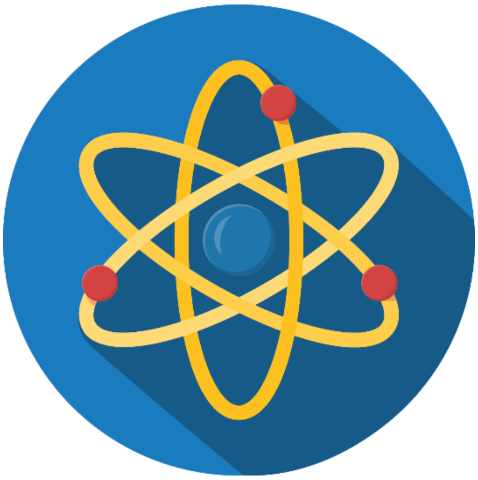
A Level Physics Summer Transition Pack

For students transitioning from GCSE to A Level Physics (Year 11- Year 12)



Objectives of this Pack:

This summer work pack is designed to:

- Refresh and strengthen key GCSE Physics concepts that underpin A Level content
- Introduce new ideas you'll encounter in Year 12
- Develop problem-solving, mathematical and analytical skills
- Encourage independent learning and curiosity

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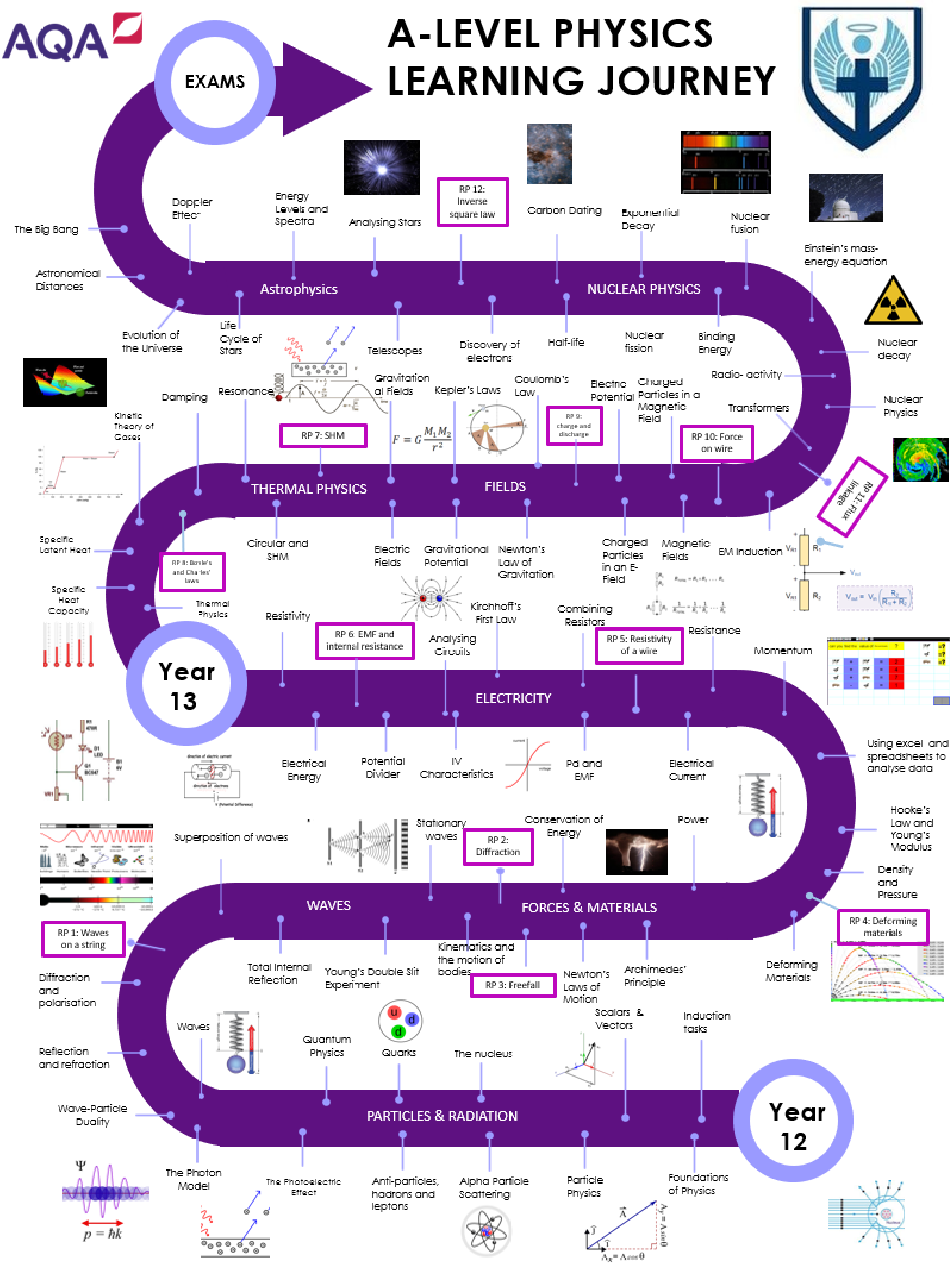
This work is compulsory. You must complete it over the summer and submit it in your first Physics lesson in September. Along with your suitability test, this will determine whether you are ready to continue A Level Physics.

A-LEVEL PHYSICS LEARNING JOURNEY



A-level Physics data and formulae

For use in exams from the June 2017 Series onwards

DATA – FUNDAMENTAL CONSTANTS AND VALUES

Quantity	Symbol	Value	Units
speed of light in vacuo	c	3.00×10^{8}	$\mathrm{m\,s^{-1}}$
permeability of free space	μ_0	$4\pi \times 10^{-7}$	$\mathrm{H\,m^{-1}}$
permittivity of free space	ε_0	8.85×10^{-12}	$\mathrm{F\,m^{-1}}$
magnitude of the charge of electron	e	1.60×10^{-19}	C
the Planck constant	h	6.63×10^{-34}	$\mathrm{J\,s}$
gravitational constant	G	6.67×10^{-11}	$\mathrm{N\,m^{2}\,kg^{-2}}$
the Avogadro constant	N_A	6.02×10^{23}	$\mathrm{mol^{-1}}$
molar gas constant	R	8.31	$\mathrm{J\,K^{-1}\,mol^{-1}}$
the Boltzmann constant	k	1.38×10^{-23}	$\mathrm{J\,K^{-1}}$
the Stefan constant	σ	5.67×10^{-8}	$\mathrm{W\,m^{-2}\,K^{-4}}$
the Wien constant	α	2.90×10^{-3}	$\mathrm{m\,K}$
electron rest mass (equivalent to 5.5×10^{-4} u)	m_e	9.11×10^{-31}	kg
electron charge/mass ratio	$\frac{e}{m_\mathrm{e}}$	1.76×10^{11}	$\mathrm{C\,kg^{-1}}$
proton rest mass (equivalent to 1.00728 u)	m_p	$1.67(3) \times 10^{-27}$	kg
proton charge/mass ratio	$\frac{e}{m_\mathrm{p}}$	9.58×10^{7}	$\mathrm{C\,kg^{-1}}$
neutron rest mass (equivalent to 1.00867 u)	m_n	$1.67(5) \times 10^{-27}$	kg
gravitational field strength	g	9.81	$\mathrm{N\,kg^{-1}}$
acceleration due to gravity	g	9.81	$\mathrm{m\,s^{-2}}$
atomic mass unit (1u is equivalent to 931.5 MeV)	u	1.661×10^{-27}	kg

ALGEBRAIC EQUATION

quadratic equation $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

ASTRONOMICAL DATA

Body	Mass/kg	Mean radius/m
Sun	1.99×10^{30}	6.96×10^{8}
Earth	5.97×10^{24}	6.37×10^{6}

GEOMETRICAL EQUATIONS

arc length	$= r\theta$
circumference of circle	$= 2\pi r$
area of circle	$= \pi r^2$
curved surface area of cylinder	$= 2\pi rh$
area of sphere	$= 4\pi r^2$
volume of sphere	$= \frac{4}{3}\pi r^3$

Particle Physics

Class	Name	Symbol	Rest energy/MeV
photon	photon	γ	0
lepton	neutrino	ν_e	0
		ν_μ	0
	electron	$e^\pm$	0.510999
	muon	$\mu^\pm$	105.659
mesons	π meson	$\pi^\pm$	139.576
		π^0	134.972
	K meson	$K^\pm$	493.821
		K^0	497.762
baryons	proton	p	938.257
	neutron	n	939.551

Properties of quarks

antiquarks have opposite signs

Type	Charge	Baryon number	Strangeness
u	$+\frac{2}{3}e$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}e$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}e$	$+\frac{1}{3}$	-1

Properties of Leptons

		Lepton number
Particles:	e^-, ν_e ; μ^-, ν_μ	$+1$
Antiparticles:	e^+, $\overline{\nu_e}$, μ^+, $\overline{\nu_\mu}$	-1

Photons and energy levels

photon energy $E = hf = \frac{hc}{\lambda}$

photoelectricity $hf = \phi + E_{k\,(max)}$

energy levels $hf = E_1 - E_2$

de Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

Waves

wave speed $c = f\lambda$ *period* $f = \frac{1}{T}$

first harmonic $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

fringe spacing $w = \frac{\lambda D}{s}$ *diffraction grating* $d \sin\theta = n\lambda$

refractive index of a substance s, $n = \frac{c}{c_s}$

for two different substances of refractive indices n_1 *and* n_2,

law of refraction $n_1 \sin\theta_1 = n_2 \sin\theta_2$

critical angle $\sin\theta_c = \frac{n_2}{n_1}$ for $n_1 > n_2$

Mechanics

moments moment $= Fd$

velocity and acceleration $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

equations of motion $v = u + at$ $s = \left(\frac{u+v}{2}\right)t$

$v^2 = u^2 + 2as$ $s = ut + \frac{at^2}{2}$

force $F = ma$

force $F = \frac{\Delta(mv)}{\Delta t}$

impulse $F\,\Delta t = \Delta(mv)$

work, energy and power $W = F\,s\cos\theta$

$E_k = \frac{1}{2}m\,v^2$ $\Delta E_p = mg\Delta h$

$P = \frac{\Delta W}{\Delta t}$, $P = Fv$

$efficiency = \frac{useful\ output\ power}{input\ power}$

Materials

density $\rho = \frac{m}{V}$ *Hooke's law* $F = k\,\Delta L$

Young modulus $= \frac{tensile\ stress}{tensile\ strain}$ *tensile stress* $= \frac{F}{A}$

tensile strain $= \frac{\Delta L}{L}$

energy stored $E = \frac{1}{2}F\Delta L$

Electricity

current and pd	$I = \frac{\Delta Q}{\Delta t}$ $\quad V = \frac{W}{Q}$ $\quad R = \frac{V}{I}$
resistivity	$\rho = \frac{RA}{L}$
resistors in series	$R_T = R_1 + R_2 + R_3 + \ldots$
resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$
power	$P = VI = I^2R = \frac{V^2}{R}$
emf	$\varepsilon = \frac{E}{Q}$ $\quad \varepsilon = I(R + r)$

Circular motion

magnitude of angular speed	$\omega = \frac{v}{r}$
	$\omega = 2\pi f$
centripetal acceleration	$a = \frac{v^2}{r} = \omega^2 r$
centripetal force	$F = \frac{mv^2}{r} = m\omega^2 r$

Simple harmonic motion

acceleration	$a = -\omega^2 x$
displacement	$x = A\cos(\omega t)$
speed	$v = \pm\omega\sqrt{(A^2 - x^2)}$
maximum speed	$v_{\max} = \omega A$
maximum acceleration	$a_{\max} = \omega^2 A$
for a mass-spring system	$T = 2\pi\sqrt{\frac{m}{k}}$
for a simple pendulum	$T = 2\pi\sqrt{\frac{l}{g}}$

Thermal physics

energy to change temperature	$Q = mc\Delta\theta$
energy to change state	$Q = ml$
gas law	$pV = nRT$
	$pV = NkT$
kinetic theory model	$pV = \frac{1}{3}Nm(c_{\mathrm{rms}})^2$
kinetic energy of gas molecule	$\frac{1}{2}m(c_{\mathrm{rms}})^2 = \frac{3}{2}kT = \frac{3RT}{2N_A}$

Gravitational fields

force between two masses	$F = \frac{Gm_1m_2}{r^2}$
gravitational field strength	$g = \frac{F}{m}$
magnitude of gravitational field strength in a radial field	$g = \frac{GM}{r^2}$
work done	$\Delta W = m\Delta V$
gravitational potential	$V = -\frac{GM}{r}$
	$g = -\frac{\Delta V}{\Delta r}$

Electric fields and capacitors

force between two point charges	$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$
force on a charge	$F = EQ$
field strength for a uniform field	$E = \frac{V}{d}$
work done	$\Delta W = Q\Delta V$
field strength for a radial field	$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$
electric potential	$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$
field strength	$E = \frac{\Delta V}{\Delta r}$
capacitance	$C = \frac{Q}{V}$
	$C = \frac{A\varepsilon_0\varepsilon_r}{d}$
capacitor energy stored	$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$
capacitor charging	$Q = Q_0(1 - e^{-\frac{t}{RC}})$
decay of charge	$Q = Q_0 e^{-\frac{t}{RC}}$
time constant	RC

Magnetic fields

force on a current	$F = BIl$
force on a moving charge	$F = BQv$
magnetic flux	$\Phi = BA$
magnetic flux linkage	$N\Phi = BAN\cos\theta$
magnitude of induced emf	$\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$
	$N\Phi = BAN\cos\theta$
emf induced in a rotating coil	$\varepsilon = BAN\omega \sin\omega t$
alternating current	$I_{\mathrm{rms}} = \dfrac{I_0}{\sqrt{2}} \quad V_{\mathrm{rms}} = \dfrac{V_0}{\sqrt{2}}$
transformer equations	$\dfrac{N_s}{N_p} = \dfrac{V_s}{V_p}$
	efficiency $= \dfrac{I_s V_s}{I_p V_p}$

Nuclear physics

inverse square law for γ radiation	$I = \dfrac{k}{x^2}$
radioactive decay	$\dfrac{\Delta N}{\Delta t} = -\lambda N,\ N = N_0 e^{-\lambda t}$
activity	$A = \lambda N$
half-life	$T_{½} = \dfrac{\ln 2}{\lambda}$
nuclear radius	$R = R_0 A^{1/3}$
energy-mass equation	$E = mc^2$

OPTIONS

Astrophysics

1 astronomical unit = 1.50×10^{11} m

1 light year = 9.46×10^{15} m

1 parsec = 2.06×10^5 AU = 3.08×10^{16} m = 3.26 ly

Hubble constant, $H = 65\ \mathrm{km\ s^{-1}\ Mpc^{-1}}$

$$M = \frac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$$

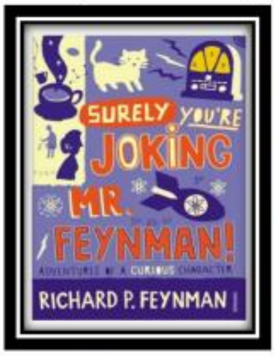
telescope in normal adjustment	$M = \dfrac{f_o}{f_e}$
Rayleigh criterion	$\theta \approx \dfrac{\lambda}{D}$
magnitude equation	$m - M = 5\log\dfrac{d}{10}$
Wien's law	$\lambda_{\max} T = 2.9 \times 10^{-3}\ \mathrm{m\ K}$
Stefan's law	$P = \sigma A T^4$
Schwarzschild radius	$R_s \approx \dfrac{2GM}{c^2}$
Doppler shift for v << c	$\dfrac{\Delta f}{f} = -\dfrac{\Delta\lambda}{\lambda} = \dfrac{v}{c}$
red shift	$z = -\dfrac{v}{c}$
Hubble's law	$v = Hd$

Medical physics

Book Recommendations

Below is a selection of books that should appeal to a physicist – someone with an enquiring mind who wants to understand the universe around us. None of the selections are textbooks full of equation work (there will be plenty of time for that!) instead each provides insight to either an application of physics or a new area of study that you will be meeting at A Level for the first time.

1. **Surely You're Joking Mr Feynman: Adventures of a Curious Character**

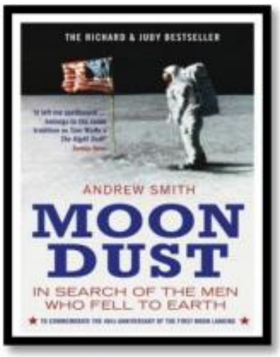


ISBN - 009917331X - Richard Feynman was a Nobel Prize winning Physicist. In my opinion he epitomises what a Physicist is. By reading this books you will get insight into his life's work including the creation of the first atomic bomb and his bongo playing adventures and his work in the field of particle physics.

(Also available on Audio book).

https://www.waterstones.com/books/search/term/surely+youre+joking+mr+feynman++adventures+of+a+curious+character

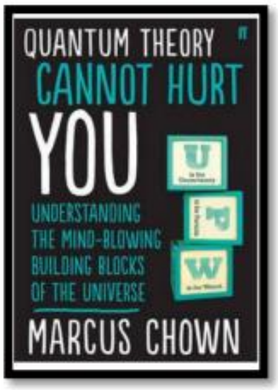
2. **Moondust: In Search of the Men Who Fell to Earth**



ISBN – 1408802384 - One of the greatest scientific achievements of all time was putting mankind on the surface of the moon. Only 12 men made the trip to the surface, at the time of writing the book only 9 are still with us. The book does an excellent job of using the personal accounts of the 9 remaining astronauts and many others involved in the space program at looking at the whole space-race era, with hopefully a new era of space flight about to begin as we push on to put mankind on Mars in the next couple of decades.

https://www.waterstones.com/books/search/term/moondust++in+search+of+the+men+who+fell+to+earth

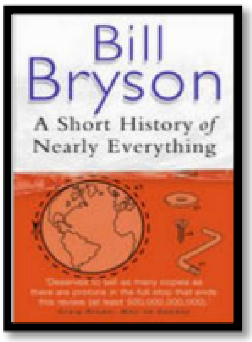
3. **Quantum Theory Cannot Hurt You: Understanding the Mind-Blowing Building Blocks of the Universe**



ISBN - 057131502X - Any Physics book by Marcus Chown is an excellent insight into some of the more exotic areas of Physics that require no prior knowledge. In your first year of A-Level study you will meet the quantum world for the first time. This book will fill you with interesting facts and handy analogies to whip out to impress your peers!

https://www.waterstones.com/book/quantum-theory-cannot-hurt-you/marcus-chown/9780571315024

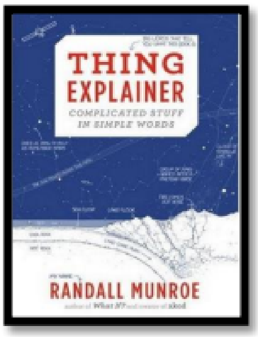
4. **A Short History of Nearly Everything**



ISBN – 0552997048 - A modern classic. Popular science writing at its best. A Short History of Nearly Everything Bill Bryson's quest to find out everything that has happened from the Big Bang to the rise of civilization - how we got from there, being nothing at all, to here, being us. Hopefully by reading it you will gain an awe-inspiring feeling of how everything in the universe is connected by some fundamental laws.

https://www.waterstones.com/books/search/term/a+short+history+of+nearly+everything

5. **Thing Explainer: Complicated Stuff in Simple Words**



ISBN – 1408802384 - This final recommendation is a bit of a wild-card – a book of illustrated cartoon diagrams that should appeal to the scientific side of everyone. Written by the creator of online comic XTCD (a great source of science humour) is a book of blueprints from everyday objects such as a biro to the Saturn V rocket and an atom bomb, each one meticulously explained BUT only with the most common 1000 words in the English Language. This would be an excellent coffee table book in the home of every scientist.

https://www.waterstones.com/book/thing-explainer/randall-munroe/9781473620919

Movie / Video Clip Recommendations

Hopefully you'll get the opportunity to soak up some of the Sun's rays over the summer – synthesising some important Vitamin-D – but if you do get a few rainy days where you're stuck indoors here are some ideas for films to watch or clips to find online.

Science Fictions Films

1. **Moon (2009)**
2. **Gravity (2013)**
3. **Interstellar (2014)**
4. **The Imitation Game (2015)**
5. **The Prestige (2006)**

Online Clips / Series

1. **Minute Physics** – Variety of Physics questions explained simply (in felt tip) in a couple of minutes. Addictive viewing that will have you watching clip after clip – a particular favourite of mine is "Why is the Sky Dark at Night?"

   https://www.youtube.com/user/minutephysics

2. **Wonders of the Universe / Wonders of the Solar System –** Both available of Netflix as of 17/4/16 – Brian Cox explains the Cosmos using some excellent analogies and wonderful imagery.

3. **Shock and Awe, The Story of Electricity** – A 3 part BBC documentary that is essential viewing if you want to see how our lives have been transformed by the ideas of a few great scientists a little over 100 years ago. The link below takes you to a stream of all three parts joined together but it is best watched in hourly instalments. Don't forget to boo when you see Edison. (alternatively watch any Horizon documentary – loads of choice on Netflix and the I-Player)

   https://www.youtube.com/watch?v=Gtp51eZkwoI

4. **NASA TV** – Online coverage of launches, missions, testing and the ISS. Plenty of clips and links to explore to find out more about applications of Physics in Space technology.

   http://www.nasa.gov/multimedia/nasatv/

5. **The Fantastic Mr. Feynman** – I recommended the book earlier, I also cannot recommend this 1 hour documentary highly enough. See the life's work of the "great explainer", a fantastic mind that created mischief in all areas of modern Physics.

   https://www.youtube.com/watch?v=LyqleIxXTpw

Research activity

To get the best grades in A Level Physics you will have to get good at completing independent research and making your own notes on difficult topics. Below are links to 5 websites that cover some interesting Physics topics.

Using the Cornell notes system: http://coe.jmu.edu/learningtoolbox/cornellnotes.html make 1 page of notes **from each site** covering a topic of your choice.

a) http://home.cern/about

   CERN encompasses the Large Hadron Collider (LHC) and is the largest collaborative science experiment ever undertaken. Find out about it here and make a page of suitable notes on the accelerator.

b) http://joshworth.com/dev/pixelspace/pixelspace_solarsystem.html

   The solar system is massive and its scale is hard to comprehend. Have a look at this award winning website and make a page of suitable notes.

c) https://phet.colorado.edu/en/simulations/category/html

   PhET create online Physics simulations when you can complete some simple experiments online. Open up the resistance of a wire html5 simulation. Conduct a simple experiment and make a one page summary of the experiment and your findings.

d) http://climate.nasa.gov/

NASA's Jet Propulsion Laboratory has lots of information on Climate Change and Engineering Solutions to combat it. Have a look and make notes on an article of your choice.

e) http://www.livescience.com/46558-laws-of-motion.html

Newton's Laws of Motion are fundamental laws for the motion of all the object we can see around us. Use this website and the suggested further reading links on the webpage to make your own 1 page of notes on the topics.

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

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

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

Atomic Structure

You will study nuclear decay in more detail at A level covering the topics of radioactivity and particle physics. In order to explain what happens you need to have a good understanding of the model of the atom. You need to know what the atom is made up of, relative charges and masses and how sub atomic particles are arranged.

The following video explains how the current model was discovered
www.youtube.com/watch?v=wzALbzTdnc8

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

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

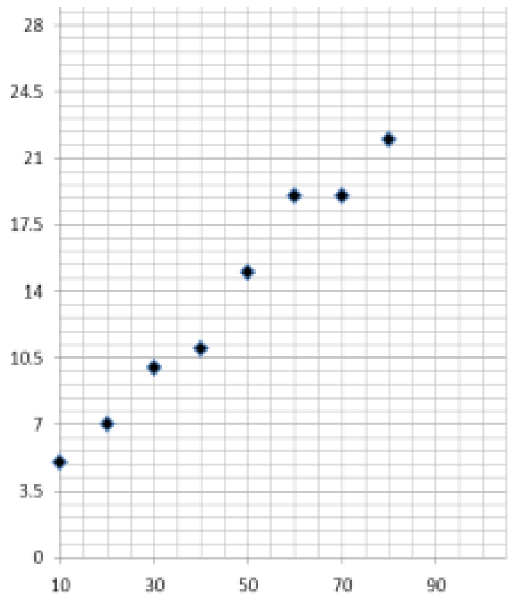
Graphs

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:

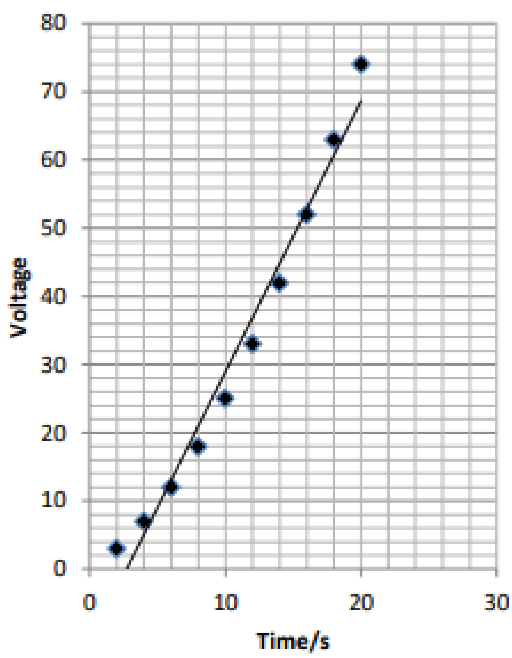
- the maximum and minimum values of each variable
- whether 0.0 should be included as a data point; graphs don't need to show the origin, a false origin can be used if your data doesn't start near zero.
- the plots should cover at least half of the grid supplied for the graph.
- the axes should use a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

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

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

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

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 $-\ 1.60\times10^{-19}$ 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 ($^{A}_{Z}X$)?	*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	$\text{wavelength }(\lambda) = \dfrac{\text{speed of light}(c)}{\text{frequency}(f)}$
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} ($s^{-1} = \frac{1}{s}$).

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.):

$\underline{3.62}$ $\underline{25.4}$ $\underline{271}$ $0.0\underline{147}$ $0.\underline{245}$ $\underline{39\,4}00$

(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:

$\underline{207}$ $\underline{405}0$ $\underline{1.01}$ (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

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.

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.

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}

2.4 Powers of ten

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

So $100 \times 1000 = 100\,000$ 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.

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

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

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, $3 \times 10^{8}\ ms^{-1}$ upwards, 273 °C, 50 kg, 3 A.

3.2 Drawing vectors

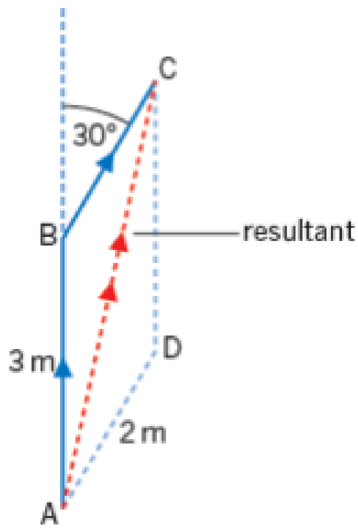
Vectors are shown on drawings by a straight arrow. The arrow starts from the point where the vector is acting and shows its direction. The length of the vector represents the magnitude.

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. $\overrightarrow{AC}$ is the resultant vector, denoted by the double arrowhead.

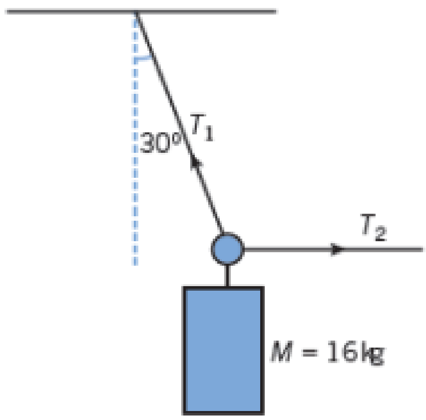
A careful drawing of a scale diagram allows us to measure these. Notice that if the vectors are combined by drawing them in the opposite order, $\overrightarrow{AD}$ and $\overrightarrow{DC}$, these are the other two sides of the parallelogram and give the same resultant.



Practice question

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

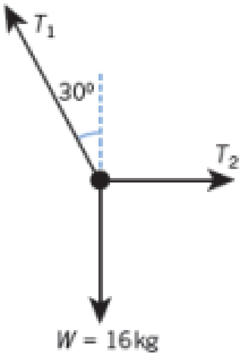


To combine forces, you can draw a similar diagram to the one above, where the lengths of the sides represent the magnitude of the force (e.g., 30 N and 20 N). The third side of the triangle shows us the magnitude and direction of the resultant force.

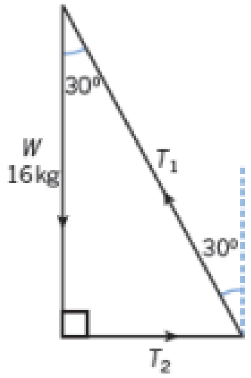
When solving problems, start by drawing a free body force diagram. The object is a small dot and the forces are shown as arrows that start on the dot and are drawn in the direction of the force. They don't have to be to scale, but it helps if the larger forces are shown to be larger. Look at this example.

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.

Free body force diagram



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).

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:

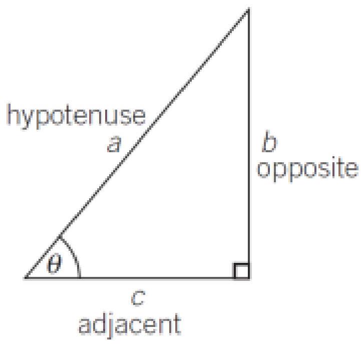
$h^2 = o^2 + a^2$

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

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

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

(soh-cah-toa).



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:

$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$

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

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

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

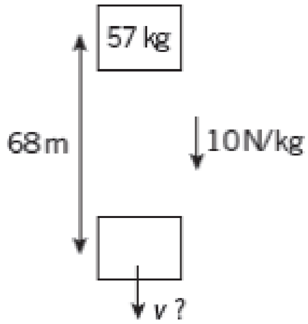
Step 3: Rearranging:

$-19.62\ s = -25$

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

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:

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

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

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

Step 4: Substitute into the equation:

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

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

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).

5.2 Power

Power is the rate of work done.

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

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

$P = \Delta W/\Delta t$ *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:

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

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.

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

(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:

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

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

AQA GCSE Revision Questions

Instructions: Answer ALL questions

01 A sphere has become positively charged. There is an electric field around the sphere.

01.1 Define 'electric field'. **[2 marks]**

01.2 Draw field lines around the sphere in **Figure 1** to show the electric field. **[2 marks]**

Figure 1

01.3 A student drops a negatively charged piece of paper near the sphere.

Write down the direction of motion of the paper. **[2 marks]**

Justify your answer.

02 Three atoms undergo nuclear decay and emit radiation.

The changes to the mass number and atomic number are shown in **Table 1**.

Table 1

Atom	Change to mass number of element	Change to atomic number of element
A	–4	–2
B	0	0
C	0	+1
D	0	–1

02.1 Identify which atom undergoes beta decay. **[1 mark]**

____

02.2 Identify which atom emits a neutron. **[1 mark]**

____

02.3 A teacher shows a class a radioactive source.

They use a Geiger counter to measure the count rate.

The teacher turns the counter on for one minute.

The display on the Geiger counter shows the number 600.

Describe what the Geiger counter is counting. **[1 mark]**

____

____

02.4 Calculate the count rate in Becquerels. **[2 marks]**

____

____

______________ Bq

02.5 The teacher puts a piece of aluminium between the source and the counter.

The counter reading after one minute is 300.

The reading does not go down to zero because the source emits gamma rays.

Describe a gamma ray. **[1 mark]**

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02.6 Explain why the teacher cannot tell which other type or types of radiation are being emitted by the source. **[2 marks]**

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02.7 Suggest how the teacher could determine which type of radiation the source is emitting.

[3 marks]

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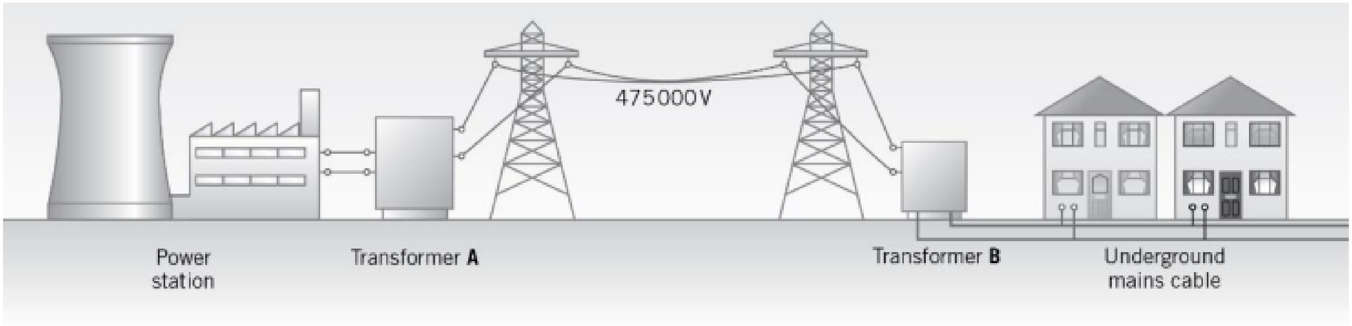
03 A power station generates electricity.

The potential difference (p.d.) needed to power appliances is transmitted by power lines.

Figure 2



03.1 Transformers change the p.d. across a primary coil (V_p) to a p.d. across a secondary coil (V_s).

Suggest which transformer, A or B, is a step-down transformer. Explain your answer. **[2 marks]**

____

____

03.2 The power station burns coal.

Give **one advantage** and **one disadvantage** of using coal in a power station. **[2 marks]**

____

____

03.3 Some people would like to see the power station replaced with a **wind farm**.

Describe **one advantage** and **one disadvantage** of using a wind farm instead of a coal-fired power station to generate electricity. **[2 marks]**

____

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03.4 The National grid supplies electricity to houses at a p.d. of 230 V.

Write down the name of the wire that carries the p.d. from the supply to the appliance. **[1 mark]**

____

03.5 Write down the name of the wire that completes the circuit. **[1 mark]**

____

03.6 A student is describing the wiring in appliances connected to the mains.

She uses the example of a toaster.

The student says 'There is another wire for safety. It never carries a current'.

Is she correct? Explain your answer. **[2 marks]**

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03.7 The current in the toaster is 4.0 A. Calculate the power of the toaster. **[2 marks]**

____

____

04 A student is standing in a dark room. When he pulls strips of sticky tape apart, he sees flashes of light.

When the student pulls the tape apart, they separate charge.

04.1 Write down the name of the particle that moves when objects become electrically charged. **[1 mark]**

____

When the tape discharges, charge flows through the air.

The air heats up and a flash of light is seen.

04.2 A charge of 15 mC flows in 10^{-4} s.

Write down the equation linking charge, current, and time. **[1 mark]**

____

04.3 Calculate the current. **[3 marks]**

Give the unit.

____

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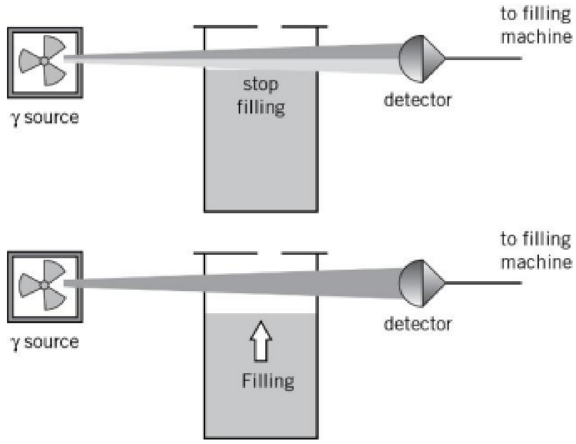
05 You can use radiation to make measurements. One example is in a factory that produces containers of liquid.

This technique is used to fill cans of soft drinks as shown in **Figure 3**.

Figure 3



05.1 Suggest why gamma radiation, and not alpha or beta radiation, is used. **[2 marks]**

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05.2 Two people have very different reactions to finding out that their drink can has been exposed to gamma radiation.

Suggest why:

- one person does not consider that using gamma radiation in the process causes a hazard when consuming the soft drink
- another person does consider that using gamma radiation in the process causes a hazard when consuming the soft drink. **[2 marks]**

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05.3 The gamma source has a half-life of 30 years.

Calculate the net decline of the source after 90 years. **[3 marks]**

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Anyone working with radioactive material receives a radiation dose.

Radiation dose is measured in millisieverts (mSv).

Table 2 shows the annual dose of radiation for different people.

Table 2

Radiation source	**Dose in mSv**
annual exposure limit for nuclear industry worker	20
nuclear medicine lung scan	2.0
UK annual average radon dose	1.3
transatlantic flight	0.08

05.4 Two of the sources in **Table 2** are **natural sources**.

Name the **two** natural sources of radiation in **Table 2**. **[2 marks]**

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____

05.5 A way to communicate the risk due to doses of radiation is to convert them to a different scale.

One such scale is the number of hours that you need to fly to receive the dose of radiation.

A transatlantic flight takes 8 hours.

Calculate the number of hours you would need to fly to get the same dose as a lung scan.

[3 marks]

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06 Milk is usually kept inside a refrigerator at 4 °C.

A container of milk is left at room temperature, which is 20 °C.

The mass of the milk is 500 g.

The milk is then put into the refrigerator.

06.1 Calculate the energy transferred from the milk as it cools to 4 °C. **[3 marks]**

Use an equation from the Physics Equation Sheet.

The specific heat capacity of milk is 3930 J/kg °C.

06.2 The energy is transferred to a liquid coolant that flows through pipes at the back of the refrigerator.

The energy transferred evaporates the coolant. This is how the refrigerator stays cool.

Explain in terms of energy and particles what happens when the coolant evaporates. **[2 marks]**

06.3 The energy transferred from the milk to the coolant is relatively small.

Suggest why it is better for the coolant to have a large specific latent heat of vaporisation.

Explain your answer. **[3 marks]**

06.4 A student wants to measure the latent heat of vaporisation of water using a kettle, a digital balance, and a timer. The power of the kettle is 2000 W.

Describe how they can use this equipment to make the measurements to calculate the specific latent heat of vaporisation of water. **[6 marks]**

The equation they use is:

energy transferred = mass change x specific latent heat of vaporisation.

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07 Nuclear fusion is a process that scientists have been working on since its discovery in the 1930s.

07.1 Write down a place where nuclear fusion takes place that is **not** on Earth. **[1 mark]**

____

07.2 One of the simplest fusion reactions is the reaction of hydrogen-2 and hydrogen-3.

Describe what the number '3' means in terms of the particles in an atom of hydrogen-3. **[1 mark]**

____

____

07.3 Write down the nuclear equation for the fusion of hydrogen-2 and hydrogen-3 into helium. The atomic mass of helium is 4 and the atomic number of helium is 2.

Use your equation to determine what, apart from helium, is produced in the reaction.

[4 marks]

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____

07.4 Fusion reactions produce about four times more energy per kg of fuel than fission reactions.

Name **one** fuel used in a fission reaction. **[1 mark]**

____

____

07.5 Nuclear fission reactors have been used to generate electricity for the National Grid since 1956. Explain, in terms of reactants and products, why nuclear fusion is preferable to nuclear fission.

[5 marks]

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08 A student puts their finger over the end of a syringe.

They push the plunger of the syringe so that the gas is compressed.

08.1 Explain why the pressure is higher when the volume is smaller. **[2 marks]**

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08.2 The pressure inside the syringe before the student compresses it is atmospheric pressure.

Atmospheric pressure = 101 000 Pa.

The volume of air is 40 cm^3.

The student compresses the gas to a volume of 10 cm^3.

Calculate the pressure of the gas in the syringe. **[4 marks]**

Use the Physics Equation Sheet.

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09 A lift carries passengers between the ground floor and different levels of a shopping centre.

09.1 Describe the store that increases in energy as the shoppers move upwards. **[1 mark]**

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09.2 The lift works on mains electricity. Suggest a store that decreases in energy as the shoppers move upwards. Explain your answer. **[2 marks]**

____

____

09.3 The lift does work on the passengers.

A family and the lift have a total mass of 1050 kg and the lift carries them up a distance of 15m.

The gravitational field strength is 10 N/kg.

Calculate the work done by the lift. **[4 marks]**

Write down an assumption that you have made in doing this calculation.

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09.4 The lift motor is 80 % efficient.

Calculate the total input energy that the lift has to supply to move the family and the lift.

Show your working. **[4 marks]**

Write your answer to an appropriate number of significant figures.

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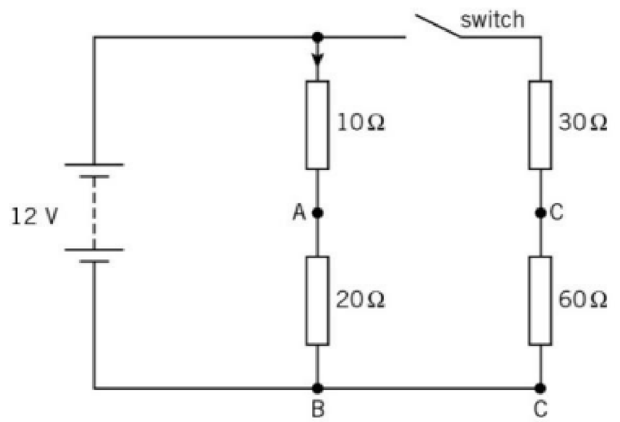
10 A student connects the circuit shown in **Figure 4**.

Figure 4



The switch is open.

10.1 Write down the equation that links current, potential difference, and resistance. **[1 mark]**

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10.2 Calculate the current through the 10 Ω resistor. **[4 marks]**

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10.3 Predict what will happen to the current through the 10 Ω resistor when the switch is closed.

Explain your answer. **[2 marks]**

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10.4 The student finds that the potential difference between points **A** and **B** is equal to the potential difference between points **C** and **D**.

Explain why this is. You may wish to use calculations to support your answer. **[4 marks]**

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01 Waves may be either longitudinal or transverse.

01.1 Define a longitudinal wave. **[1 mark]**

01.2 Electromagnetic radiation is a type of transverse wave.

Give the speed of all electromagnetic radiation. **[1 mark]**

01.3 **Figure 1** shows the different types of electromagnetic radiation.

Complete **Figure 1**. **[2 marks]**

Figure 1

Increasing wavelength →

Gamma			Visible		Microwave	

01.4 X-rays and gamma rays are commonly used in hospitals for imaging. However, ultrasound is used to image fetuses.

Describe the uses of X-rays and gamma rays in imaging.

Describe the dangers associated with using X-rays and gamma rays.

Explain why ultrasound is used instead of X-rays or gamma rays to image fetuses. **[6 marks]**

02 A student wants to determine the direction of current in a piece of wire.

02.1 Describe how they can use a plotting compass and a piece of card to determine the direction of the current. **[3 marks]**

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02.2 A second student sprinkles iron filings on the card instead. These are small pieces of iron which are influenced by the wire's magnetic field.

Suggest what this second student would observe.

Explain why the second student will not be able to determine the direction of the current in the wire. **[3 marks]**

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03 All objects emit and absorb black body radiation based on their temperature and material.

03.1 Define a perfect black body. **[1 mark]**

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03.2 A student wants to know which of three surfaces acts most like a black body. The student filled coloured beakers with water and positioned them all 20 cm from an infrared heater. The data collected is shown in **Table 1**.

Table 1

	Temperature in °C		
Time in min	**Black**	**White**	**Silver**
0	20	20	20
1	32	28	25
2	40	34	29
3	48	38	24
4	53	41	37
5	56	43	40

Identify the anomaly. **[1 mark]**

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03.3 Explain which surface acts most like a perfect black body. **[2 marks]**

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04 The Sun is a main sequence star which is currently fusing hydrogen into helium.

04.1 A student has attempted to write the equation for this fusion reaction. However, they realise that something is missing in order to balance it.

$$^{2}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} \rightarrow ^{4}_{2}\mathrm{He} + \_\_\_$$

Complete the equation and identify the missing particle. **[2 marks]**

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04.2 The Sun is a low mass star.

Describe how it will change after it runs out of hydrogen to fuse. **[4 marks]**

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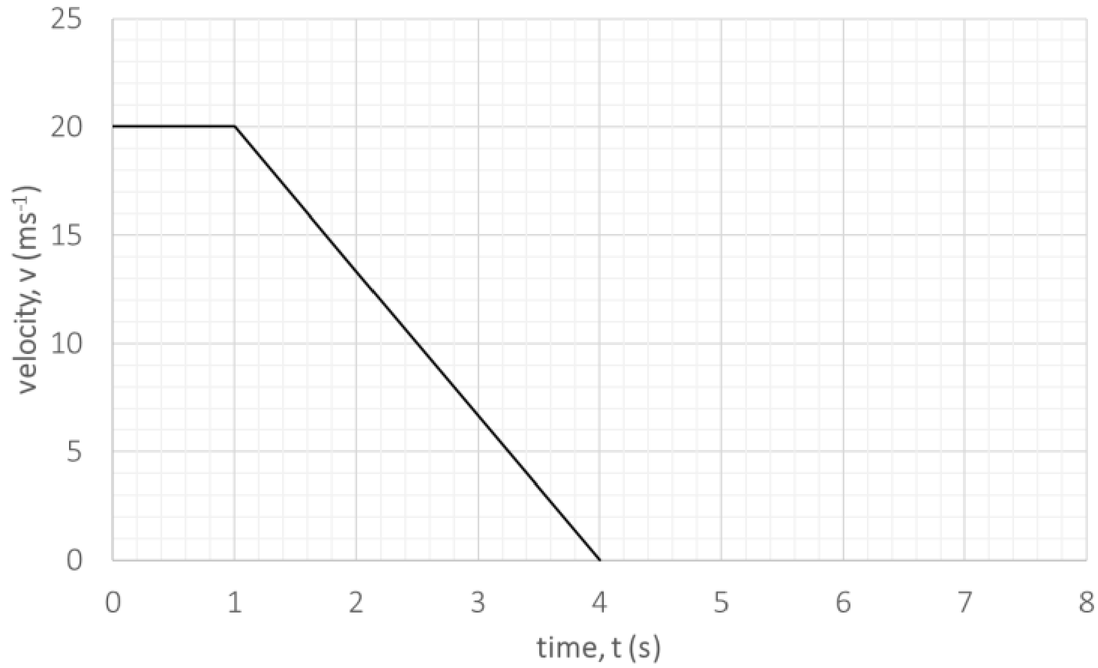
05 A driver sees a deer run into the road and emergency brakes to stop the car.

Figure 2 shows the velocity–time graph for the total stopping distance of the car.

Figure 2



5.1 Describe what is meant by the driver's reaction time for this situation. **[1 mark]**

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05.2 Which of these factors would affect the thinking distance?

Tick **one** box. **[1 mark]**

Icy road ☐

Tiredness of the driver ☐

Condition of the brakes ☐

05.3 Determine the total stopping distance of the car using **Figure 2**. **[3 marks]**

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05.4 While braking, the 1200 kg car experiences a resultant force of –8000 N.

Calculate the car's acceleration and give the unit. **[5 marks]**

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05.5 Describe how the graph could have been used to determine the same acceleration. **[1 mark]**

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05.6 Sketch another line on **Figure 2** to show how the stopping distance would be different if the driver had consumed alcohol beforehand and the car's tyres were in poor condition. **[2 marks]**

05.7 Use your graph to explain why there is a legal driving limit for alcohol. **[1 mark]**

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05.8 Some safety features are required to make vehicles road legal. These features make it safer in the event of a crash.

Describe these features and explain how they prevent serious injuries for the occupants of the vehicle. **[4 marks]**

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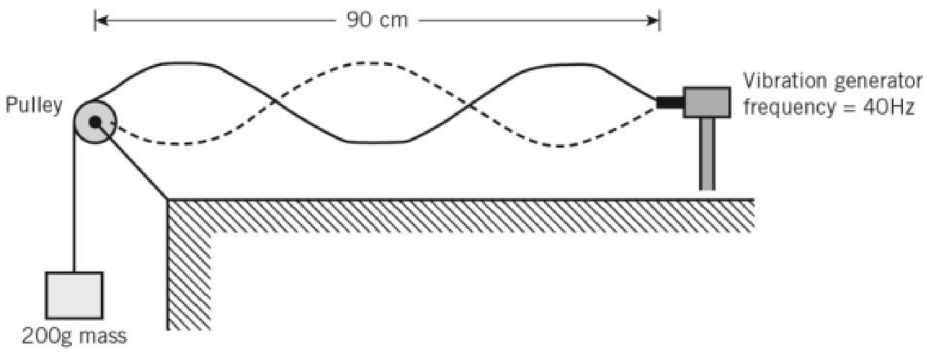
06 A student sets up a stationary wave on a string to determine the speed of a wave through solids.

Figure 3 shows the experimental set-up.

Figure 3



06.1 Use **Figure 3** to determine the wavelength of the stationary wave. **[1 mark]**

______________________ m

06.2 Calculate the wave speed of the wave on the string. **[3 marks]**

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06.3 In order to confirm their measurements, the student repeats the experiment but with a different frequency.

Identify the dependent, independent, and control variables in their method.

Draw **one** line from each type of variable to the correct description. **[3 marks]**

Variable	**Description**
	Mass hanging
Dependent variable	
	Frequency
Independent variable	
	Wavelength
Control variable	
	Material of string

07 A DVD player uses the motor effect to spin discs.
The player consists of a coil of wire inside a pair of bar magnets with a magnetic flux density of 0.04 T.

07.1 Define the motor effect. **[1 mark]**

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07.2 In order for the motor to work it needs to include a split-ring commutator.

Describe the role of this part.

Explain what would happen to the motor without it, with reference to Fleming's left-hand rule.

[4 marks]

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07.3 The motor consists of 140 loops of wire inside the magnetic field.

Each loop has a length of 8 cm.

Calculate the total length of the wire. **[1 mark]**

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07.4 The force required to spin the discs is 2.7 N.

Show that the current required is 6 A.

Use an equation from the Physics Equation Sheet. **[3 marks]**

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07.5 A student measures the current required and finds it to be 6.8 A.

Suggest why the current required is more than that calculated above. **[1 mark]**

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08 Two students decide to see who can travel the furthest when running for 5 minutes. However, they do not run in a straight line. The distances and directions covered by each student are shown in **Table 2**.

Table 2

Student A	100 m north	200 m east	200 m south	240 m west	50 m south	40 m east
Student B	40 m west	60 m south	160 m east	100 m south	120 m west	

08.1 Student A claims to have won the race because they have covered the most distance.

Determine whether or not they are correct. **[2 marks]**

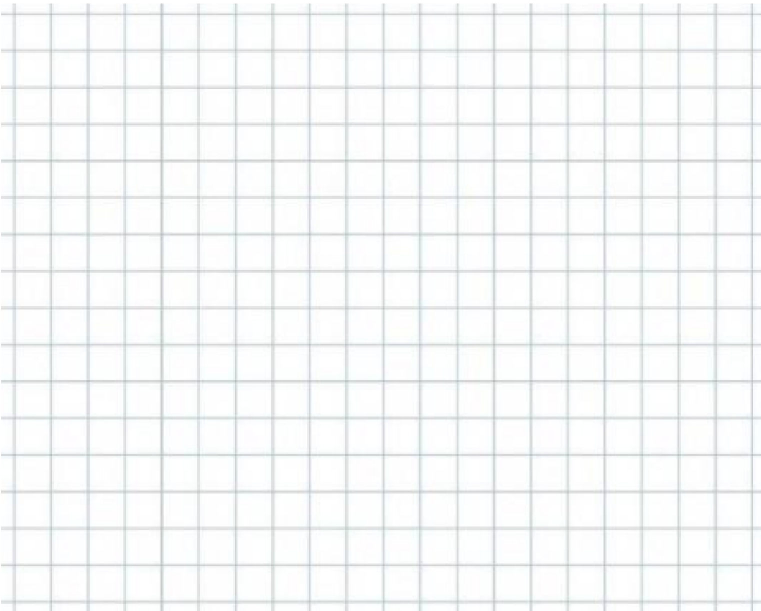
08.2 However, student B claims to have won because they have the greater displacement from the start.

Give the difference between distance and displacement. **[1 mark]**

08.3 Student A's displacement at the end was 150 m due south.

Draw a vector diagram on **Figure 4** to calculate the final displacement of student B. **[4 marks]**

Figure 4



09 Electricity is generated inside a power station, with a potential difference of 25 kV.

Before transmission using the National Grid, a transformer is used to increase the potential difference to 400 kV.

09.1 Identify the transformer as step-up or step-down. **[1 mark]**

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09.2 Describe the structure of a transformer and explain how it works. **[5 marks]**

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09.3 The transformer used has 4600 turns on its primary coil.

Calculate the number of turns on its secondary coil. **[3 marks]**

Use an equation from the Physics Equation Sheet.

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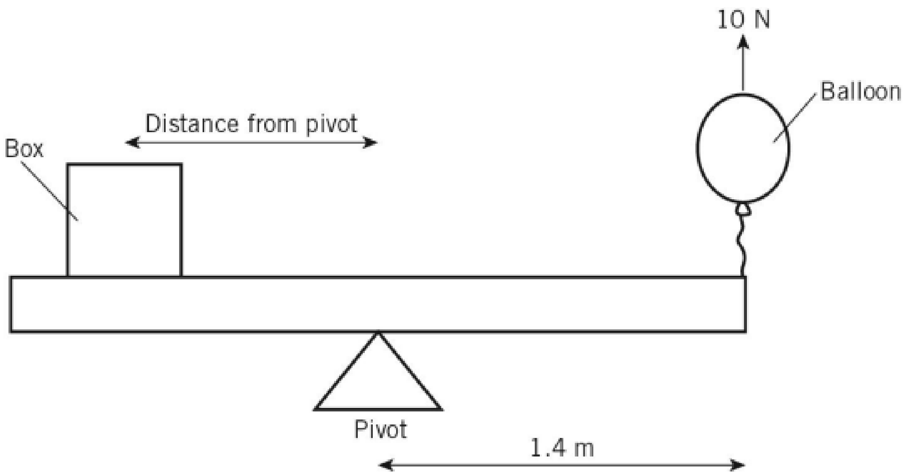
10 A student decides to perform an investigation into moments.

They tie a helium balloon to one end of a see-saw so that it has an initial anticlockwise moment.

They then place a box at different positions along the see-saw and see how the motion of the see-saw changes, as shown in **Figure 5**.

Figure 5



From their observations, the student records the information in **Table 3.**

They record the distance as negative when the box is on the left of the pivot, and positive when it is on the right.

They use the data to calculate the weight of the box.

Table 3

Distance of box from pivot in m	Observed motion of the see-saw
–0.50	Large rotation anticlockwise
–0.25	Medium rotation anticlockwise
0.00	Small rotation anticlockwise
+0.25	Stationary
+0.50	Small rotation clockwise

10.1 Describe the conditions for the see-saw to be balanced. **[1 mark]**

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10.2 Calculate the weight of the box. Give the units. **[5 marks]**

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10.3 Afterwards the student finds out that the upwards force from the balloon is actually 9 N.

Predict how this would affect their calculated weight of the box. **[1 mark]**

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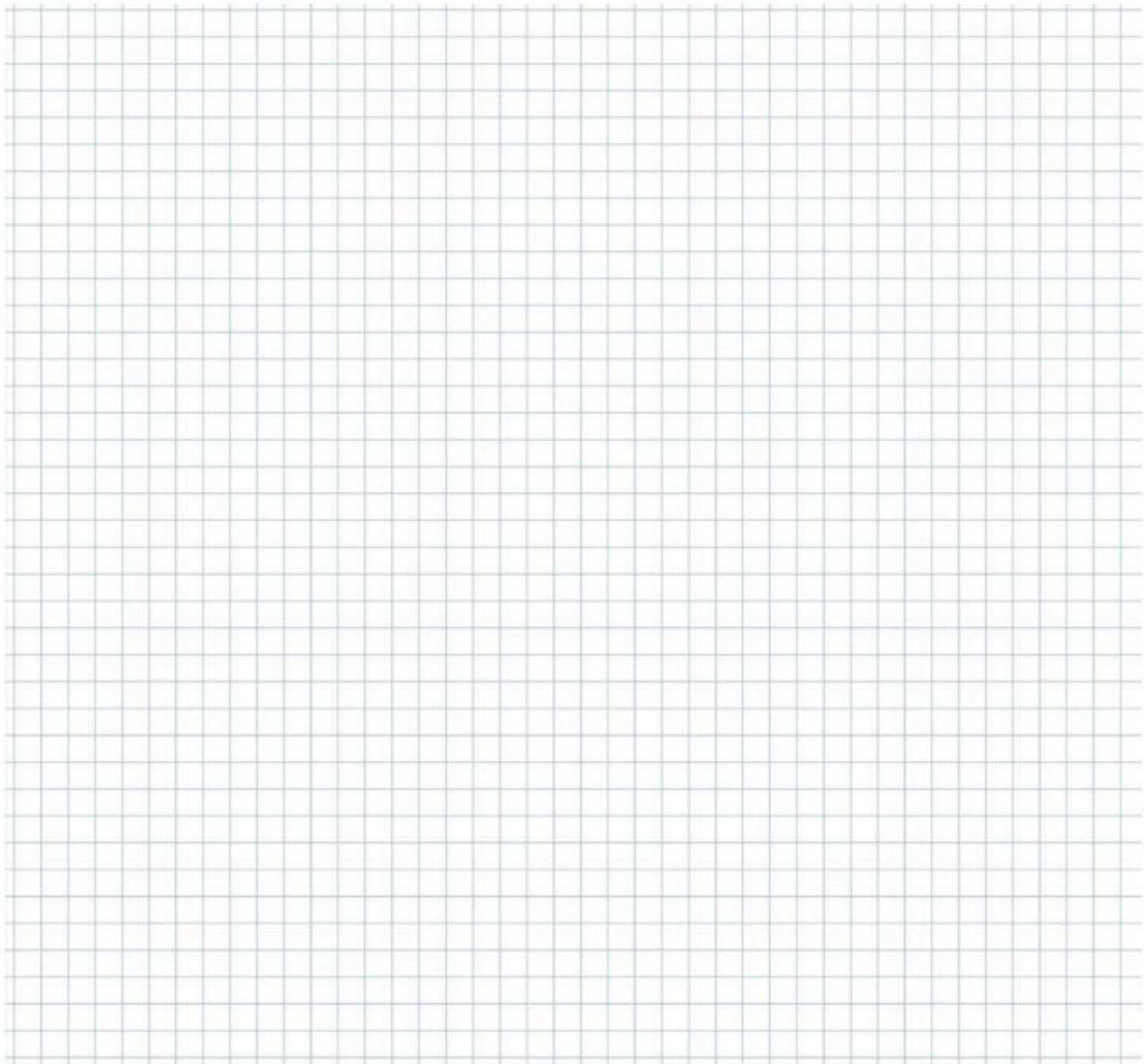
11 **Table 4** shows data for the six innermost planets in the solar system.

Table 4

Average distance from the Sun in $\times 10^9$ m	Orbital speed in km/s
60	47
110	35
150	30
230	24
780	13
1400	10

11.1 Plot the data onto **Figure 6** to produce a graph of orbital speed (y-axis) versus distance (x-axis). **[4 marks]**

Figure 6



11.2 Draw a line of best fit on **Figure 6.** **[1 mark]**

11.3 Describe and explain the trend shown in **Figure 6**. **[4 marks]**

11.4 Identify the planet with an orbital speed of 35 km/s. **[1 mark]**

11.5 Suggest why the distance from the Sun is an average distance. **[1 mark]**

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11.6 Johannes Kepler was a German astronomer. Between 1609 and 1619, he published his three 'Laws of Planetary Motion'.

Kepler's Third Law states:

"The orbital period of a planet squared is directly proportional to its distance from the Sun cubed"

$$T^2 \propto R^3$$

The orbital period of a planet can be calculated using the equation:

$$T = \frac{2\pi R}{v}$$

Use the data for any two planets to demonstrate that Kepler's Third Law holds. **[5 marks]**

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End of questions.

Have an Amazing Summer and See you September

Physics Glossary – Year 11 to Year 12 Transition

This glossary contains key terms and definitions to support your transition from GCSE to AQA A-level Physics. It covers essential terminology from GCSE that forms the foundation of A-level study, as well as new terms and concepts you will encounter early in the course.

Acceleration: The rate of change of velocity with time. Measured in m/s^2.

Amplitude: The maximum displacement from the rest position in a wave.

Base Units: The standard units in the SI system (e.g., metre, kilogram, second, ampere).

Conservation of Energy: Energy cannot be created or destroyed, only transferred or transformed.

Current (Electric): The flow of electric charge, measured in amperes (A).

Displacement: The distance and direction of an object's change in position from the starting point.

Efficiency: The ratio of useful energy output to total energy input, often expressed as a percentage.

Electric Field: A region around a charged particle where a force is exerted on other charges.

Elastic Potential Energy: Energy stored in an elastic object when it is stretched or compressed.

Frequency: The number of wave cycles per second, measured in hertz (Hz).

Gravitational Field Strength: The force per kilogram experienced by a mass in a gravitational field, measured in N/kg.

Hooke's Law: The extension of a spring is directly proportional to the force applied, up to the limit of proportionality.

Instantaneous Speed: The speed of an object at a particular moment in time.

Kinetic Energy: Energy of a moving object, calculated as $KE = \frac{1}{2}mv^2$.

Momentum: The product of mass and velocity of an object. Momentum is conserved in closed systems.

Newton's First Law: An object remains at rest or in uniform motion unless acted on by a resultant force.

Newton's Second Law: $F = ma$, where force equals mass times acceleration.

Newton's Third Law: For every action, there is an equal and opposite reaction.

Ohm's Law: The current through a conductor is directly proportional to the voltage across it, provided temperature remains constant: $V = IR$.

Potential Difference (Voltage): The energy transferred per coulomb of charge, measured in volts (V).

Power: The rate of energy transfer or work done, measured in watts (W): $P = E/t$ or $P = IV$.

Resistance: A measure of how much a component resists the flow of current: $R = V/I$.

Resistivity: A material property that affects resistance, defined as $\rho = RA/L$.

Resultant Force: The single force that has the same effect as all the individual forces acting on an object.

Scalar Quantity: A quantity with magnitude only (e.g., speed, energy, mass).

Systematic Error: An error that consistently skews results in one direction due to flaws in equipment or method.

Vector Quantity: A quantity with both magnitude and direction (e.g., velocity, force, displacement).

Velocity: Speed in a given direction, a vector quantity.

Wave front: A surface over which the wave has the same phase (used in understanding wave propagation).

Wavelength: The distance between successive crests or troughs in a wave.

Work Done: The energy transferred when a force moves an object: $W = Fd\cos(\theta)$, measured in joules (J).