times10^{-9}$

$f = \frac{v}{\lambda} = \frac{3.0\times10^8}{650\times10^{-9}} = 0.00462\times10^{17} = 4.62\times10^{14}$ Hz

3 $E = 4.01\times10^4$ J and $m = 0.120$ g $= 0.120$ kg

$E = mL$ so $4.01\times10^4 = 0.120 \times L$

$L = \frac{E}{m} = \frac{4.01\times10^4}{0.120} = 334\,166$ J/kg $= 3.34\times10^5$ J/kg in standard form

5 Work done, power, and efficiency

1 22×10^3 N $\times$ 2×10^3 m = 44 000 000 J = 44 MJ

2 $\frac{62.5\times10^3 \text{ J}}{500 \text{ N}} = 125$ m

3 $\frac{260\,000 \text{ N}\times25 \text{ m}}{48 \text{ s}} = 13\,541.6$ W = 14 000 W or 14 kW (2 s.f.)

4 $\frac{2500 \text{ N}\times15 \text{ m}}{5 \text{ s}} = 7500$ W = 7.5 kW

5 $\frac{8400}{11200} \times 100 = 75\%$

6 $\frac{850}{1.2\times10^3}\times100 = 71\%$

7 $\frac{7.5}{8.0}\times100 = 94\%$

8 0.74 s

Bridging the Gap from GCSE Physics and Preparing for A-level

Physics is Challenging

It is said time and time again, by people that should know better, that physics is a hard subject. But physics is like any other area of human endeavour. It is challenging because it is worth while.

Physics is challenging and it should be. If at any point you find the material too trivial, after checking you have the work correct, please ask for more demanding work. Education should be a mental gymnasium where you perspire, ache and then grow. Anyone will be able to succeed in a challenging field if they commit to working hard and are prepared to ask for advice and help.

This booklet will hopefully prepare in part for the challenges ahead. Over the summer it is strongly advised that you work through this booklet **and** revise the physics components from your GCSEs. A levels, in all subjects, are more challenging and rigorous than GCSEs so make sure you give ourself the best opportunity to succeed!

Measuring and Estimating

Measuring techniques and being able to estimate quantities play a very important part in the A level Physics course. So here are a few tasks to do over the summer break. Be prepared to bring this work in and talk about it at the start of next term.

1. Using objects you can find in the kitchen, measure the density of water.
2. Explain how you did this and show all working.
3. Measure as accurately as you can the thickness of a yellow page from the Yellow Pages. Again explain how you did this and show all working.
4. Estimate the height of your house. Explain how you did this.
5. Work out how long your average foot step is using Google maps
6. Try to calculate the height of your house using trigonometry- do not measure it!

Practice Mathematics

Many students worry about the mathematical content of physics A-level. It is true that the mathematical component of this course can be demanding yet there is no way to circumvent this. This challenge needs to be taken head on. "Practice makes perfect" should be the motto that is inscribed into your work ethic.

Below you will find five areas that need to be mastered for any student to succeed in A-level physics. Ideally, each section should be completed and understood by the time you start in September.

1. Physical Quantities

Maths and Physics have an important but overlooked distinction by students. Numbers in Physics have meaning – they are the size of physical quantities which exist. To give numbers meaning we suffix them with units. There are two types of units:

Base units These are the seven fundamental quantities defined by the Système international d'Unités (SI units). Once defined, we can make measurements using the correct unit and make comparisons between values.

Basic quantity	Unit	
	Name	Symbol
Mass	kilogram	kg
Length	metre	m
Time	second	s
Current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Derived units These are obtained by multiplying or dividing base units. Some derived units are complicated and are given simpler names, such as the unit of power Watt (W) which in SI units would be m^2kgs^{-3}.

Derived quantity	Unit	
	Name	Symbols
Volume	cubic metre	m^3
Velocity	metre per second	ms^{-1}
Density	kilogram per cubic metre	kgm^{-3}

Notice that at A-Level we use the equivalent notation ms^{-1} rather than m/s.

Do not become confused between the symbol we give to the quantity itself, and the symbol we give to the unit. For some examples, see the table on the right.

Quantity	Quantity symbol	Unit name	Unit symbols
Length	L or l or h or d or s	metre	m
Wavelength	λ	metre	m
Mass	m or M	kilogram	kg
Time	t	second	s
Temperature	T	kelvin	K
Charge	Q	coulomb	C
Momentum	p	kilogram metres per second	kg ms^{-1}

Often the value of the quantity we are interested in is very big or small. To save space and simplify these numbers, we prefix the units with a set of symbols.

Prefix	Symbol	Name	Multiplier
femto	f	quadrillionth	10^{-15}
pico	p	trillionth	10^{-12}
nano	n	billionth	10^{-9}
micro	μ	millionth	10^{-6}
milli	m	thousandth	10^{-3}
centi	c	hundredth	10^{-2}
kilo	k	thousand	10^{3}
mega	M	million	10^{6}
giga	G	billion	10^{9}
tera	T	trillion	10^{12}
peta	P	quadrillion	10^{15}

Knowledge of standard form and how to input it into your calculator is essential.

For example: 245×10^{-12} m = 245 pm
2.45×10^{3} m = 2.45 km

We may need to convert units to make comparisons.

For example: Which is bigger, 0.167 GW or 1500 MW?

0.167 GW = 0.167×10^9 W
= 167×10^6 W
= 167 MW < 1500 MW

Physical Quantities - Questions

1) The unit of energy is the joule. Find out what this unit is expressed in terms of the base SI units.

2) Convert these numbers into normal form:
   a) 5.239×10^{3}
   b) 4.543×10^{4}
   c) 9.382×10^{2}
   d) 6.665×10^{-6}
   e) 1.951×10^{-2}
   f) 1.905×10^{5}
   g) 6.005×10^{3}

3) Convert these quantities into standard form:
   a) 65345 N
   b) 765 s
   c) 486856 W
   d) 0.987 cm^2
   e) 0.000567 F
   f) 0.0000605 C
   g) 0.03000045 J

4) Write down the solutions to these problems, giving your answer in standard form:
   a) $(3.45 \times 10^{-5} + 9.5 \times 10^{-6}) \div 0.0024$
   b) $2.31 \times 10^{5} \times 3.98 \times 10^{-3} + 0.0013$

5) Calculate the following:
   a) 20mm in metres
   b) 3.5kg in grams
   c) 589000 µm in metres
   d) 1m^2 in cm^2 (careful)
   e) 38 cm^2 in m^2

6) Find the following:
   a) 365 days in seconds, written in standard form
   b) 3.0×10^{4} g written in kg
   c) 2.1×10^{6} Ω written in MΩ
   d) 5.9×10^{-7} m written in µm
   e) Which is bigger? 1452 pF or 0.234 nF

Mark = /27

2. Significant Figures

Number in Physics also show us how certain we are of a value. How sure are you that the width of this page is 210.30145 mm across? Using a ruler you could not be this precise. You would be more correct to state it as being 210 mm across, since a ruler can measure to the nearest millimetre.

To show the precision of a value we will quote it to the correct number of significant figures. But how can you tell which figures are significant?

The Rules

1. All non-zero digits are significant.
2. In a number with a decimal point, all zeros to the right of the right-most non-zero digit are significant.
3. In a number without a decimal point, trailing zeros may or may not be significant, you can only tell from the context.

Examples

Value	# of S.F.	Hints
23	2	There are two digits and both are non-zero, so are both significant
123.654	6	All digits are significant – this number has high precision
123.000	6	Trailing zeros after decimal are significant and claim the same high precision
0.000654	3	Leading zeros are only placeholders
100.32	5	Middle zeros are always significant
5400	2, 3 or 4	Are the zeros placeholders? You would have to check how the number was obtained

When taking many measurements with the same piece of measuring apparatus, all your data should have the same number of significant figures.

For example, measuring the width of my thumb in three different places with a micrometer:

20.91×10^{-3} m 21.22×10^{-3} m 21.00×10^{-3}m   **all to 4 s.f**

Significant Figures in Calculations

We must also show that calculated values recognise the precision of the values we put into a formula. We do this by giving our answer to the same number of significant figures as the least precise piece of data we use.

There is no way we can state the runners speed this precisely.

For example: A man runs 110 m in 13 s. Calculate his average speed.

Speed = Distance / Time = 110 m / 13 s = 8.4615384615384615384615384615 38 m/s

= 8.5 m/s to 2 s.f.

This is the same number of sig figs as the time, which is less precise than the distance.

Significant Figures - Questions

1) Write the following lengths to the stated number of significant figures:
    a) 5.0319 m to 3 s.f.
    b) 500.00 m to 2 s.f.
    c) 0.9567892159 m to 2 s.f.
    d) 0.000568 m to 1 s.f.

2) How many significant figures are the following numbers quoted to?
    a) 224.4343
    b) 0.000000000003244654
    c) 344012.34
    d) 456
    e) 4315.0002
    f) 200000 stars in a small galaxy
    g) 4.0

3) For the numbers above that are quoted to more than 3 s.f, convert the number to standard form and quote to 3 s.f.

4) Calculate the following and write your answer to the correct number of significant figures:
    a) 2.65 m x 3.015 m
    b) 22.37 cm x 3.10 cm
    c) 0.16 m x 0.02 m
    d) $\frac{54.401 \text{ m}^3}{4 \text{ m}}$

Mark = /19

3. Using Equations

You are expected to be able to manipulate formulae correctly and confidently. You must practise rearranging and substituting equations until it becomes second nature. We shall be using quantity symbols, and not words, to make the process easier.

Key points

- Whatever mathematical operation you apply to one side of an equation must be applied to the other.
- Don't try and tackle too many steps at once.

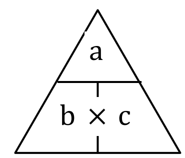
Simple formulae

The most straightforward formulae are of the form $a = b \times c$ (or more correctly $= bc$).

Rearrange to set b as the subject: Divide both sides through by c $\frac{a}{c} = \frac{b \times c}{c}$ therefore $\frac{a}{c} = b$

Rearrange to set c as the subject: Divide both sides through by b $\frac{a}{b} = \frac{b \times c}{b}$ therefore $\frac{a}{b} = a$

Alternatively you can use the formula triangle method. From the formula you know put the quantities into the triangle and then cover up the quantity you need to reveal the relationship between the other two quantities. This method only works for simple formulae, it doesn't work for some of the more complex relationships, so you must learn to rearrange.



More complex formulae

Formulae with more than 3 terms	Formulae with additions or subtractions	Formulae with squares or square roots
Find ρ $R = \frac{\rho l}{A}$	**Find h** $Ek = hf - \Phi$	**Find *g*** $T = 2\pi\sqrt{\frac{l}{g}}$
Divide by l $\frac{R}{l} = \frac{\rho l}{Al}$	Add Φ $Ek + \Phi = hf - \Phi + \Phi$	Square $T^2 = 4\pi^2 \frac{l}{g}$
Cancel l $\frac{R}{l} = \frac{\rho l}{Al}$	Cancel Φ $Ek + \Phi = hf$	Multiply by g $gT^2 = 4\pi^2 l$
Multiply by A $\frac{R}{l} = \frac{\rho l}{Al}$	Divide by f $\frac{Ek+\Phi}{f} = \frac{hf}{f}$	Divide by T^2 $g = \frac{4\pi^2 l}{T^2}$
Cancel A $\frac{R}{l} = \frac{\rho l}{Al}$	Cancel f $\frac{Ek+\Phi}{f} = h$	

Symbols on quantities

Sometimes the symbol for a quantity may be combined with some other identifying symbol to give more detail about that quantity. Here are some examples.

Symbol	Meaning
Δx	A change in x (difference between two values of x)
$\Delta x / \Delta t$	A rate of change of x
$\langle x \rangle$ or $\bar{x}$	Mean value of x
$\vec{x}$	Quantity x is a vector
x_1 x_2	Subscripts distinguish between same types of quantity

Using Equations - Questions

1) Make t the subject of each of the following equations:

   a) $V = u + at$

   b) $S = \frac{1}{2} at^2$

   c) $Y = k(t - t_0)$

   d) $F = \frac{mv}{t}$

   e) $Y = \frac{k}{t^2}$

   f) $Y = 2t^{1/2}$

   g) $v = \frac{\Delta s}{\Delta t}$

2) Solve each of the following equations to find the value of *t*:

   a) $30 = 3t - 3$

   b) $4(t + 5) = 28$

   c) $\frac{5}{t^2} = 10$

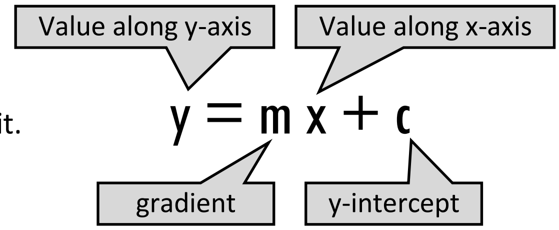
   d) $3t^2 = 36$

   e) $t^{-1/2} = 6$

   f) $t^{1/3} = 3$

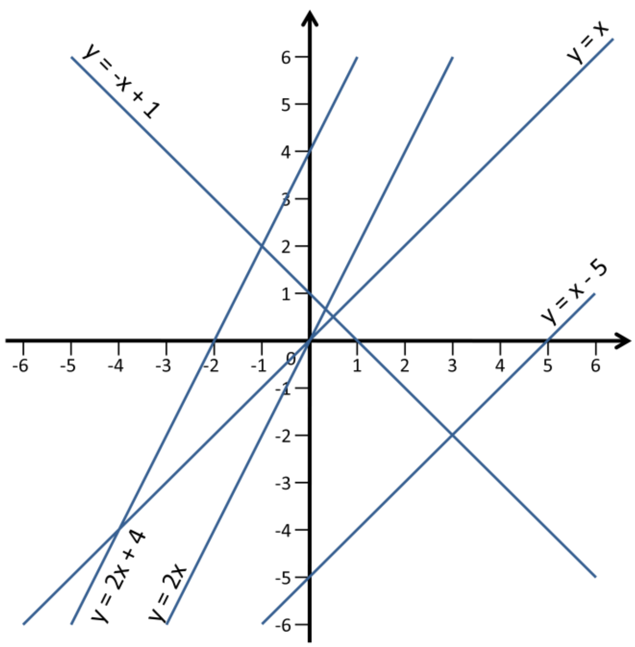
Mark = /13

4. Straight Line Graphs



If a graph is a straight line, then there is a formula that will describe it.

Here are some examples:



y = x	A positive line through the origin	
	Gradient, m = 1	y-intercept, c = 0
y = x – 5	Parallel to y = x but transposed by -5.	
	Gradient, m = 1	y-intercept, c = -5
y = 2x	A positive line through the origin	
	Gradient, m = 2	y-intercept, c = 0
y = 2x + 4	Parallel to y = 2x ,transposed by 4.	
	Gradient, m = 2	y-intercept, c = 4
y = -x + 1	A negative line, parallel to y = -x	
	Gradient, m = -1	y-intercept, c = 1

DIRECTLY PROPORTIONAL describes any straight line **through the origin**. Both y α x and Δy α Δx

LINEAR describes any other straight line. Only Δy α Δx.

Using Straight Line Graphs in Physics

If asked to plot a graph of experimental data at GCSE, you would plot the *independent variable* along the x-axis and the *dependent variable* up the y-axis. Then you might be able to say something about how the two variables are related.

At A-Level, we need to be cleverer about our choice of axes. Often we will need to find a value which is not easy to measure. We take a relationship and manipulate it into the form y = mx + c to make this possible.

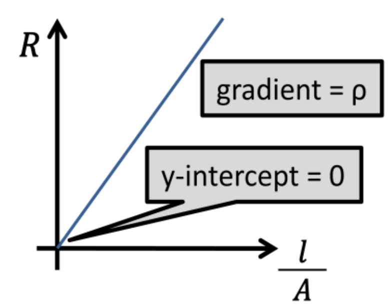
Example: $R = \frac{\rho l}{A}$ is the relationship between the resistance R of a conductor, the resistivity ρ of the material which it is made of, its length l, and its area A.

We do an experiment to find R, l and A, which are all easy to measure.
We want to find the resistivity ρ, which is harder.

This example doesn't need rearranging,
just rewriting $R = \frac{\rho l}{A}$ into the shape y = mx + c:

R	=	ρ	$\frac{l}{A}$	
y		m	x	+ c

So it is found that by plotting R on the y-axis and l/A on the x-axis, the resitivity ρ will be the gradient of the graph.



Straight Line Graphs - Questions

1) For each of the following equations that represent straight line graphs, write down the gradient and the y intercept:

   a) $y = 5x + 6$

   b) $y = -8x + 2$

   c) $y = 7 - x$

   d) $2y = 8x - 3$

   e) $y + 4x = 10$

   f) $3x = 5(1-y)$

   g) $5x - 3 = 8y$

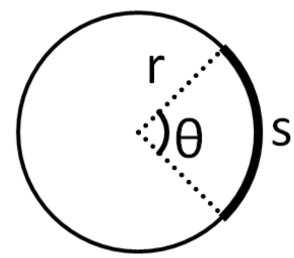
Mark = /14

5. Trigonometry

When dealing with vector quantities or systems involving circles, it will be necessary to use simple trigonometric relationships.

Angles and Arcs

There are two measurements of angles used in Physics.



- **Degrees** There are 360° in a circle
- **Radians** There are 2π radians in a circle

Whichever you use, make sure your calculator is in the correct mode!

To swap from one to the other you need to find what fraction of a circle you are interested in, and then multiply it by the number of degrees or radians in a circle.

$$\theta_{\text{radians}} = \frac{\theta_{\text{degrees}}}{360} \times 2\pi \quad \text{or} \quad \theta_{\text{degrees}} = \frac{\theta_{\text{radians}}}{2\pi} \times 360$$

For example: To convert 90° into radians: $\theta_{\text{radians}} = \frac{\theta_{\text{degrees}}}{360} \times 2\pi = \frac{90}{360} \times 2\pi = \frac{1}{4} \times 2\pi = \frac{\pi}{2}$ radians
(We tend to leave answers in radians as fractions of π)

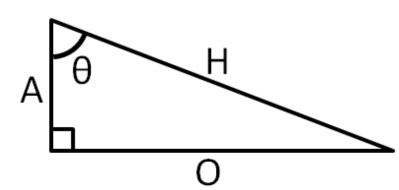
To find the length of an arc, use $s = \theta r$. The angle must be in radians. What would the relationship be if you wanted the entire circumference? Compare to this formula.

Sine, Cosine, Tangent

Recall from your GCSE studies the relationships between the lengths of the sides and the angles of right-angled triangles.

Using SOHCHATOA:

$$\sin\theta = \frac{\mathrm{O}}{\mathrm{H}} \qquad \cos\theta = \frac{\mathrm{A}}{\mathrm{H}} \qquad \tan\theta = \frac{\mathrm{O}}{\mathrm{A}}$$



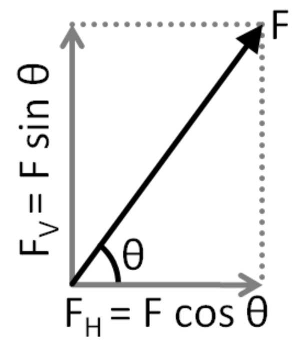
Vector Rules

A **vector** is a quantity which has two parts: SIZE and DIRECTION
(e.g. force, velocity, acceleration)

A **scalar** is a quantity which just has SIZE
(e.g. temperature, length, time, speed)

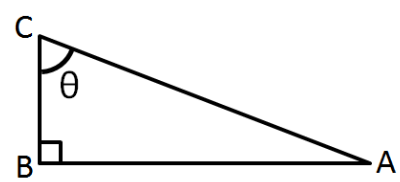
We represent vectors on diagrams with arrows.

To simplify problems in mechanics we will separate a vector into horizontal and vertical components. This is done using the trigonometry rules.



Trigonometry - Questions

1) Calculate:
   a) The circumference of a circle of radius 0.450 m
   b) the length of the arc of a circle of radius 0.450m for the following angles between the arc and the centre of the circle:
      i. 340^{o}
      ii. 170^{o}
      iii. 30^{o}



2) For the triangle ABC shown, calculate:
   a) Angle θ if AB = 30cm and BC = 40cm
   b) Angle θ if AC = 80cm and AB = 35cm
   c) AB if θ = 36° and BC = 50 mm
   d) BC if θ = 65° and AC = 15 km

3) Calculate the horizontal component A and the vertical component B of a 65 N force at 40^{o} above the horizontal.

Mark = /10

Mathematical Requirements

A summary of the mathematical requirements appears below. Once you have mastered a concept you can place a tick next to that part of the mathematical content. This will serve as a visual check on what you need to work on and what to ask the teaching staff for advice on.

1. Arithmetic and numerical computation

(a) recognise and use expressions in decimal and standard form

(b) use ratios, fractions and percentages

(c) use calculators to find and use power, exponential and logarithmic functions

(d) use calculators to handle $\sin x$, $\cos x$, $\tan x$ when x is expressed in degrees or radians

2. Handling data

(a) use appropriate number of significant figures

(b) find arithmetic means

(c) make order of magnitude calculations

3. Algebra

(a) understand and use the symbols $= < > \approx$

(b) change the subject of an equation

(c) substitute numerical values into algebraic equations using appropriate units for physical quantities

(d) solve simple algebraic equations

4. Graphs

(a) translate information between graphical, numerical and algebraic forms

(b) plot two variables from experimental or other data

(c) understand that $y = mx + c$ represents a linear relationship

(d) determine the slope and intercept of a linear graph

(e) draw and use the slope of a tangent to a curve as a measure of rate of change

(f) understand the possible physical significance of the area between a curve and the x axis and be able to calculate it or measure it by counting squares as appropriate

(g) use logarithmic plots to test exponential and power law variations

(h) sketch simple functions including $y = k/x$; $y = kx^2$; $y = sinx$; $y = cosx$; $y = e^{-x}$

5. Geometry and trigonometry

(a) calculate areas of triangles, circumferences and ares of circles, surface areas and volumes of rectangular blocks, cylinders and spheres

(b) use Pythagoras' theorem, and the angle sum of a triangle

(c) use sin, cos and tan in physical problems

(d) understand the relationship between degrees and radians and translate from one to the other

(e) use relationship for triangles: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

Transition Pack for A Level Physics

Get ready for A-level!

A guide to help you get ready for A-level Physics, including everything from topic guides to days out and online learning courses.

Commissioned by The PiXL Club Ltd. February 2016

Please note: these resources are non-board specific. Please direct your students to the specifics of where this knowledge and skills most apply.

So you are considering A Level Physics?

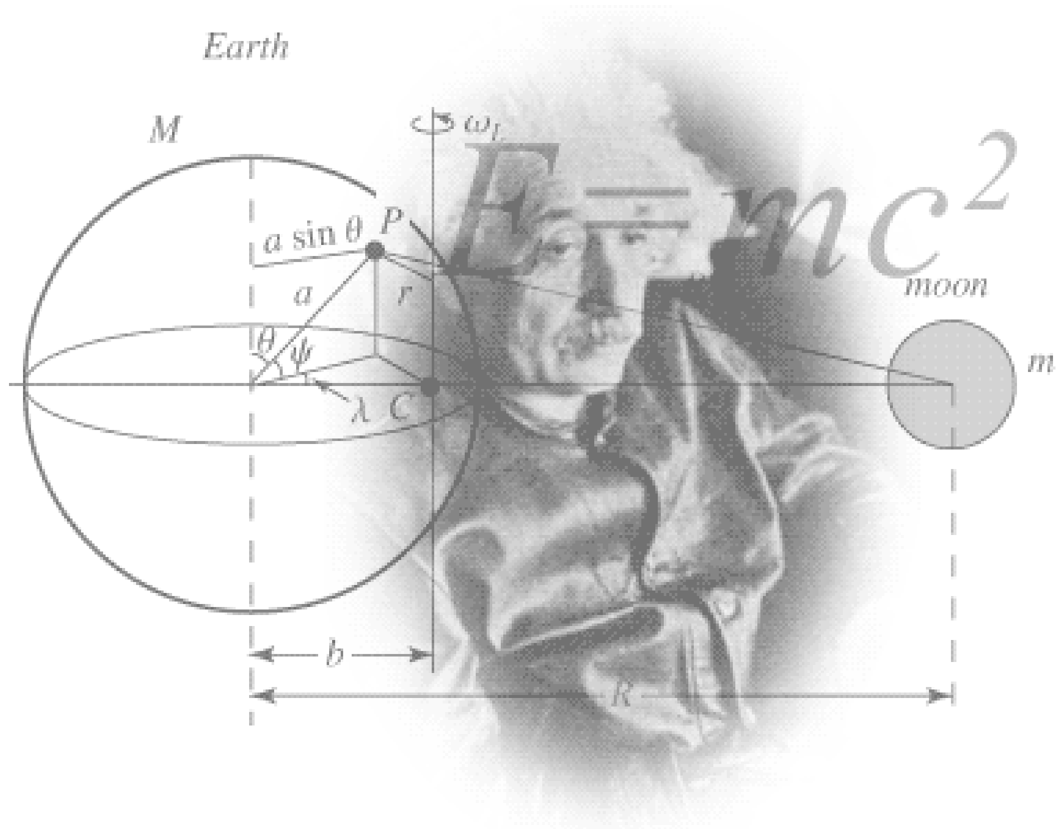


Figure 1 http://scienceworld.wolfram.com/physics/images/main-physics.gif

This pack contains a programme of activities and resources to prepare you to start an A level in Physics in September. It is aimed to be used after you complete your GCSE, throughout the remainder of the Summer term and over the Summer Holidays to ensure you are ready to start your course in September.

Pre-Knowledge Topics

Below are ten topics that are essential foundations for you study of A-Level Physics. Each topics has example questions and links where you can find our more information as you prepare for next year.

Symbols and Prefixes

Prefix	Symbol	Power of ten
Nano	n	x 10^{-9}
Micro	µ	x 10^{-6}
Milli	m	x 10^{-3}
Centi	c	x 10^{-2}
Kilo	k	x 10^{3}
Mega	M	x 10^{6}
Giga	G	x 10^{9}

At A level, unlike GCSE, you need to remember all symbols, units and prefixes. Below is a list of quantities you may have already come across and will be using during your A level course

Quantity	Symbol	Unit
Velocity	v	ms^{-1}
Acceleration	a	ms^{-2}
Time	t	S
Force	F	N
Resistance	R	Ω
Potential difference	V	V
Current	I	A
Energy	E or W	J
Pressure	P	Pa
Momentum	p	$kgms^{-1}$
Power	P	W
Density	ρ	kgm^{-3}
Charge	Q	C

Solve the following:

1. How many metres in 2.4 km?
2. How many joules in 8.1 MJ?
3. Convert 326 GW into W.
4. Convert 54600 mm into m.
5. How many grams in 240 kg?
6. Convert 0.18 nm into m.
7. Convert 632 nm into m. Express in standard form.
8. Convert 1002 mV into V. Express in standard form.
9. How many eV in 0.511 MeV? Express in standard form.
10. How many m in 11 km? Express in standard form.

Standard Form

At A level quantity will be written in standard form, and it is expected that your answers will be too.

This means answers should be written as ....x 10^y. E.g. for an answer of 1200kg we would write 1.2 x 10^3kg. For more information visit: www.bbc.co.uk/education/guides/zc2hsbk/revision

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 12.2 in standard form.
7. Write 2.4 x 10^{2} as a normal number.
8. Write 3.505 x 10^{1} as a normal number.
9. Write 8.31 x 10^{6} as a normal number.
10. Write 6.002 x 10^{2} as a normal number.
11. Write 1.5 x 10^{-4} as a normal number.
12. Write 4.3 x 10^{3} as a normal number.

Rearranging formulae

This is something you will have done at GCSE and it is crucial you master it for success at A level. For a recap of GCSE watch the following links:

www.khanacademy.org/math/algebra/one-variable-linear-equations/old-school-equations/v/solving-for-a-variable

www.youtube.com/watch?v=_WWgc3ABSj4

Rearrange the following:

1. E=m x g x h to find h
2. Q= I x t to find I
3. E = ½ m v^2 to find m
4. E = ½ m v^2 to find v
5. v = u + at to find u
6. v = u + at to find a
7. $v^2 = u^2 + 2as$ to find s
8. $v^2 = u^2 + 2as$ to find u

Significant figures

At A level you will be expected to use an appropriate number of significant figures in your answers. The number of significant figures you should use is the same as the number of significant figures in the data you are given. You can never be more precise than the data you are given so if that is given to 3 significant your answer should be too. E.g. Distance = 8.24m, time = 1.23s therefore speed = 6.75m/s

The website below summarises the rules and how to round correctly.

http://www.purplemath.com/modules/rounding2.htm

Give the following to 3 significant figures:

1. 3.4527
2. 40.691
3. 0.838991
4. 1.0247
5. 59.972

Calculate the following to a suitable number of significant figures:

6. 63.2/78.1
7. 39+78+120
8. (3.4+3.7+3.2)/3
9. 0.0256 x 0.129
10. 592.3/0.1772

Recording Data

Whilst carrying out a practical activity you need to write all your raw results into a table. Don't wait until the end, discard anomalies and then write it up in neat.

Tables should have column heading and units in this format quantity/unit e.g. length /mm

All results in a column should have the same precision and if you have repeated the experiment you should calculate a mean to the same precision as the data.

Below are link to practical handbooks so you can familiarise yourself with expectations.

http://filestore.aqa.org.uk/resources/physics/AQA-7407-7408-PHBK.PDF

http://www.ocr.org.uk/Images/295483-practical-skills-handbook.pdf

http://www.ocr.org.uk/Images/295483-practical-skills-handbook.pdf

Below is a table of results from an experiment where a ball was rolled down a ramp of different lengths. A ruler and stop clock were used.

1) Identify the errors the student has made.

	Time			
Length/cm	**Trial 1**	**Trial 2**	**Trial 3**	**Mean**
10	1.45	1.48	1.46	1.463
22	2.78	2.72	2.74	2.747
30	4.05	4.01	4.03	4.03
41	5.46	5.47	5.46	5.463
51	7.02	6.96	6.98	6.98
65	8.24	9.68	8.24	8.72
70	9.01	9.02	9.0	9.01

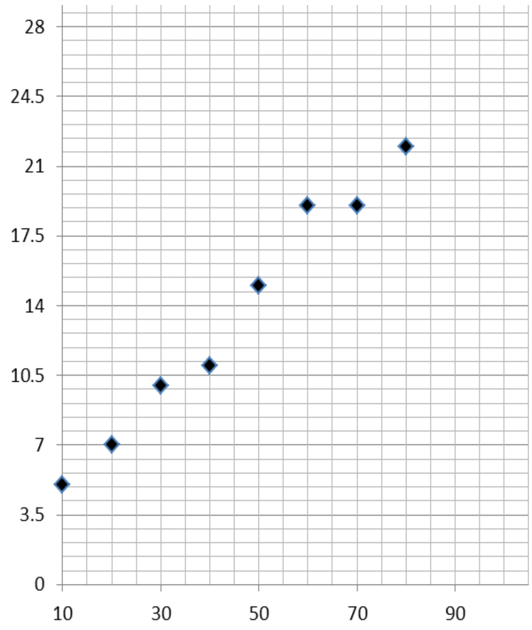
Graphs

After a practical activity the next step is to draw a graph that will be useful to you. Drawing a graph is a skill you should be familiar with already but you need to be extremely vigilant at A level. Before you draw your graph to need to identify a suitable scale to draw taking the following into consideration:

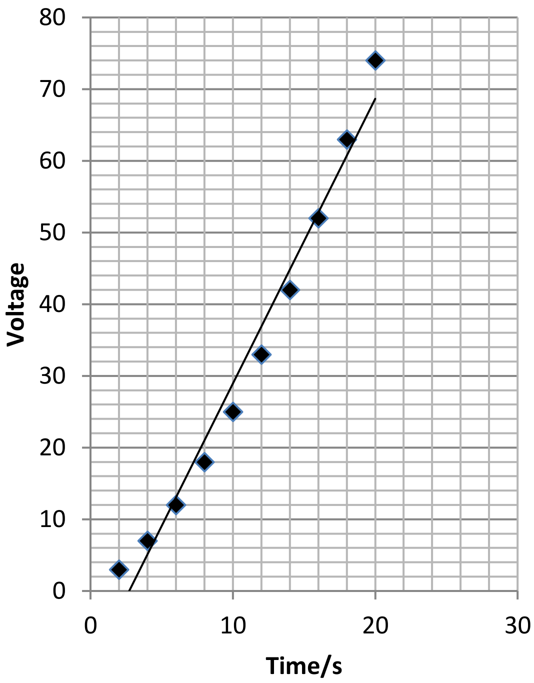
- the maximum and minimum values of each variable
- whether 0.0 should be included as a data point; graphs don't need to show the origin, a false origin can be used if your data doesn't start near zero.
- the plots should cover at least half of the grid supplied for the graph.
- the axes should use a sensible scale e.g. multiples of 1,2, 5 etc)

Identify how the following graphs could be improved

Graph 1



Graph 2



Forces and Motion

At GCSE you studied forces and motion and at A level you will explore this topic in more detail so it is essential you have a good understanding of the content covered at GCSE. You will be expected to describe, explain and carry calculations concerning the motion of objects. The websites below cover Newton's laws of motion and have links to these in action.

http://www.physicsclassroom.com/Physics-Tutorial/Newton-s-Laws

http://www.sciencechannel.com/games-and-interactives/newtons-laws-of-motion-interactive/

Sketch a velocity-time graph showing the journey of a skydiver after leaving the plane to reaching the ground.

Mark on terminal velocity.

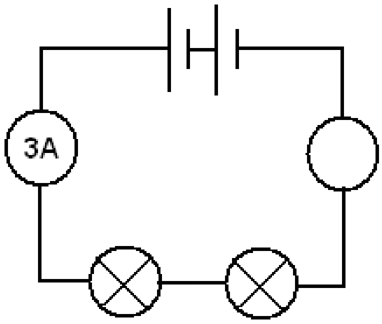
Electricity

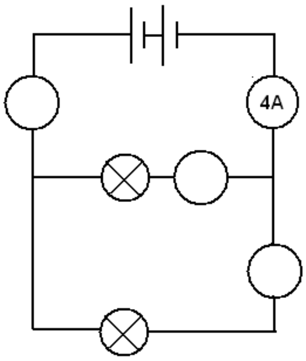
At A level you will learn more about how current and voltage behave in different circuits containing different components. You should be familiar with current and voltage rules in a series and parallel circuit as well as calculating the resistance of a device.

http://www.allaboutcircuits.com/textbook/direct-current/chpt-1/electric-circuits/

http://www.physicsclassroom.com/class/circuits

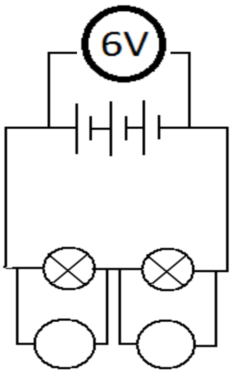
1a) Add the missing ammeter readings on the circuits below.

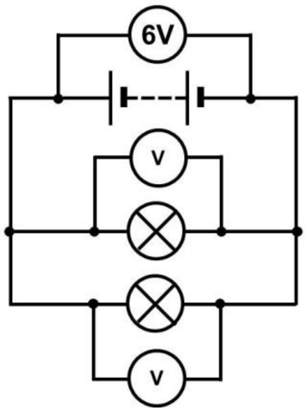




b) Explain why the second circuit has more current flowing than the first.

2) Add the missing potential differences to the following circuits





Waves

You have studied different types of waves and used the wave equation to calculate speed, frequency and wavelength. You will also have studied reflection and refraction.

Use the following links to review this topic.

http://www.bbc.co.uk/education/clips/zb7gkqt

https://www.khanacademy.org/science/physics/mechanical-waves-and-sound/mechanical-waves/v/introduction-to-waves

https://www.khanacademy.org/science/physics/mechanical-waves-and-sound/mechanical-waves/v/introduction-to-waves

1) Draw a diagram showing the refraction of a wave through a rectangular glass block. Explain why the ray of light takes this path.

2) Describe the difference between a longitudinal and transverse waves and give an example of each

3) Draw a wave and label the wavelength and amplitude

Pre-Knowledge Topics Answers:

Symbols and prefixes

1. 2400
2. 8 100 000
3. 326 000 000 000
4. 54.6
5. 240 000
6. 1.8×10^{-8}
7. 6.32×10^{-7}
8. 1.002
9. 5.11×10^{-5}
10. 1.1×10^{4}

Standard Form:

1. 2.53
2. 2.8
3. 7.7
4. 9.1
5. 1.872
6. 1.22
7. 2400
8. 35.05
9. 8 310 000
10. 600.2
11. 0.00015
12. 4300

Rearranging formulae

1. h= E/ (m x g)
2. I = Q/t
3. m = (2 x E)/v^2 or E/(0.5 x v^2)
4. v= √((2 x E)/m)
5. u = v – at
6. a = (v-u)/t
7. s = (v^2 – u^2) / 2a
8. u = √(v^2-2as)

Significant figures

1. 3.35
2. 40.7
3. 0.839
4. 1.02
5. 60.0
6. 0.809
7. 237
8. 3.4
9. 0.00330
10. 3343

Atomic Structure

contains protons, neutrons and electrons

Relative charge:

protons are positive (+1)

electrons are negative (-1)

neutrons are uncharged (0)

Relative mass:

proton 1

neutron 1

electron (about) 1/2000

protons and neutrons make up the nucleus

the nucleus is positively charged

electrons orbit the nucleus at a relatively large distance from the nucleus

most of the atom is empty space

nucleus occupies a very small fraction of the volume of the atom

most of the mass of the atom is contained in the nucleus

total number of protons in the nucleus equals the total number of electrons orbiting it in an atom

Recording data

Time should have a unit next to it

Length can be measured to the nearest mm so should be 10.0, 22.0 etc

Length 65 trial 2 is an anomaly and should have been excluded from the mean

All mean values should be to 2 decimal places

Mean of length 61 should be 6.99 (rounding error)

Graphs

Graph 1:

Axis need labels

Point should be x not dots

Line of best fit is needed

y axis is a difficult scale

x axis could have begun at zero so the y-intercept could be found

Graph 2:

y-axis needs a unit

curve of best fit needed not a straight line

Point should be x not dots

Forces and motion

Graph to show acceleration up to a constant speed (labelled terminal velocity). Rate of acceleration should be decreasing. Then a large decrease in velocity over a short period of time (parachute opens), then a decreasing rate of deceleration to a constant speed (labelled terminal velocity)

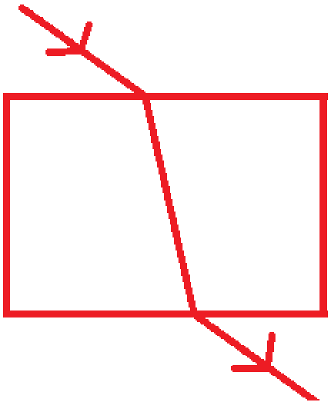
Electricity

1a) Series: 3A, Parallel top to bottom: 4A,2A,2A

b) Less resistance in the parallel circuit. Link to R=V/I. Less resistance means higher current.

2) Series: 3V, 3V, Parallel: 6V 6V

Waves



1) When light enters a more optically dense material it slows down and therefore bends towards the normal. The opposite happened when it leaves an optically dense material.

2) A longitudinal wave oscillates parallel to the direction of energy transfer (e.g. sound). A transverse waves oscillated perpendicular to the direction of energy transfer (e.g. light)

3)

.