Sixth Form Handbook
Physics

Contents

About the course

Why study A-level Physics?

Not only is Physics a fascinating subject that allows you to understand how and why things work,
A-level Physics is highly regarded and is identified as a key facilitating subject by the Russell Group of Elite Universities. This means that, along with some other A-Levels, Physics is given a slightly higher weighting when applying for courses at the top universities.

Through your study of Physics, you will develop your ability to problem solve; a highly desirable skill, work with numbers and communicate ideas clearly.

The study of Physics could lead to future careers in Architecture, Law, Medicine, Veterinary Science, Dentistry, Computing, Economics, Chemistry, Biology, Mathematics and Environmental Science. Physics will also prepare students for industry careers, such as those within the engineering or electronics sectors

What will I study?

We follow the **AQA Physics A Level Course** (specification can be accessed via the link below)
http://www.aqa.org.uk/subjects/science/as-and-a-level/physics-7407-7408

The course content is as follows;

Year 12:

Section 1: Measurements and their errors
Section 2: Particles and radiation
Section 3: Waves
Section 4: Mechanics and materials
Section 5: Electricity.

Year 13:

Section 6: Further mechanics and thermal physics
Section 7: Fields and their consequences
Section 8: Nuclear physics

And one optional topic chosen from:

Astrophysics
Medical physics
Engineering physics
Turning points in physics
Electronics

How you will be assessed

Physics A level is a linear course and so you will sit all the exams at the end of your two year course. The AS qualification is separate from, and counts in no way towards, the A-Level course. As such, students studying A Level Physics will not sit AS exams at the end of year 1.

A Level (at the end of your second year of study)

Paper 1

What will I be assessed on?
Sections 1 – 5, of the course content, along with 6.1: 'Periodic motion'
Paper length / weighting.
Written exam: 2 hours 85 marks 34% of A-Level
Question style.
60 marks of short and long answer questions and 25 multiple choice questions on content.

Paper 2

What will I be assessed on?
Sections 6.2: 'Thermal Physics', 7 and 8 + Assumed knowledge from sections 1 to 6.1
Paper length / weighting.
Written exam: 2 hours 85 marks 34% of A-Level
Question style.
60 marks of short and long answer questions and 25 multiple choice questions on content.

Paper 3

What will I be assessed on?
Section A: Compulsory section: Practical skills and data analysis Section B: One of sections 9, 10, 11, 12 or 13 (option units)
Paper length / weighting.
Written exam: 2 hours 80 marks 32% of A-Level
Question style.
45 marks of short and long answer questions on practical experiments and data analysis. 35 marks of short and long answer questions on optional topic.

Practical Endorsement (see appendix)

The assessment of practical skills is a compulsory requirement of the course; it will appear on your certificate as a separately reported result.

You will be assessed, against Common Practical Assessment Criteria (CPAC), whilst undertaking a minimum of 12 practical activities over the two years.

You will need to keep a lab book record of your practical work.

Course Reading List & Materials

Books

The following books are **provided by the School for your use in lesson** (you are not expected to buy these books but purchase details have been included in case you would prefer to have your own copy)

AQA A-level Physics Year 1 Student Book

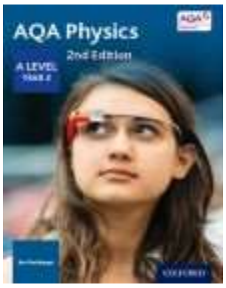
Author: Jim Breithaupt

Publisher: Oxford University Press (including Nelson Thornes)

ISBN-13: 978-0-1983-5186-3

Price: £24.99

AQA A-level Physics Year 2 Student Book



Author: Jim Breithaupt

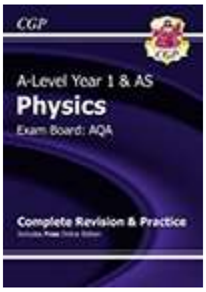
Publisher: Oxford University Press (including Nelson Thornes)

ISBN-13: 978-0-19-835772-8

Price: £24.99

The following books can be **purchased through school (at reduced prices) for your use at home**

AQA A-level Year 1 & AS Complete Revision & Practice with Online Edition

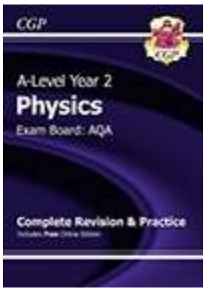


Publisher: **CGP**

ISBN-13: 978 1 78294 292 4

Price: £10.99

AQA A-level Year 2 & AS Complete Revision & Practice with Online Edition



Publisher: **CGP**

ISBN-13: 978 1 78294 343 3

Price: £10.99

Useful websites

The following websites have been found to be very useful by other students:

- AQA website - this is the course website. Here you will find the specification, past papers, mark schemes, the data booklet and other useful materials.

- http://www.antonine-education.co.uk/ - a comprehensive set of notes and 'test-yourself' questions.

- http://www.s-cool.co.uk/a-level/physics - revision style notes.

- http://www.cyberphysics.co.uk/ - indexed notes pages.

- http://www.iop.org/ - the institute of physics website: help and information about studying physics, at A Level and beyond, in the student section

- www.youtube.com – many pupils and teachers are sharing their resources.

Who can I contact for help?

Head of Physics
Miss A McCarthy

mccarthy.amira@poolehigh.co.uk

Tasks before September

You need to join the course with a solid knowledge of GCSE Physics.

You will need to thoroughly revise your GCSE knowledge ready for the start of the course.
This should include completing the **P1 and P2** past paper. (Link below)

TRILOGY

Paper 1:
https://filestore.aqa.org.uk/sample-papers-and-mark-schemes/2018/june/AQA-8464P1H-QP-JUN18.PDF
Paper 2:
https://filestore.aqa.org.uk/sample-papers-and-mark-schemes/2018/june/AQA-8464P2H-QP-JUN18.PDF

TRIPLE

Paper 1:
https://filestore.aqa.org.uk/sample-papers-and-mark-schemes/2018/june/AQA-84631H-QP-JUN18.PDF
Paper 2:
https://filestore.aqa.org.uk/sample-papers-and-mark-schemes/2018/june/AQA-84632H-QP-JUN18.PDF

AS Physics
Skills

Contents

AS Physics	
Skills	# 1. Prefixes and units

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}	0.00000000000000 1	↑ ÷ 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:

$$wave\ speed = frequency \times wavelength$$
$$(m/s) \qquad (Hz) \qquad (m)$$

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 5.0×10^2 / 2.6×10^2 = 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.** 5.02×10^4 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		2.483×10^4		69324.8	
500		750000		0.0006		0.0063	
0.136		310		5906.4291		9.81×10^4	
0.0300		3.10×10^4		200000		40000.00	
54.1		3.1×10^2		12.711		0.0004×10^4	

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		

<u>When multiplying or dividing numbers</u>

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…) = **<u>110</u>** (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		

<u>When calculating a mean</u>

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 **<u>9.0</u>** (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.

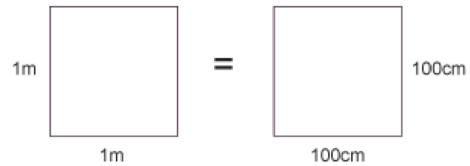
Converting Areas

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

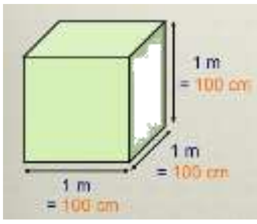
Converting Volumes

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
$5 \times 10^{-4}\ cm^3$	=	m^3
$8.3 \times 10^{-6}\ m^3$	=	mm^3
$3.5 \times 10^2\ m^2$	=	cm^2
$152000\ mm^2$	=	m^2

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

31×10^8 m^2	=	km^2
59 cm^2	=	mm^2
24 dm^3	=	cm^3
4 500 mm^2	=	cm^2
5×10^{-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 3.0×10^2 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}

4. Rearranging Equations

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

Equation		Rearrange Equation	Equation		Rearrange Equation
$V = IR$	R		$hf = \phi + E_K$	f	
$I = \frac{Q}{t}$	t		$E_P = mgh$	g	
$\rho = \frac{RA}{l}$	A		$E = \frac{1}{2}Fe$	F	
$\varepsilon = V + Ir$	r		$v^2 = u^2 + 2as$	u	
$s = \frac{(u+v)}{2}t$	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

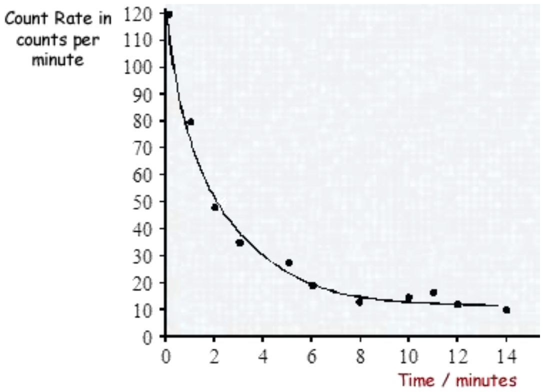
6. Drawing Lines of Best Fit

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."

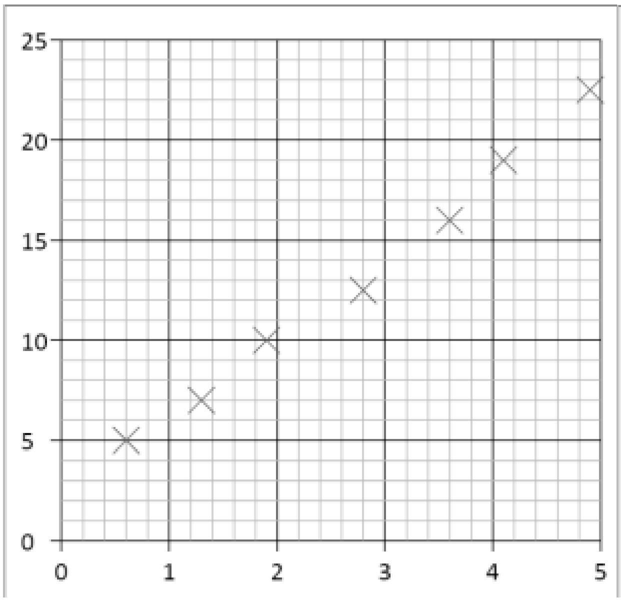
Substitute the quantities into X and Y, and choose either of the two options to describe the graph.

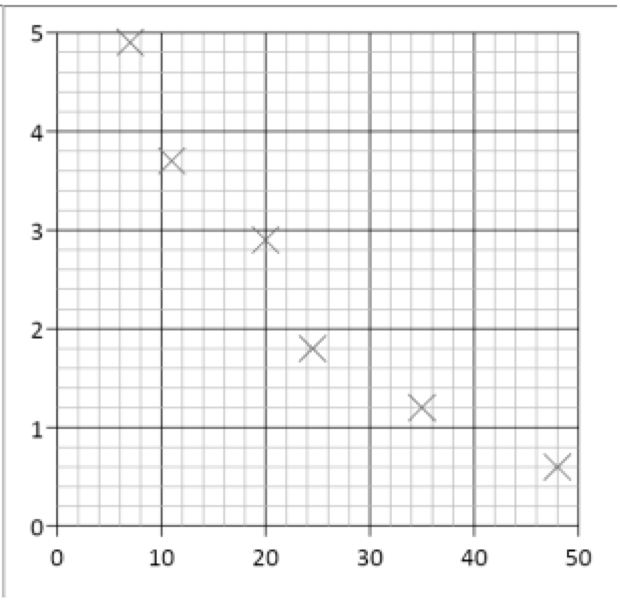


Eg.

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

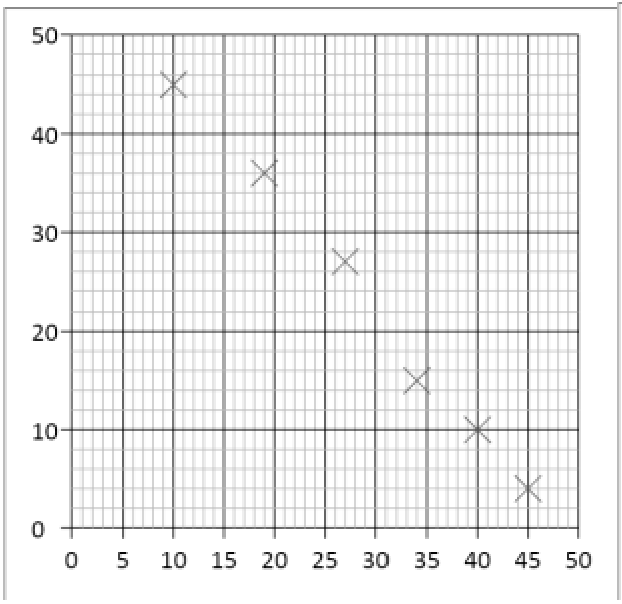
Draw a line of best fit for each of the graphs and describe the trend shown by each (call the quantities X and Y).





1.

2.



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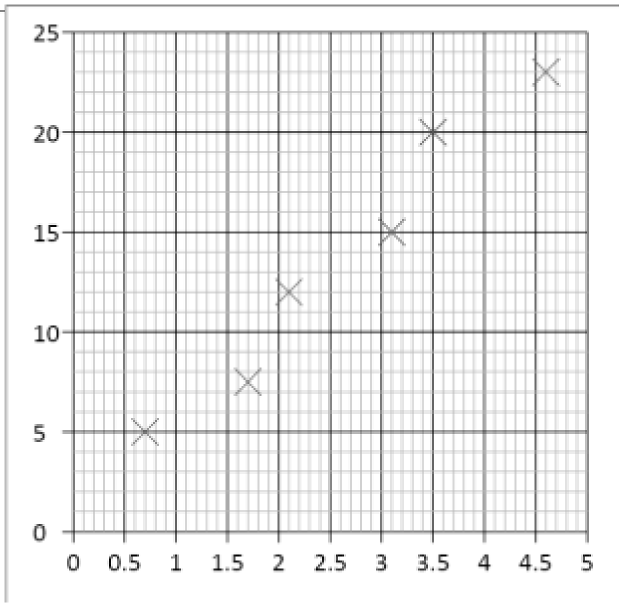
0 5 10 15 20 25 30 35 40 45 50



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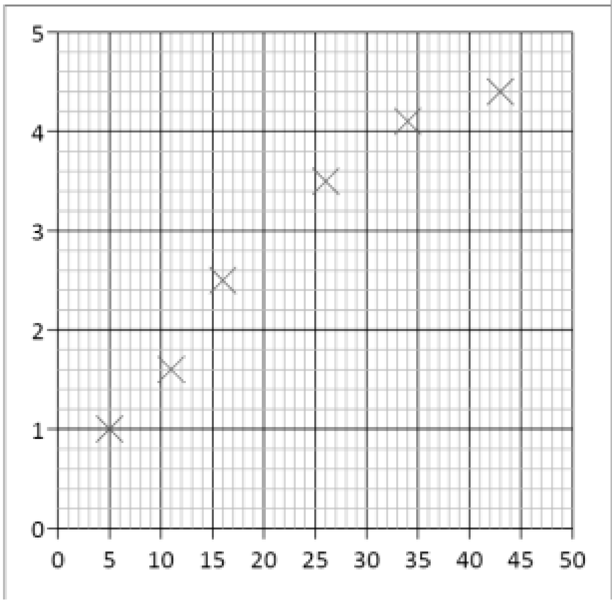
3.

4.



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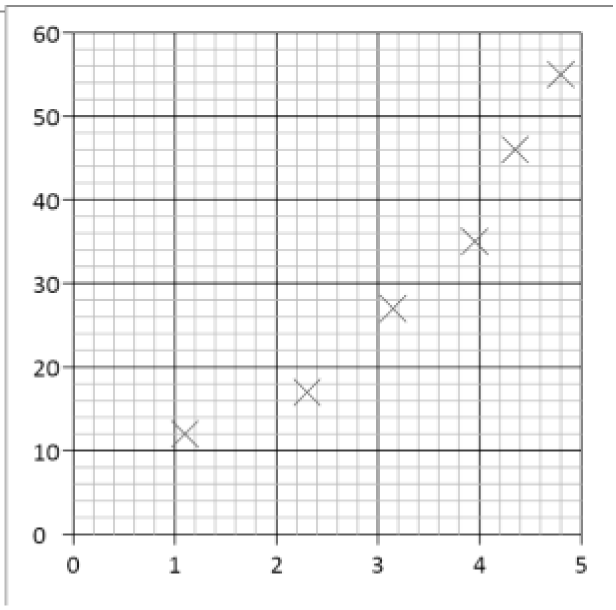
0 5 10 15 20 25 30 35 40 45 50



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

5.

6.

AS Physics	# 7. Calculating Gradients – Straight Lines
Skills	

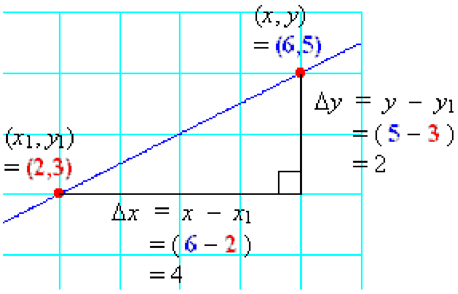
Gradients are a useful tool that show how fast or slow quantities change – eg speed tells us how fast distance is changing, or how quickly energy is being lost over time.

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:

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

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.

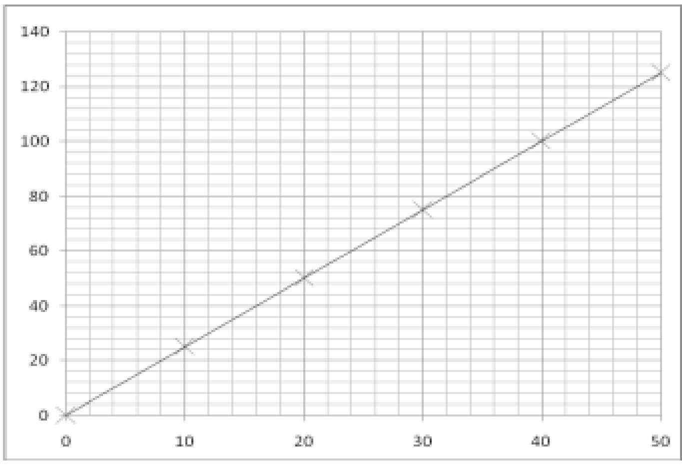


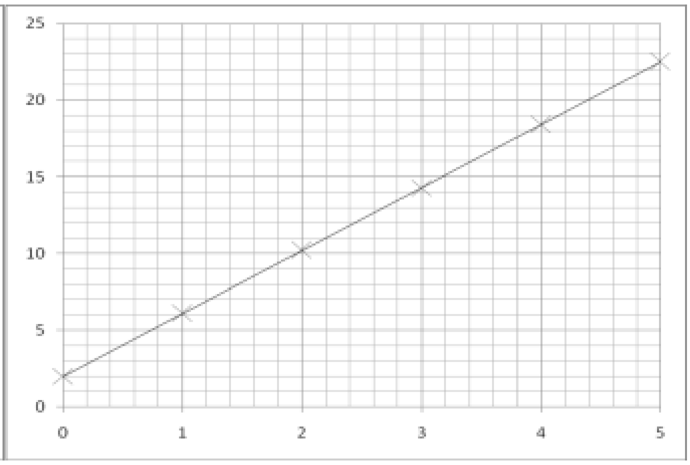
$$Gradient = \frac{difference\ in\ y}{difference\ in\ x}$$

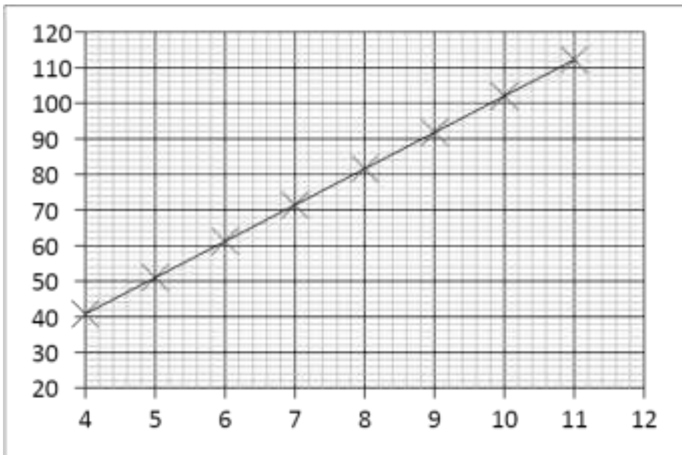
$$= \frac{2}{4}$$

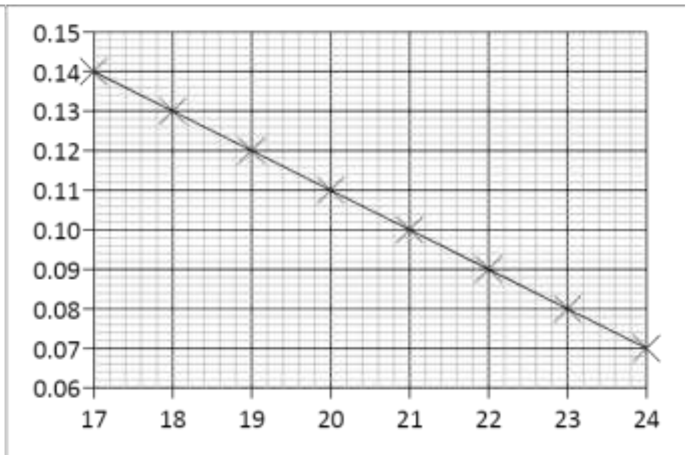
$$= \mathbf{0.5}$$

Calculate the gradients of the graphs below









AS Physics	# 8. Calculating Gradients – Curved Lines
Skills	

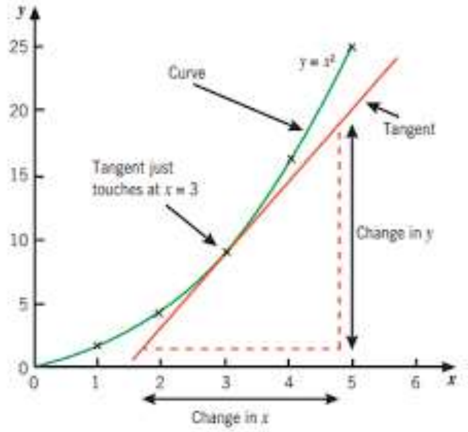
Most graphs in real life are not straight lines, but curves; however it is still useful to know how the quantity changes over time, hence we still need to calculate gradients.

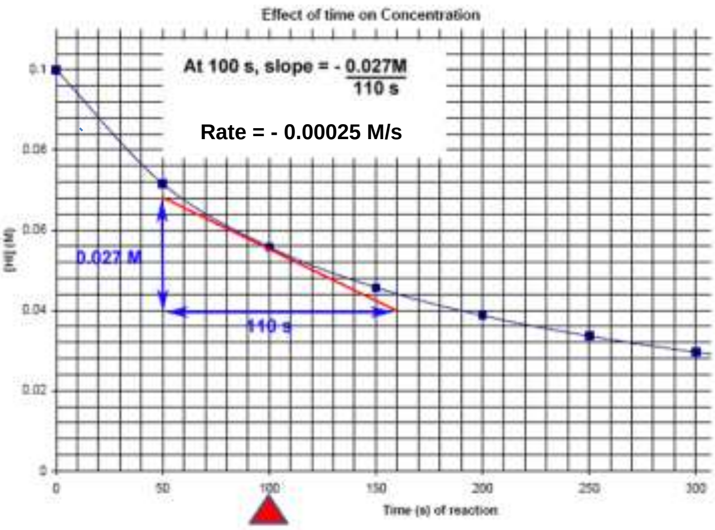
If we want to know the gradient at a particular point, firstly we need to draw a *tangent* to the curve at that point.

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.

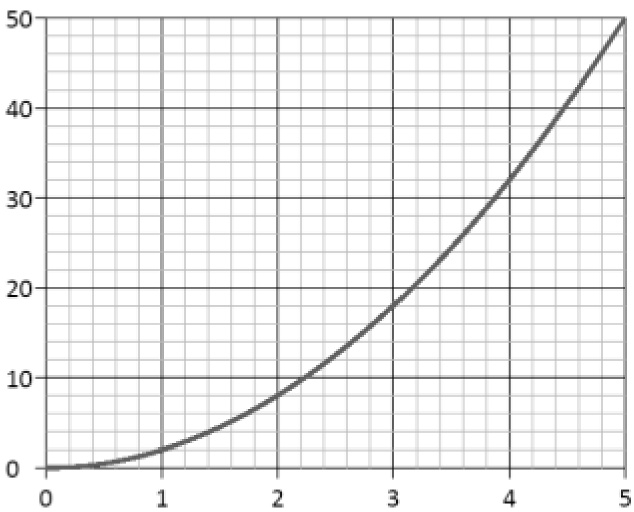
Tip – make sure your tangents and gradient triangles are as big as possible to be as accurate as you can!

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

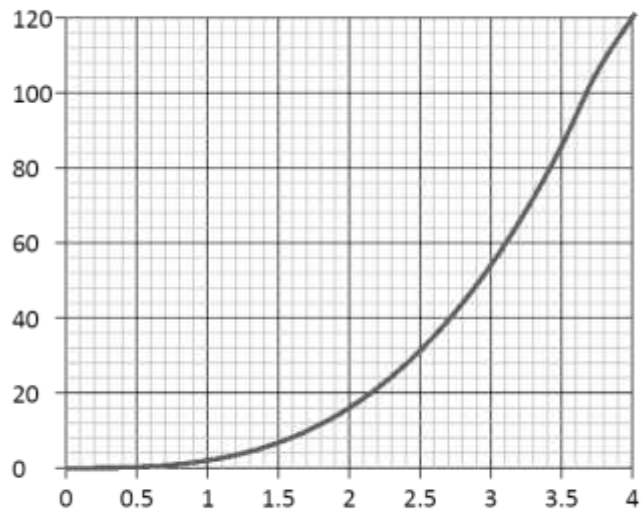




Draw a tangent to the line and calculate its gradient at the following x-axis values:



2.0 and 4.0



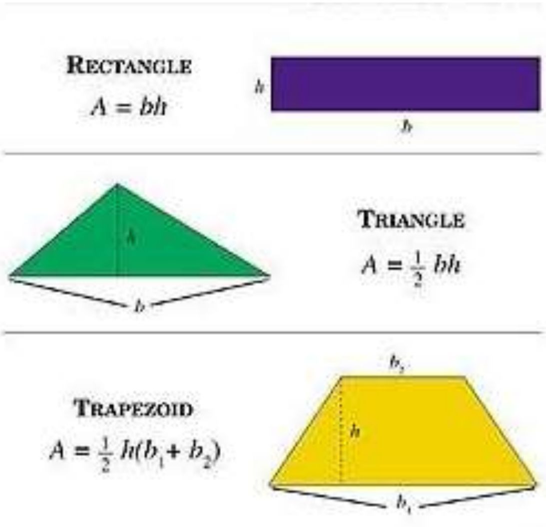
1.5 and 3.5

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

AS Physics	# 9. Calculating Areas – Straight line Graphs
Skills	

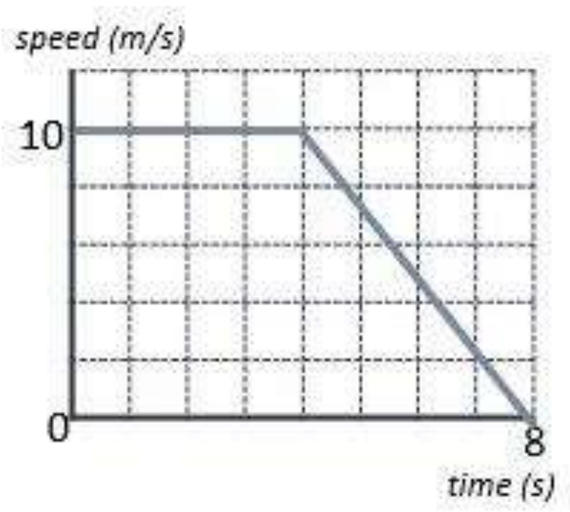
Often other quantities can be found by multiplying the two quantities represented on a graph together (for example, multiplying velocity and time gives distance travelled). The exact quantity can be found by calculating the area under the graph.

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

A

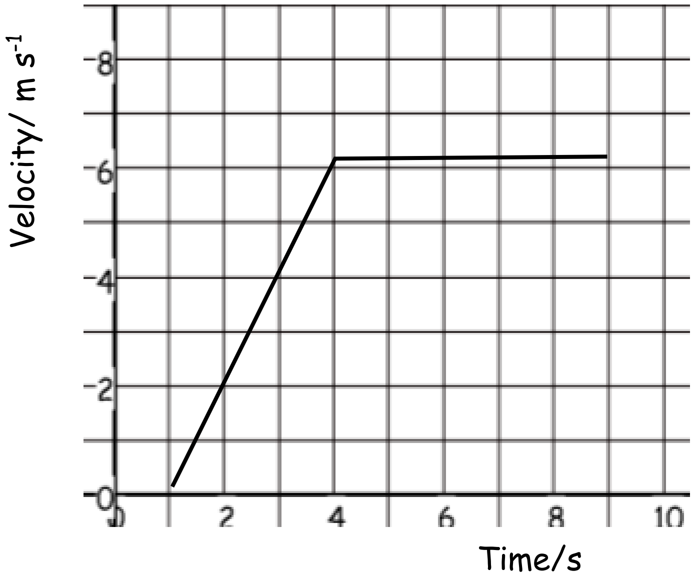
B

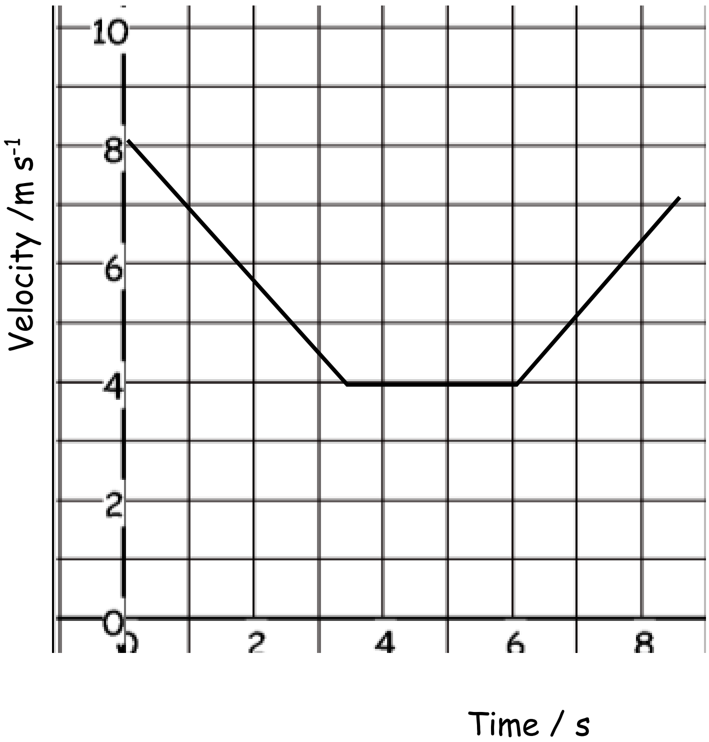
Total Area = A + B = 40 + 20 = **60 m**

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.



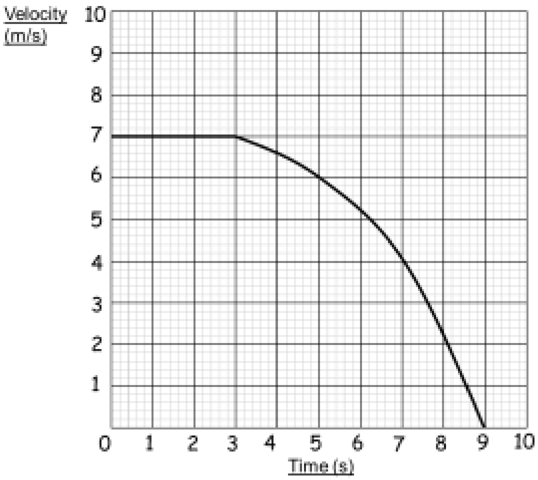


AS Physics	10. Calculating Areas – Curved line Graphs
Skills	

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.

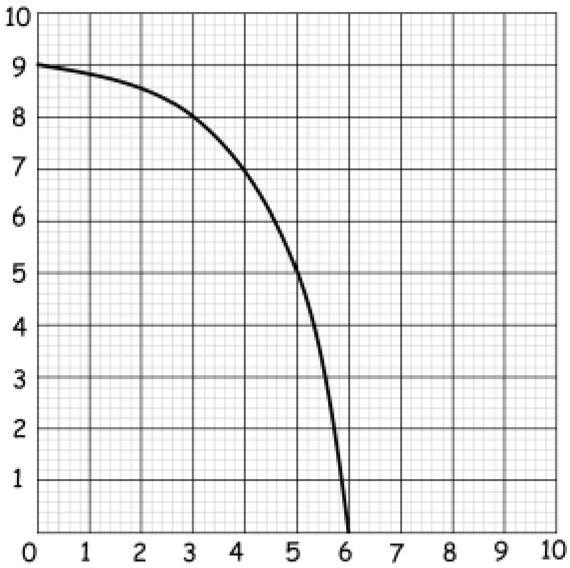
Eg. Work out the distance travelled by calculating the area under the graph.



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 = **48 m**

Calculate the area under the following graphs.

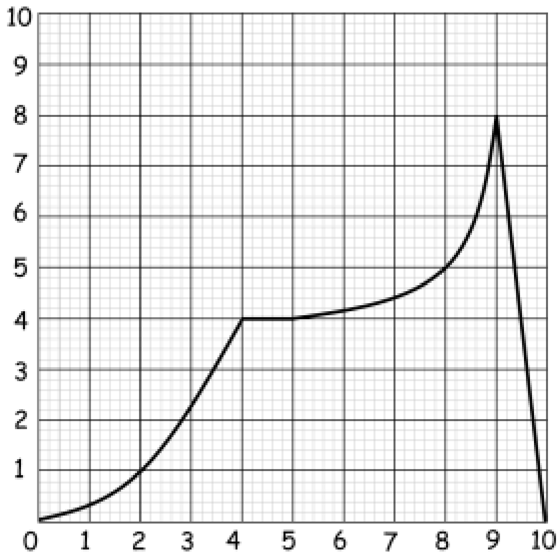
velocity/m s^{-1}



time /s

time /min

velocity/ km s^{-1}



AS Physics	# 10. 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.

AS Physics	# 12. Identifying Errors
Skills	

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.

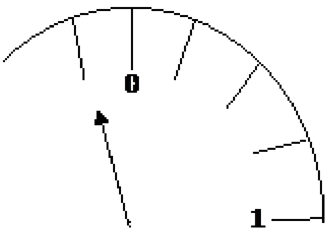
The best way to reduce random error is to use as large values as possible (eg. Large distances) and repeat and average readings, as well as taking precaution when carrying out the experiment.

Systematic errors have occurred when all readings are shifted by the same amount away from the true value.

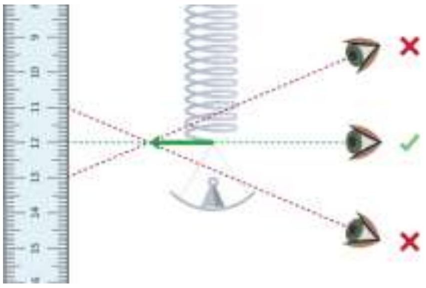
The two main types of systematic error are:

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

Skills

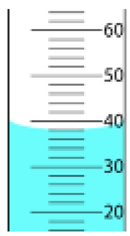
13. Improving Experiments – Accuracy, Resolution and Reliability

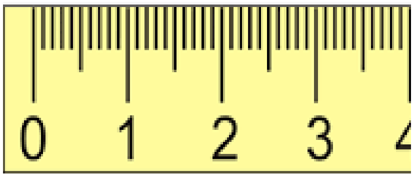
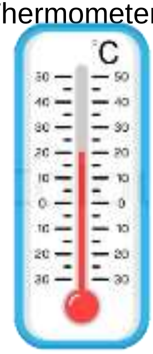
When improving **accuracy**, you must describe how to make sure your *method* obtains the best results possible. You should also try to *use as <u>large quantities</u> as possible as this reduces the percentage error in your results*. Also make your <u>range as large as possible</u>, with <u>small intervals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

Appendix (Practical Endorsement)

Common Practical Assessment Criteria (CPAC)

Common Practical Assessment Criteria (CPAC)		
CPAC 1	Follows written procedures	(a) Correctly follows written instructions to carry out the experimental techniques or procedures.
CPAC 2	Applies investigative approaches and methods when using instruments and equipment	(a) Correctly uses appropriate instrumentation, apparatus and materials (including ICT) to carry out investigative activities, experimental techniques and procedures with minimal assistance or prompting.
		(b) Carries out techniques or procedures methodically, in sequence and in combination, identifying practical issues and making adjustments where necessary.
		(c) Identifies and controls significant quantitative variables where applicable, and plans approaches to take account of variables that cannot readily be controlled.
		(d) Selects appropriate equipment and measurement strategies in order to ensure suitably accurate results.
CPAC 3	Safely uses a range of practical equipment and materials	(a) Identifies hazards and assesses risks associated with those hazards, making safety adjustments as necessary, when carrying out experimental techniques and procedures in the lab or field.
		(b) Uses appropriate safety equipment and approaches to minimise risks with minimal prompting.
CPAC 4	Makes and records observations	(a) Makes accurate observations relevant to the experimental or investigative procedure.
		(b) Obtains accurate, precise and sufficient data for experimental and investigative procedures and records this methodically using appropriate units and conventions.
CPAC 5	Researches, references and reports	(a) Uses appropriate software and/or tools to process data, carry out research and report findings.
		(b) Cites sources of information demonstrating that research has taken place, supporting planning and conclusions.

Required Practical Work.

Year 1
Investigation into the variation of the frequency of stationary waves on a string with length, tension and mass per unit length of the string.
Investigation of interference effects to include the Young's slit experiment and interference by a diffraction grating.
Determination of g by a free-fall method.
Determination of the Young modulus by a simple method.
Determination of resistivity of a wire using a micrometer, ammeter and voltmeter.
Investigation of the emf and internal resistance of electric cells and batteries by measuring the variation of the terminal pd of the cell with current in it
Year 2
Investigation into simple harmonic motion using a mass-spring system and a simple pendulum.
Investigation of Boyle's (constant temperature) law and Charles's (constant pressure) law for a gas.
Investigation of the charge and discharge of capacitors. Analysis techniques should include log-linear plotting leading to a determination of the time constant *RC*.
Investigate how the force on a wire varies with flux density, current and length of wire using a top pan balance.
Investigate, using a search coil and oscilloscope, the effect on magnetic flux linkage of varying the angle between a search coil and magnetic field direction.
Investigation of the inverse-square law for gamma radiation.