Introduction to A Level Physics
Induction Booklet

Department of Physics

The Burgate School and Sixth Form

"Know how to solve every problem that has been solved."

\- Feynman

Contents

You're studying A Level Physics, congratulations!

Welcome to A Level Physics!

Physics is a challenging but hugely rewarding subject to study at A level. Throughout the course you will have the opportunity to revisit GCSE topics but in far greater depth, as well as looking at completely new areas of physics, ranging from fundamental particles to space physics and everything in between. You will constantly need to apply your knowledge and skills to unfamiliar situations as you solve problems and learn more about the world around you.

Whilst A level maths is not compulsory, mathematics is the language of physics and therefore you should expect the level of maths to be higher than at GCSE.

The aim of this booklet is to help prepare you for studying Physics at A level. It contains details about the course you will be studying, as well as additional information and links to useful resources.

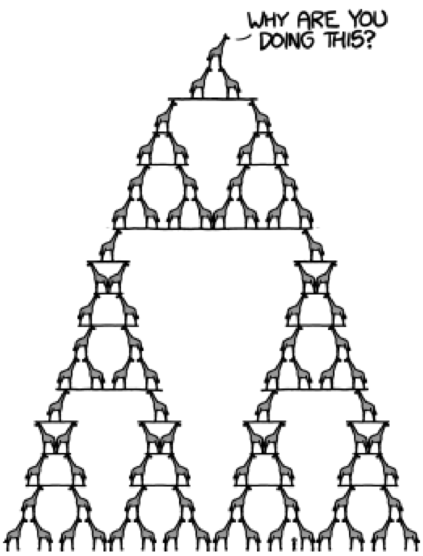
The transition activities are intended to give you practice at the sorts of skills that you need on the A level physics course. Please complete the tasks before the start of term and bring the completed booklet to your first Physics lesson.

Even more important are the suggestions in the final section, 'Resources that can help you become a better physicist'. If you have anything that you think ought to be added to the lists, let me know.

As a department we look forward to meeting you and supporting you as you make the transition from GCSE to A level and throughout the course to ensure you achieve your full potential.

See you in September,

Dr G Hobbs
Head of A Level Physics
The Burgate School and Sixth Form



Why study A Level Physics?

Through their study of matter, energy and their interactions, physicists explore the fundamental nature of almost everything we know of. During your A level Physics course you will study a range of topics, from the fundamental particles that are the building blocks of matter to the stars and galaxies that make up the entire universe, and everything in between.

Even if you choose not to study physics beyond A level, or use the knowledge you have gained directly, you will have developed a range of transferrable skills. The ability to research, problem-solve, think logically and analytically, communicate difficult concepts effectively, work as part of a team and manage your time are all highly valued by universities and employers. For this reason, A level Physics is a great choice for those of you who don't yet know what you would like to do after A level.

Possible degree options

Students who study Physics at A level go on to study a wide range of courses at degree level including:

- Physics
- Mathematics
- Mechanical engineering
- Computer science
- Civil engineering
- Economics
- Business

For more information please visit **https://www.ucas.com/**

Future careers

Studying Physics at A level or degree level opens a wide range of potential career opportunities.

- Engineering
- Architect
- Medical physicist or healthcare scientist
- Theoretical physicist
- Higher education lecturer or secondary school teacher
- Research scientist
- Radiation protection practitioner
- Research scientist
- Meteorologist
- Astrophysics
- Chemical physics
- Renewable energy sector
- Computer programmer

For more information please visit **http://www.physics.org/careers.asp?contentid=381**

Specification at a glance

You will study the OCR Physics A specification (H556) which includes six modules, divided into key topics.

Module 1: Development of practical skills in physics

- Practical skills assessed in a written examination
- Practical skills assessed in the practical endorsement

Module 2: Foundations in physics

- Physical quantities and units
- Making measurements and analysing data
- Nature of quantities

Module 3: Forces and motion

- Motion
- Forces in action
- Work, energy and power
- Materials
- Newton's laws of motion and momentum

Module 4: Electrons, waves and photons

- Charge and current
- Energy, power and resistance
- Electrical circuits
- Waves
- Quantum physics

Module 5: Newtonian world and astrophysics

- Thermal physics
- Circular motion
- Oscillations
- Gravitational fields
- Astrophysics and cosmology

Module 6: Particles and medical physics

- Capacitors
- Electric fields
- Electromagnetism
- Nuclear and particle physics
- Medical imaging

Practical skills endorsement

You will also gain practical skills that are assessed in written papers and as part of the practical skills endorsement. This is an additional qualification that certifies that you have developed the relevant practical skills through completion of a minimum of 12 practical investigations throughout the course. They are like the required practical activities at GCSE, but unlike those must be completed in order to pass the course. You will need to keep clear records of your work and results in order to provide the necessary evidence for your teachers and any external moderators.

Assessment at A level

You will sit three external exams at the end of the two-year A level course. The first two examine different module, whilst the third is a synoptic paper with questions on all modules from the course.

Component	Marks	Duration	Weighting
Modelling Physics (01) Assesses content from modules 1, 2, 3 and 5	100	2 hours 15 mins	37%
Exploring physics Assesses content from modules 1, 2, 4 and 6	100	2 hours 15 mins	37%
Unified physics (03) Assesses content from all modules (1 to 6)	70	1 hour 30 mins	26%
Practical endorsement in physics (04) Non-exam assessment	-	-	-

Useful information

The OCR website contains information on:

- the OCR Physics A exam specification which explains everything you need to know.
  https://www.ocr.org.uk/qualifications/as-and-a-level/physics-a-h156-h556-from-2015/specification-at-a-glance/

- OCR Physics A past paper questions and mark schemes.
  https://www.ocr.org.uk/qualifications/past-paper-finder/

- The practical skills handbook containing information and guidance on the practical work you need to know.
  https://pdf.ocr.org.uk/Images/295483-practical-skills-handbook.pdf

- The mathematical skills handbook containing information and guidance on the maths skills you will need to know.
  https://pdf.ocr.org.uk/Images/295471-mathematical-skills-handbook.pdf

- The OCR Physics A data, formulae and relationships booklet as you will not need to memorise formula at A level.
  https://www.physicstutoronline.co.uk/wp-content/uploads/2019/05/OCR-A-PHYSICS-AS-AND-A-LEVEL-363796-units-h156-and-h556-data-formulae-and-relationships-booklet.pdf

- Greek letters are often used in science as symbols for numbers, quantities or prefixes.

  The Greek alphabet is shown below.

Uppercase	Lowercase	Name
Α	α	Alpha
Β	β	Beta
Γ	γ	Gamma
Δ	δ	Delta
Ε	ε	Epsilon
Ζ	ζ	Zeta
Η	η	Eta
Θ	ο	Theta
Ι	ι	Iota
Κ	κ	Kappa
Λ	λ	Lambda
Μ	μ	Mu

Uppercase	Lowercase	Name
Ν	ν	Nu
Ξ	ξ	Ksi
Ο	ο	Omicron
Π	π	Pi
Ρ	ρ	Rho
Σ	σ	Sigma
Τ	τ	Tau
Υ	υ	Upsilon
Φ	ϕ	Phi
Χ	χ	Chi
Ψ	ψ	Psi
Ω	ω	Omega

Transition activities

The activities below are designed to highlight just some of the core knowledge and skills you will need to apply when studying A level Physics.

It is recommended you complete these to help prepare for the start of your A level physics course.

Answers can be found in the appendix at the end of the booklet.

Prefixes and units

One of the highest jumps between GCSE and A level Physics is the way things are written down. At A level you are expected to start using standard scientific notation.

Standard notation means:

- using the conventional symbols for quantities
- writing all quantities in terms of SI units (Système International)
- writing very large and very small numbers in standard form (e.g. 10^{-6} instead of 0.000001)

You will need to have memorised the unit prefixes shown in the table on the right – they are used in exams and it is assumed that you know what they mean.

multiple	prefix	symbol
10^{12}	tera-	T
10^{9}	giga-	G
10^{6}	mega-	M
10^{3}	kilo-	k
10^{-3}	milli-	m
10^{-6}	micro-	μ
10^{-9}	nano-	n
10^{-12}	pico-	p

You'll also encounter non-standard units in the physics course itself – megaparsecs, electronvolts and a.m.u. for example.

In the following ten pairs of quantities, circle the quantity which is greater.

a. 12 mW or 12 MW

b. 3.0 μs or 3.0 ns

c. 27 kV or 27 GV

d. 6 pm or 6 μm

e. 1024 TW or 1024 GW

f. 22×10^{-2} Ω or 220 Ω

g. 300 kg or 3×10^{3} kg

h. 121 kN or 0.0121×10^{6} N

i. 30×10^{-6} F or 0.003 pF

j. 14000 MHz or 1.4×10^{9} Hz

When you write out the name of a unit in full it is always written completely in lower case letters. For example: the unit of power is the watt (symbol W). In the box above, next to each question write the full name of the SI unit in the question. Bonus points if you find out why some symbols are written using upper case (e.g. N) whereas other unit symbols are written using lower case (e.g. s).

You must bring a working scientific calculator to all your physics lessons and exams. Your calculator has a button that says $\boxed{\text{ENG}}$. Find out what this button does, and why it will be useful to you on your physics course. Describe the function and usefulness in the space below.

Convert the figures into the units required.

6 km	=	6 x 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 x 10^9	V
	µA	=	0.5 x 10^{-6}	A
	Gm	=	93.09 x 10^9	m
	kN	=	32 x 10^5	N
	nm	=	0.024 x 10^{-7}	m

Convert the figures into the prefixes required.

s	**ms**	**µs**	**ns**	**ps**
0.00045	0.45	450	450 000 or 450 x10^3	450 x 10^6
0.000000789				
0.000 000 000 64				

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

Significant figures

1. **All non-zero numbers ARE significant.** The number 33.2 has THREE significant figures because all 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.
6. **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		

Vectors quantities

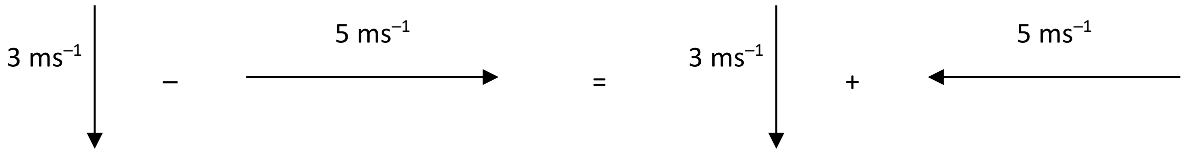
You should already know that a quantity like speed only has a size (e.g. 13 ms^{-1}), but there is another type of quantity (called a vector) that has a size and direction, e.g. a velocity of 13 ms^{-1} *to the left*. You can represent velocities with arrows – the longer the arrow the greater the size (speed) of the velocity.

At A level you will become proficient at working in more than one dimension, and in order to do this you will need to master vectors. For example, the formula for working out the change in velocity looks simple enough:

change in velocity (ms^{-1}) = final velocity (ms^{-1}) – initial velocity (ms^{-1})

However, you can't just subtract one speed from the other – you must account for the directions of the two velocities.

Example: find the magnitude (size) of the change in velocity if you have an initial velocity of 5 ms^{-1} to the right and a final velocity of 3 ms^{-1} downwards.



Δv is the <u>change in velocity</u>.

You find Δv by reversing the arrow for the intial velocity and adding this new arrow to the final velocity.

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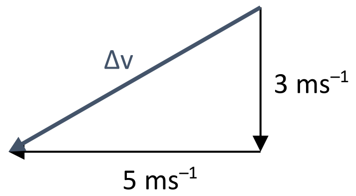


Either by measuring from a scale drawing, or by using Pythagoras' theorem, the answer is **Δv = 5.8 ms^{-1}**.

Have a go at finding the changes in velocity in these two cases:

a. initial velocity = 4 ms^{-1} upwards;
final velocity = 4 ms^{-1} to the right

b. initial velocity = 3 ms^{-1} down;
final velocity = 4 ms^{-1} to the left.

Rearranging equations

It is vital that you can rearrange the many equations you will need to apply at A level.

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	

Using equations

As well as rearranging equations you will need to be able to apply them to calculate quantities to an appropriate number of significant figures with correct units.

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 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.

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

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 300×10^{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.

Forces stretch things, squash things and twist things. When we consider things as whole objects ("bodies" in physics language) then Newton's Second Law of Motion deals with the way that forces make bodies go faster, slower or change direction. The resultant force acting on a body makes it accelerate, and the size of the acceleration is directly proportional to the size of the force.

resultant force (N) = mass of body (kg) × acceleration (ms^{-2})

or, in symbols

F = m a

Example: A car of mass 1000 kg accelerates uniformly from rest at a rate of 0.75 ms^{-2}. What is the size of the resultant force accelerating it?

Solution: F = m a = 1000 kg × 0.75 ms^{-2} = 750 N

Answer the following in the spaces provided:

a. A bus of mass 10000 kg accelerates at 0.25 ms^{-2}. What is the resultant force acting on it?

b. A car pulls a caravan of mass 800 kg. If it accelerates at 0.4 ms^{-2}, what force must the caravan experience?

Example: What would the acceleration of a 0.5 kg body be if a force of 10 N acted on it?

Solution: F = ma. Dividing both sides by m gives F/m = a, so a=F / m = 10 N /0.5 kg = 20 ms^{-2}.

Answer the following in the spaces provided:

a. What would be the initial acceleration of an arrow of mass 0.3 kg shot from a bow if the force from the bow-string is 200 N?

b. What would be the acceleration of a train of mass 10^4 kg if the force form the engine is 8kN?

Example: What is the mass of a body if a force of 250 N produces an acceleration of 2 ms^{-2}?

Solution: F = ma. Dividing both sides by a gives F/a = m, so m = F/a = 250 N / 2 ms^{-2} = 125 kg

Answer the following in the spaces provided:

a. What is the mass of a sailing boat if a force of 120 N produces an acceleration of 0.5 ms^{-2}?

b. What is the mass of an electron if a force of 1.8×10^{-14} N produces an acceleration of 2.0×10^{16} ms^{-2}?

Variables

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: ______________________________

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. 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 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.

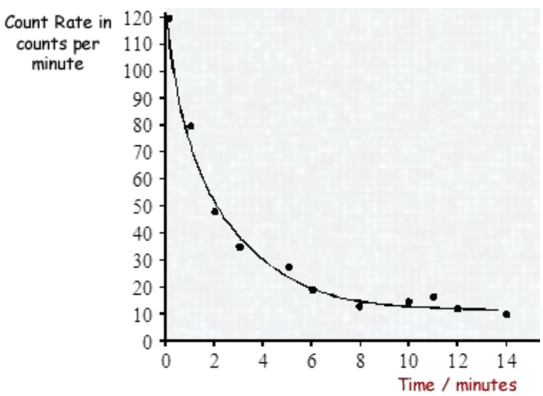
Drawing lines of best fit

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."

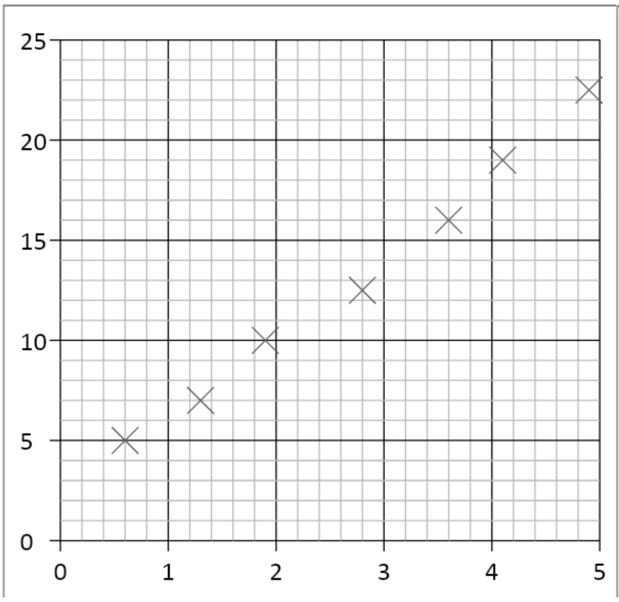
Substitute the quantities into X and Y, and choose either of the two options to describe the graph.



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).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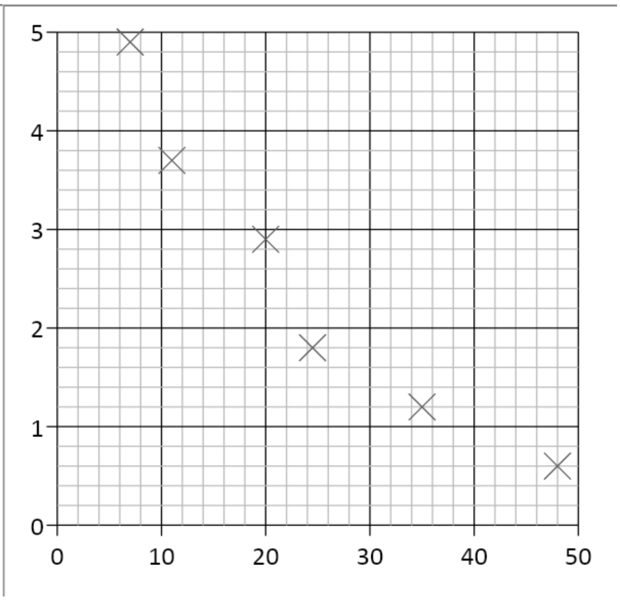
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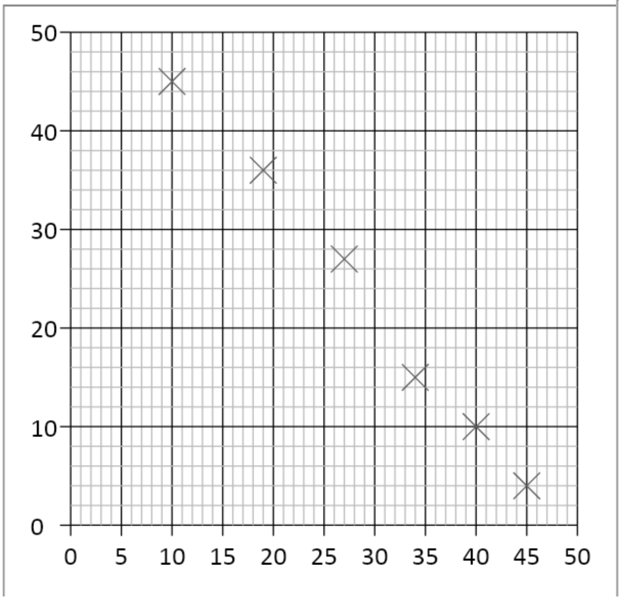
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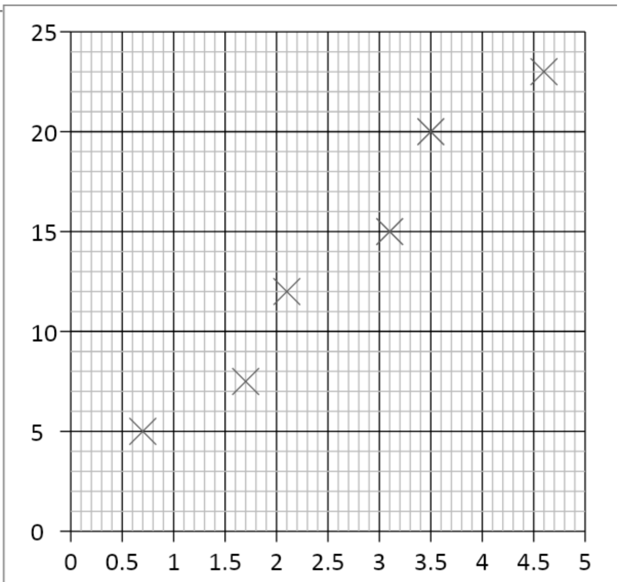
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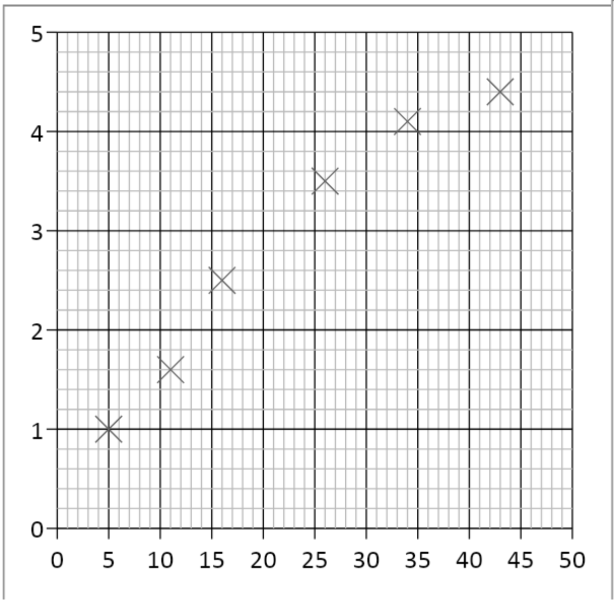
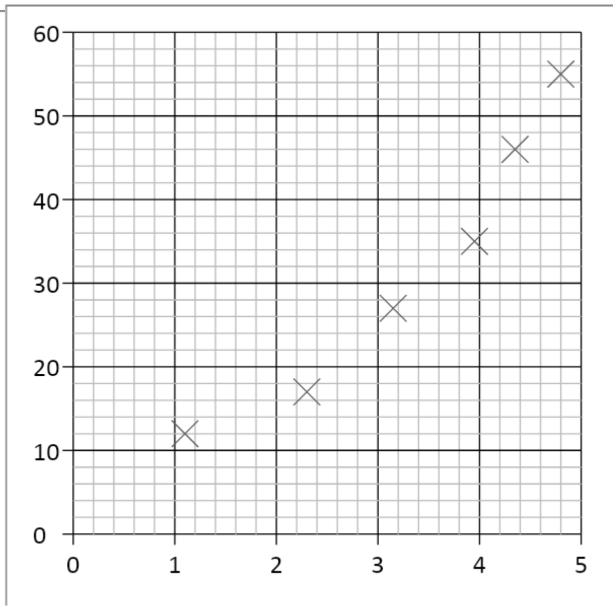




5. **6.**

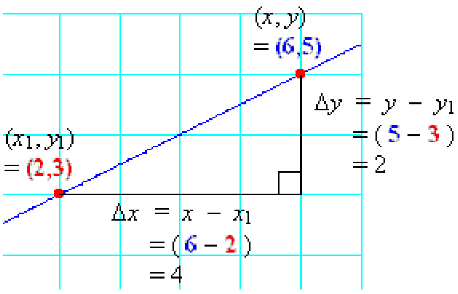
Calculating gradients

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.

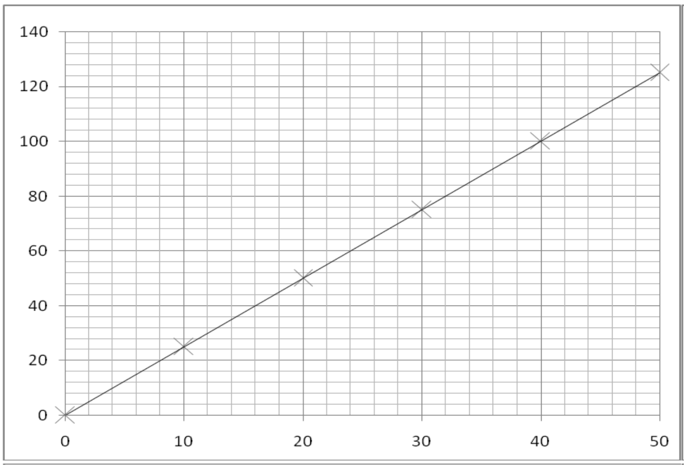


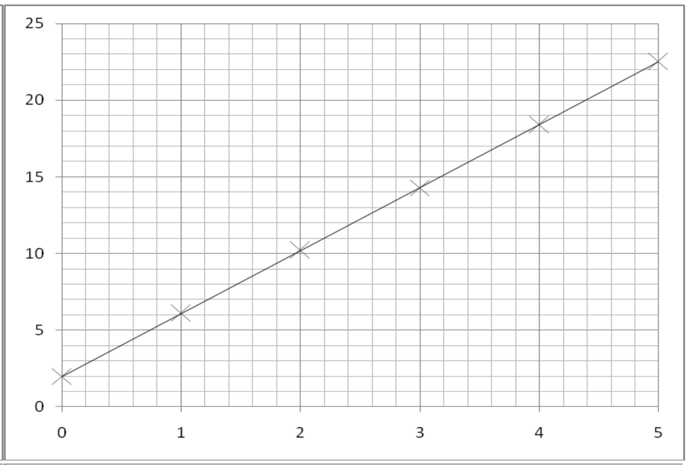
$$Gradient = \frac{difference\ in\ y}{difference\ in\ x}$$

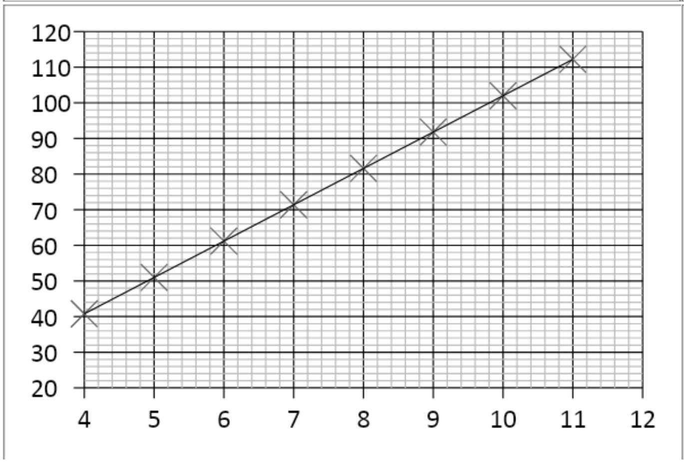
$$= \frac{2}{4}$$

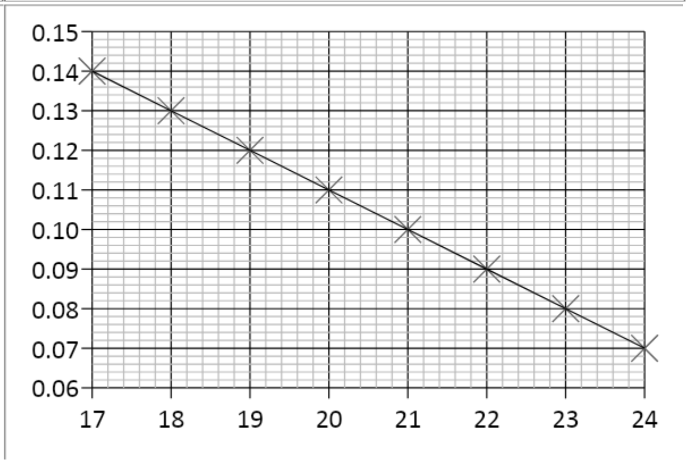
$$\underline{\boldsymbol{= 0.5}}$$

Calculate the gradients of the graphs below







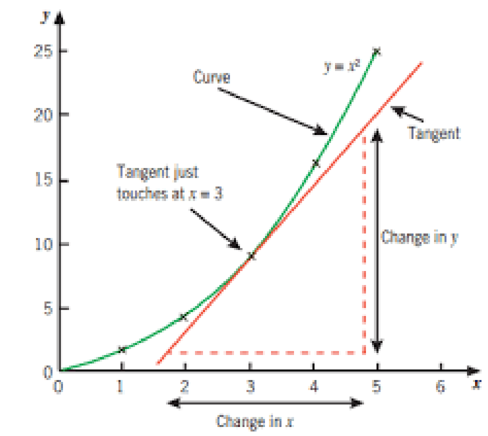


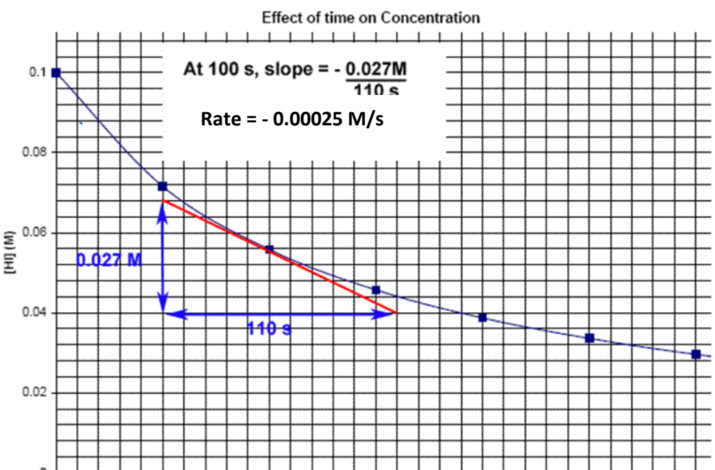
Most graphs in real life are not straight lines, but curves; however, it is still useful to know how the quantity changes over time, hence we still need to calculate gradients.

If we want to know the gradient at a 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 the same way as the previous page showed.

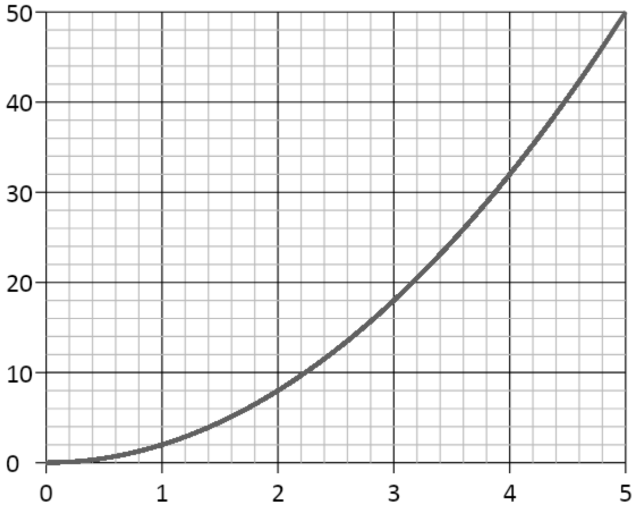
Tip – make sure your tangents and gradient triangles are as big as possible to be as accurate as you can!

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

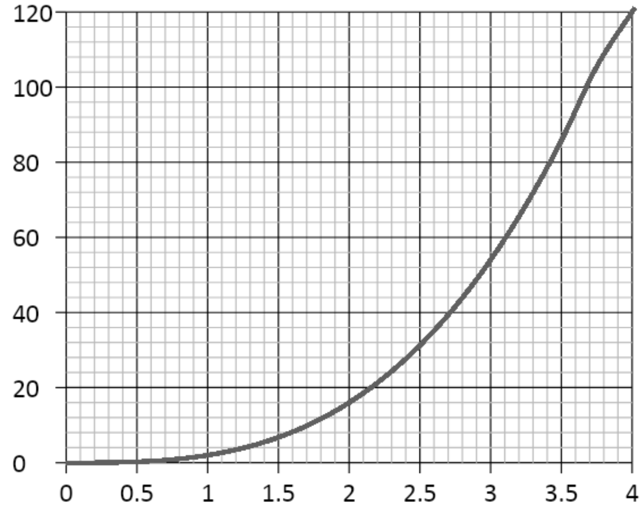




Draw a tangent to the line and calculate its gradient at the following x-axis values:



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)

Resources that can help you become a better physicist

Join the Institute of Physics (IOP)

It is completely free for A-level students, although if you want to receive paper copies of the monthly 'Physics World' magazine then there is an annual fee. The IOP carry out research as well as producing resources for students at GCSE and A level.

http://www.iop.org/tailored/students/

Read books

It will help to stand back and see physics in its wider context and to look in more detail at some areas of physics that you may currently know very little about. The books highlighted in bold would be the easiest way to do this. The books are written at a level that assumes very little about your prior subject knowledge but reading them will stretch you into areas that go beyond university level. The other books are also highly recommended.

- ***A Short History of Nearly Everything* by Bill Bryson**
- ***Big Bang: The Most Important Scientific Discovery of All Time and Why You Need to Know About It* by Simon Singh**
- ***What If?: Serious Scientific Answers to Absurd Hypothetical Questions* by Randall Munroe**
- *A Brief History of Time* by Stephen Hawking
- *The Universe in a Nutshell* by Stephen Hawking
- *The Making of the Atomic Bomb* by Richard Rhodes
- *Carrying the Fire: An Astronaut's Journeys* by Michael Collins (the Apollo 11 astronaut).
- *13 Things That Don't Make Sense: The Most Intriguing Scientific Mysteries of Our Time* by Michael Brooks
- *Six Easy Pieces: Fundamentals of Physics Explained* by Richard P Feynman (or any other book by the same author)

Watch online videos

- Watch any or all of the "Schools Lecture series" videos made by the Institute of Physics. Don't be put off by the title – they are all presented by experts in physics at the right kind of level, and the topics covered will really help you understand some of the details of the A level course. The link is: **http://www.iop.org/resources/videos/education/**

- There are huge numbers of physics videos online. Some highly recommended are – Minute Physics - **http://www.youtube.com/user/minutephysics**
  Veritasium - **https://www.youtube.com/user/1veritasium**

Sixty Symbols - **https://www.youtube.com/user/sixtysymbols**

- Richard Feynman's "**Messenger Lectures**" on physics, archived with transcripts on Microsoft's Project Tuva website. **http://research.microsoft.com/apps/tools/tuva/**

Watch television programmes

Channels on Freeview such as BBC2, BBC4, Quest and Dave often include science based programmes. Specific programmes to look out for are:

- **Mythbusters** (on Quest, but also on cable and satellite channels) – Arguably the best show about scientific investigation, with added rockets! Watch it.
- **The Sky at Night** (BBC4) – longest running science TV programme in the universe, everything current in space and astronomy with proper experts.
- **Horizon** (BBC2 and BBC4) – topical science documentary, often physics-based. A bit wooly sometimes, but there have been interesting ones about neutrinos, time, black holes, etc.

Listen to audio

Mainly BBC Radio 4 broadcasts / iplayer / podcasts. Usually archived so they don't expire! These are in order, starting with the most relevant...

- **In Our Time** - Melvyn Bragg and guests discuss the history of ideas. Vast archive going back years, and more being added all the time. Examples of relevant episodes: The Age of the Universe, Radiation, The Vacuum of Space, The Measurement Problem in Physics, The Multiverse, Gravitational Waves, The Speed of Light...

- **The Life Scientific** - Professor Jim Al-Khalili talks to leading scientists about their life and work, finding out what inspires and motivates them and asking what their discoveries might do for mankind. Many episodes available on iplayer.
- **The Infinite Monkey Cage** – science/maths-based comedy discussion series presented by Brian Cox and Robin Ince.

Get busy with your devices

- **SETI@home** is a scientific experiment that uses Internet-connected computers in the Search for Extra-terrestrial Intelligence (SETI). You can participate by running a free program that downloads and analyses radio telescope data.
http://setiathome.berkeley.edu/

- **Asteroid watch.** Search for Near Earth Objects (i.e. asteroids) in observations that have been taken and report back their positions. **http://www.schoolsobservatory.org.uk/activ/asteroidwatch**

- **Galaxy zoo.** To understand how galaxies, and our own, formed we need your help to classify them according to their shapes — a task at which your brain is better than even the most advanced computer. If you're quick, you may even be the first person in history to see each of the galaxies you're asked to classify. **http://www.galaxyzoo.org/**

- **Zooniverse**. Many other projects like galaxy zoo: solar storm watch, planet hunters, the Milky Way project.
  https://www.zooniverse.org/

- **PhET interactive simulations**. Fun, interactive, research-based simulations of physical phenomena from the PhET project at the University of Colorado. This site will be used again and again during your A level course.
  http://phet.colorado.edu/

Follow physicists on Twitter

- Brian Cox (@ProfBrianCox)
- Jim Al-Khalili (@jimalkhalili)
- Andy Newsam (@AstroAndyN)
- Michio Kaku (@michiokaku)

Read magazines

- **New Scientist** is the big one.

Answers to transition activities

Prefixes and units

In the following ten pairs of quantities, circle the quantity which is greater.

a. 12 mW or **12 MW**

b. **3.0 µs** or 3.0 ns

c. 27 kV or **27 GV**

d. 6 pm or **6 µm**

e. **1024 TW** or 1024 GW

f. 22×10^{-2} Ω or **220 Ω**

g. 300 kg or **3×10^{3} kg**

h. **121 kN** or 0.0121×10^{6} N

i. **30×10^{-6} F** or 0.003 pF

j. **14000 MHz** or 1.4×10^{9} Hz

6 km	=	6×10^{3}	m
54 MN	=	**5.4×10^{7}**	N
0.086 µV	=	**8.6×10^{-8}**	V
753 GPa	=	**7.53×10^{11}**	Pa
23.87 mm/s	=	**2.287×10^{-2}**	m/s

640	GV	=	640×10^{9}	V
0.5	µA	=	0.5×10^{-6}	A
93.09	Gm	=	93.09×10^{9}	m
3,200	kN	=	32×10^{5}	N
2.4	nm	=	0.024×10^{-7}	m

s	ms	µs	ns	ps
0.00045	0.45	450	450 000 or 450×10^{3}	450×10^{6}
0.000000789	**0.000789**	**0.789**	**789**	**789×10^{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**

Significant figures

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

Vector quantities

Have a go at finding the changes in velocity in these two cases:

a. initial velocity = 4 ms^{-1} upwards;
final velocity = 4 ms^{-1} to the right

Using Pythagoras' theorem:

$$\Delta v = \sqrt{4^2 + 4^2}$$

$$\Delta v = 5.7 ms^{-1}$$

b. initial velocity = 3 ms^{-1} down;
final velocity = 4 ms^{-1} to the left.

Using Pythagoras' theorem:

$$\Delta v = \sqrt{3^2 + 4^2}$$

$$\Delta v = 5 \ ms^{-1}$$

Rearranging equations

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

$u = 2s/t - v$ $f = (\Phi + E_K)/h$ $g = E_P / mh$ $F = 2E/e$

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

Using equations

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

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

Answer the following in the spaces provided:

c. A bus of mass 10000 kg accelerates at 0.25 ms^{-2}. What is the resultant force acting on it?

F = m a = 10000 kg x 0.25 ms^{-2} = 2500 N = 2.5 x 10^{3}- N = 2.5 kN

d. A car pulls a caravan of mass 800 kg. If it accelerates at 0.4 ms^{-2}, what force must the caravan experience?

F = m a = 800 kg x 0.4ms^{-2} = 320 N = 0.32 kN

Example: What would the acceleration of a 0.5 kg body be if a force of 10 N acted on it?

Solution: F = ma. Dividing both sides by m gives F/m = a, so a=F / m = 10 N /0.5 kg = 20 ms^{-2}.

Answer the following in the spaces provided:

c. What would be the initial acceleration of an arrow of mass 0.3 kg shot from a bow if the force from the bow-string is 200 N?

a = F / m = 200 N / 0.3 kg = 666.666… ms^{-2} = 670 ms^{-2} (to 2 sig. figs)

d. What would be the acceleration of a train of mass 10^4 kg if the force form the engine is 8kN?

a = F / m = 8 kN / 10^4 kg = 8,000 N / 10,000 kg = 0.8 ms^{-2}

Example: What is the mass of a body if a force of 250 N produces an acceleration of 2 ms^{-2}?

Solution: F = ma. Dividing both sides by a gives F/a = m, so m = F/a = 250 N / 2 ms^{-2} = 125 kg

Answer the following in the spaces provided:

c. What is the mass of a sailing boat if a force of 120 N produces an acceleration of 0.5 ms^{-2}?

m = F / a = 120 N / 0.5 ms^{-2} = 240 kg

d. What is the mass of an electron if a force of 1.8×10^{-14} N produces an acceleration of 2.0×10^{16} ms^{-2}?

m = F / a = 1.8 x 10^{-14-} N / 2.0 x 10^{16} ms^{-2} = 9 x 10^{-31} kg

Variables

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

Constructing tables of results

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

Drawing lines of best fit

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.

Calculating gradients

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

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