Physics

Subject	Physics
Exam Board	AQA
Head of Department	Ms Clarke / Mr Ahmed

Assessment

Paper 1		Paper 2		Paper 3	
34% of A level	Written Exam 2 hours. 85 marks	34% of A Level	Written Exam 2 hours. 85 marks	32% of A level	Written Exam 2 hours. 80 Marks

Welcome to A Level Physics,

This transition pack will provide you with a brief outline of the course structure and a reading list of sources and videos. You may wish to use these sources before and throughout the course to improve your wider understanding. This pack also contains some interesting and fun activities to get you ready for the first few weeks of the course. Please submit your work by the set **due dates** to sixthform@sta.islington.sch.uk for the attention of Ms Buckley or Mr Ahmed.

Curriculum Map (Term 1 Provisional)

September - October 2020

Measurements and their errors in practical

- Use of mass, length, time, amount of substance, temperature, electric current and their associated SI units.
- Identify random and systematic errors and suggest ways to reduce or remove them
- Understand the link between the number of significant figures in the value of a quantity and its associated uncertainty
- Combine uncertainties in cases where the measurements that give rise to the uncertainties are added, subtracted, multiplied, divided, or raised to powers

Maths skills

- Knowledge and use of the SI prefixes, values and standard form.
- Estimate approximate values of physical quantities to the nearest order of magnitude.

November - December 2020

Mechanics

- Identify scalars and vectors
- Investigate conditions for equilibrium for two or three coplanar forces acting at a point.
- Carry out calculations involving motion in a straight line and trajectory of a projectile.
- Application of Newton's three laws of motion in appropriate situations
- Quantitatively apply the principle of conservation of linear momentum to problems

Materials

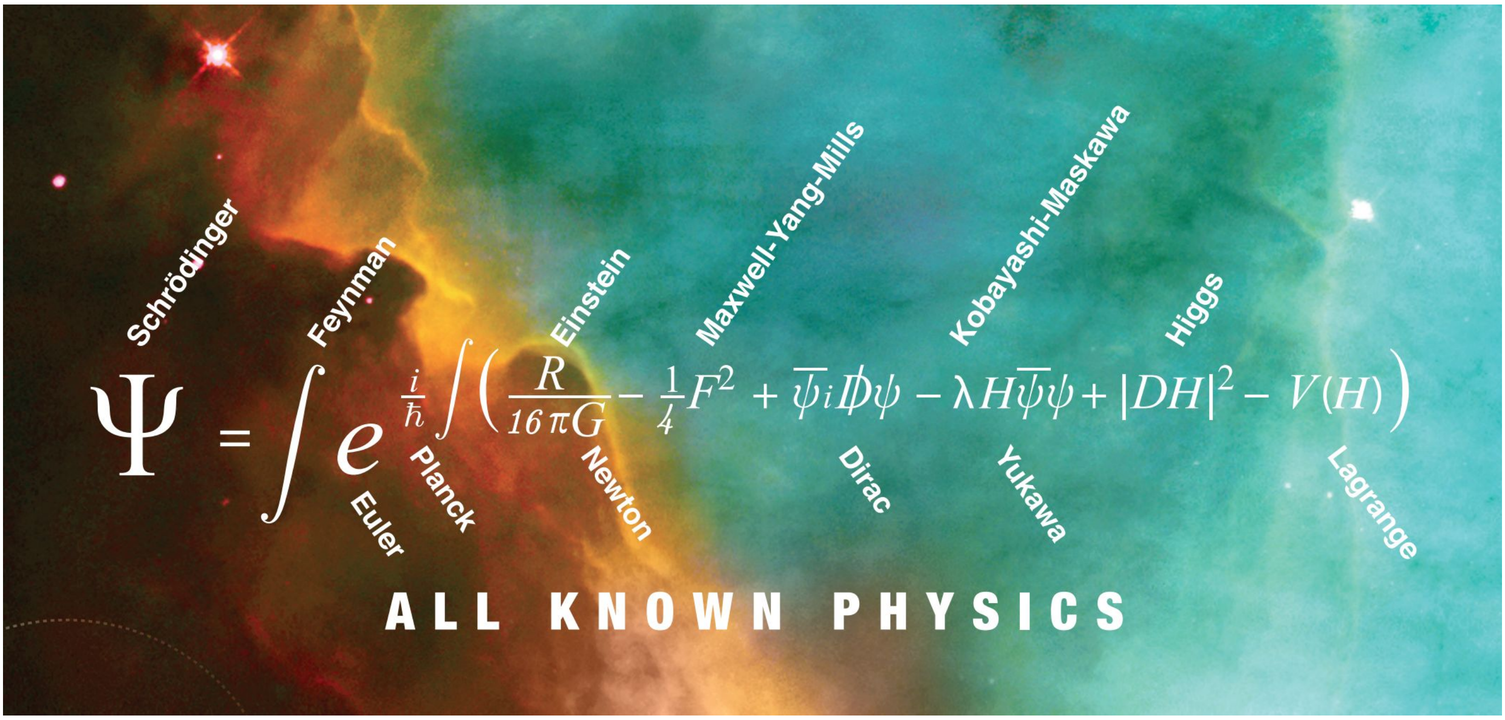
- Describe plastic behaviour, fracture and brittle behaviour linked to force–extension graphs.
- Investigate Hooke's Law
- Use of stress–strain graphs to find the Young modulus

Subject Specific Reading List:

https://isaacphysics.org/concepts
www.senecalearning.com
Notes and Exam questions

Useful Websites:

- Feynman Lectures - My favourite educator and Physicist
- Prof https://www.microsoft.com/en-us/research/project/tuva-richard-feynman/?from=http://research.microsoft.com/apps/tools/tu va/
- Institute of Physics http://www.iop.org/tailored/students/
- Lewis Matheson's very popular Physics videos lesson by lesson https://www.youtube.com/channel/UCZzatyx-xC-Dl_VVUVHYDYw/about
- Dr Physics A's videos http://www.bobeagle.co.uk/drphysicsa.html
- Demo of required Practicals - Malmesbury School https://www.youtube.com/channel/UC-TM-z1-tmX1iK_H4SxVhw w
- MIT university's resources https://ocw.mit.edu/courses/physics/



Part 1

Introduction to A Level Physics

AQA Realising potential

Transition guide: Physics

We have created this student support resource to help you make the transition from GCSE to AS or A-level Physics.

Contents

You're studying AS or A-level Physics, congratulations!

Studying physics after your GCSEs really develops your practical and mathematical skills. If you enjoy experimenting in the lab, you'll love it.

At first, you may find the jump in demand from GCSE a little daunting, but if you follow the tips and advice in this guide, you'll soon adapt.

We recommend you keep this somewhere safe, as you may like to refer to the information inside throughout your studies.

Why study A-level Physics?

Physicists explore the fundamental nature of almost everything we know of. They study everything from the fundamental particles that build matter, to the galaxies that make up the universe itself. Join them to enter a world deep beneath the surface of normal human experience.

Even if you don't decide to work in physics, studying it still develops useful and transferable skills for other careers. You'll develop research, problem solving and analytical skills, alongside teamwork and communication. Universities and business regard all of these very highly.

Possible degree options

According to bestcourse4me.com the top seven degree courses taken by students who have A-level Physics are:

- mathematics
- physics
- mechanical engineering
- computer science
- civil engineering
- economics
- business.

For more details, go to bestcourse4me.com or UCAS.

Which career appeals to you?

Studying Physics at A-level or degree level opens up all sorts of career opportunities.

- Geophysicist/field seismologist
- Healthcare scientist, medical physics
- Higher education lecturer or secondary school teacher
- Radiation protection practitioner
- Research scientist (physical sciences)
- Scientific laboratory technician
- Meteorologist
- Structural or Acoustic engineer
- Product/process development scientist
- Systems developer
- Technical author.

You can also move into engineering, astrophysics, chemical physics, nanotechnology, renewable energy and more. With physics, the opportunities are endless.

Specification at a glance

AS and A-level

1 Measurements and their errors

2 Particles and radiation

3 Waves

4 Mechanics and materials

5 Electricity

A-level only

6 Further mechanics and thermal physics

7 Fields and their consequences

8 Nuclear physics

9 Optional topics. You will study one of these: Astrophysics, Medical physics, Engineering physics, Turning points in physics or Electronics.

The assessment for the A-level consists of three exams

Paper 1	Paper 2	Paper 3
What's assessed Sections 1 – 5 and 6.1 (Periodic motion)	What's assessed Sections 6.2 (Thermal Physics), 7 and 8 Assumed knowledge from sections 1 to 6.1	What's assessed Section A: Compulsory section: Practical skills and data analysis Section B: Optional topic
Assessed • written exam: 2 hours • 85 marks • 34% of A-level	Assessed • written exam: 2 hours • 85 marks • 34% of A-level	Assessed • written exam: 2 hours • 80 marks • 32% of A-level
Questions 60 marks of short and long answer questions and 25 multiple choice questions on content.	Questions 60 marks of short and long answer questions and 25 multiple choice questions on content.	Questions 45 marks of short and long answer questions on practical experiments and data analysis. 35 marks of short and long answer questions on optional topic.

Resources to help

Our website is a great place to start.

Our Physics webpages are aimed at teachers, but you may find them useful too. Information includes:

- The specification – this explains exactly what you need to learn for your exams.
- Practice exam papers
- Lists of command words and subject specific vocabulary – so you understand the words to use in exams
- Practical handbooks explain the practical work you need to know
- Past papers from the old specification. Some questions won't be relevant to the new AS and A-level, so please check with your teacher.
- Maths skills support.

Institute of Physics (IOP)

The IOP do everything from research like that taking place at CERN to lobbying MPs. You'll find lots of handy resources on their website at iop.org/tailored/students/

The student room

Join the A-level Physics forums and share thoughts and ideas with other students if you're stuck with your homework. Just be very careful not to share any details about your assessments, there are serious consequences if you're caught cheating. Visit thestudentroom.co.uk

Textbooks

Our approved textbooks are published by Collins, Hodder and Oxford University Press. Textbooks from other publishers will also be suitable, but you'll need to double check that the content and formula symbols they use match our specification.

Revision guides

These are great if you want a quick overview of the course when you're revising for your exams. Remember to use other tools as well, as these aren't detailed enough on their own.

YouTube

YouTube has thousands of Physics videos. Just be careful to look at who produced the video and why because some videos distort the facts. Check the author, date and comments – these help indicate whether the clip is reliable. If in doubt, ask your teacher.

Magazines

Focus, New Scientist or Philip Allan updates can help you put the physics you're learning in context.

Useful information and activities

Greek letters

Greek letters are used often in science. They can be used as symbols for numbers (such as π = 3.14…), as prefixes for units to make them smaller (eg μm = 0.000 000 001 m) or as symbols for particular quantities (such as λ which is used for wavelength).

The Greek alphabet is shown below.

Α	α	alpha
Β	β	beta
Γ	γ	gamma
Δ	δ	delta
Ε	ε	epsilon
Ζ	ζ	zeta
Η	η	eta
Θ	θ	theta
Ι	ι	iota
Κ	κ	kappa
Λ	λ	lambda
Μ	μ	mu

Ν	ν	nu
Ξ	ξ	ksi
Ο	ο	omicron
Π	π	pi
Ρ	ρ	rho
Σ	ς or σ	sigma
Τ	τ	tau
Υ	υ	upsilon
Φ	φ	phi
Χ	χ	chi
Ψ	ψ	psi
Ω	ω	omega

<u>Part 2</u>

Recap of **Maths Skills** and **S.I.units**

(Level: Low demand)

<u>Task</u>: Complete Activity 1 to 14

<u>Due date</u>: 29th May 2020

Activity 1

List all of the uses of Greek letters that you have encountered in your GCSE Science and Maths studies.

SI units

Every measurement must have a size (eg 2.7) and a unit (eg metres or °C). Sometimes, there are different units available for the same type of measurement. For example ounces, pounds, kilograms and tonnes are all used as units for mass.

To reduce confusion, and to help with conversion between different units, there is a standard system of units called the SI units which are used for most scientific purposes.

These units have all been defined by experiment so that the size of, say, a metre in the UK is the same as a metre in China.

The seven SI base units are:

Physical quantity	Usual quantity symbol	Unit	Abbreviation
mass	m	kilogram	kg
length	l or x	metre	m
time	t	second	s
electric current	I	ampere	A
temperature	T	kelvin	K
amount of substance	N	mole	mol
luminous intensity	(not used at A-level)	candela	cd

All other units can be derived from the SI base units. For example, area is measured in square metres (written as m^2) and speed is measured in metres per second (written as ms^{-1}).

Some derived units have their own unit names and abbreviations, often when the combination of SI units becomes complicated. Some common derived units are:

Physical quantity	Usual quantity symbol	Unit	Abbreviation	SI unit
Force	F	newton	N	$kg\ m\ s^{-2}$
Energy	E or W	joule	J	$kg\ m^2\ s^{-2}$
Frequency	f	hertz	Hz	s^{-1}

It is not always appropriate to use a full unit. For example, measuring the width of a hair or the distance from Manchester to London in metres would cause the numbers to be difficult to work with.

Prefixes are used to multiply each of the units. You will be familiar with centi (meaning 1/100), kilo (1000) and milli (1/1000) from centimetres, kilometres and millimetres.

There is a wide range of prefixes. The majority of quantities in scientific contexts will be quoted using the prefixes that are multiples of 1000. For example, a distance of 33 000 m would be quoted as 33 km. The most common prefixes you will encounter are:

Prefix	Symbol	Multiplication factor		
Tera	T	10^{12}	1 000 000 000 000	
Giga	G	10^{9}	1 000 000 000	
Mega	M	10^{6}	1 000 000	
kilo	k	10^{3}	1000	
deci	d	10^{-1}	0.1	1/10
centi	c	10^{-2}	0.01	1/100
milli	m	10^{-3}	0.001	1/1000
micro	μ	10^{-6}	0.000 001	1/1 000 000
nano	n	10^{-9}	0.000 000 001	1/1 000 000 000
pico	p	10^{-12}	0.000 000 000 001	1/1 000 000 000 000
femto	f	10^{-15}	0.000 000 000 000 001	1/1 000 000 000 000 000

Activity 2

Which SI unit and prefix would you use for the following quantities?

1. The length of a finger
2. The temperature of boiling water
3. The time between two heart beats
4. The width of an atom
5. The mass of iron in a bowl of cereal
6. The current in a simple circuit using a 1.5 V battery and bulb

Sometimes, there are units that are used that are not combinations of SI units and prefixes.

These are often multiples of units that are helpful to use. For example, a light year is a distance of $9.46 \times 10^{12}\ \mathrm{km}$.

Activity 3

Re-write the following in SI units.

1. 1 minute
2. 1 hour
3. 1 tonne

Activity 4

Re-write the following quantities:

1. 1502 metres in kilometres

2. 0.000 45 grams in micrograms

3. 0.000 45 metres in millimetres

4. 1055 kilometres in metres

5. 180 megaseconds in seconds

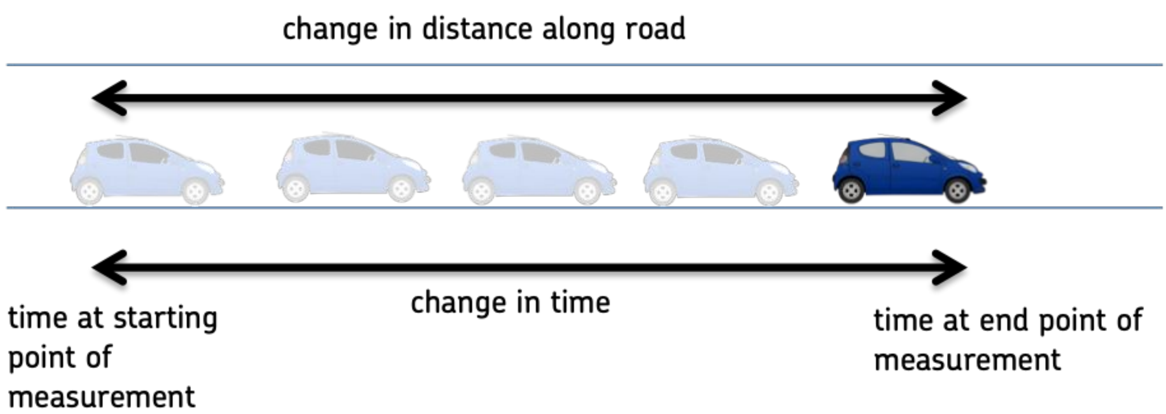
6. 2500 centimetres in millimetres

The delta symbol Δ

The delta symbol is used to mean "change in". For example, at GCSE, you would have learned the formula:

$speed = \frac{distance}{time}$ which can be written as $s = \frac{d}{t}$

What you often measure is the change in the distance of the car from a particular point, and the change in time from the beginning of your measurement to the end of it.



Because of the fact that the distance and the speed are changing, you use the delta symbol to emphasise this. The A-level version of the above formula becomes:

$velocity = \frac{displacement}{time}$ which can be written as $v = \frac{\Delta s}{\Delta t}$

Note: the delta symbol is a property of the quantity it is with, so you treat "Δs" as one thing when rearranging, and you cannot cancel the delta symbols in the equation above.

Activity 5

Research exercise

1. Find out the difference between:

   speed and velocity

   distance and displacement

2. Look at the A-level Physics formula sheet on the AQA website (it's under "assess" on the Physics A-level page). Which equations look similar to ones you've encountered at GCSE, but include the delta symbol?

Important vocabulary for practical work

There are many words used in practical work. You will have come across most of these words in your GCSE studies. It is important that you are using the right definition for each word. The activity on the next page tests your understanding of terms used in practical work.

Activity 6

Join the boxes to link the word to its definition.

Accurate	A statement suggesting what may happen in the future.
Data	An experiment that gives the same results when a different person carries it out, or a different set of equipment or technique is used.
Precise	A measurement that is close to the true value.
Prediction	An experiment that gives the same results when the same experimenter uses the same method and equipment.
Range	Physical, chemical or biological quantities or characteristics.
Repeatable	A variable that is kept constant during an experiment.
Reproducible	A variable that is measured as the outcome of an experiment.
Resolution	This is the smallest change in the quantity being measured (input) of a measuring instrument that gives a perceptible change in the reading.
Uncertainty	The interval within the true value can be expected to lie.
Variable	The spread of data, showing the maximum and minimum values of the data.
Control variable	Measurements where repeated measurements show very little spread.
Dependent variable	Information, in any form, that has been collected.

Maths help

Physics uses the language of mathematics to make sense of the world. It is important that you are able to use maths. The following exercises will help you to practise some of the maths you have covered during your GCSE studies to help with your A-level course.

Activity 7: Standard form

1. Write in standard form

   (a) 379.4

   (b) 0.0712

2. Write as ordinary numbers (use the data sheet on the last page of this booklet):

   (a) The speed of light

   (b) The charge on an electron

3. Write one quarter of a million in standard form.

4. Write these constants in ascending order (ignoring units):

   permeability of free space; the Avogadro constant; proton rest mass;

   acceleration due to gravity; mass of the Sun.

5. Work out the value of the following.

   Give your answer in standard form.

   The mass of an electron/the mass of the Earth (use the data sheet).

6. Solve $(2.4 \times 10^7)x = 1.44 \times 10^9$

   Give your answer in standard form.

Activity 8: Decimal places, significant figures and rounding

1. How many rockets would be needed to deliver 30 tonnes of material to a space station, if every rocket could hold 7 tonnes?

2. A power station has an output of 3.5 MW. The coal used had a potential output of 9.8 MW.

   Work out the efficiency of the power station.

   Give your answer as a percentage to one decimal place.

3. A radioactive source produces 17 804 beta particles in 1 hour.

   Calculate the mean number of beta particles produced in 1 minute.

   Give your answer to one significant figure.

Activity 9: Fractions, ratios and percentages

1. The ratio of turns of wire on a transformer is 350 : 7000 (input : output)

   What fraction of the turns are on the input side?

2. A bag of electrical components contains resistors, capacitors and diodes.

   $\frac{2}{5}$ of the components are resistors.

   The ratio of capacitors to diodes in a bag is 1 : 5. There are 100 components in total.

   How many components are diodes?

3. The number of coins in two piles are in the ratio 5 : 3. The coins in the first pile are all 50p coins. The coins in the second pile are all £1 coins.

   Which pile has the most money?

4. A rectangle measures 3.2 cm by 6.8 cm. It is cut into four equal sized smaller rectangles.

   Work out the area of a small rectangle.

5. Small cubes of edge length 1 cm are put into a box. The box is a cuboid of length 5 cm, width 4 cm and height 2 cm.

   How many cubes are in the box if it is half full?

6. In a circuit there are 600 resistors and 50 capacitors. 1.5% of the resistors are faulty. 2% of the capacitors are faulty.

   How many faulty components are there altogether?

7. How far would you have to drill in order to drill down 2% of the radius of the Earth?

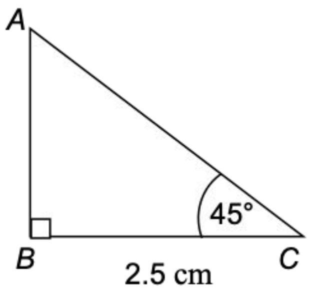
8. Power station A was online 94% of the 7500 days it worked for.

   Power station B was online $\frac{8}{9}$ of the 9720 days it worked for.

   Which power station was offline for longer?

Activity 10: Use sine, cosine and tangent

1 (a) Work out the length of *AB*.



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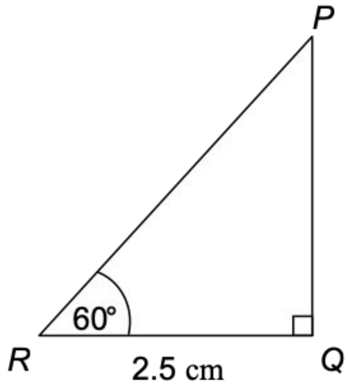
(b) Work out the length of *PR*.



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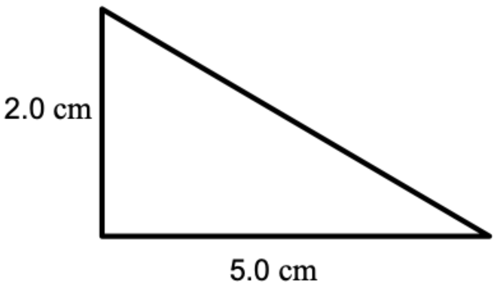
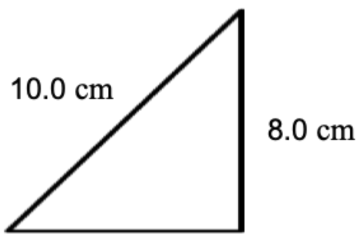
Activity 11: Pythagoras's theorem

Work out the lengths of the unlabelled sides.





Activity 12: Arithmetic means

1. The mean weight of 9 people is 79 kg

   A 10th person is such that the mean weight increases by 1 kg

   How heavy is the 10th person?

2. A pendulum completes 12 swings in 150 s.

   Work out the mean swing time.

Activity 13: Rearranging formulas

1. Rearrange $y = 2x + 3$ to make x the subject.

2. Rearrange $C = 2\pi r$ to make r the subject.

3. Rearrange $E = \frac{1}{2}mv^2$ to make v the subject.

4. Rearrange $s = ut + \frac{1}{2}at^2$ to make u the subject.

5. Rearrange $s = ut + \frac{1}{2}at^2$ to make a the subject.

6. Rearrange $\omega = \frac{v}{r}$ to make r the subject.

7. Rearrange $T = 2\pi\sqrt{\frac{v}{r}}$ to make r the subject.

8. Rearrange $v = \omega\sqrt{A^2 - x^2}$ to make x the subject.

Note: in science, subscripts are often used to label quantities. So in the following two examples, there are two masses, m_1 and m_2. The 1 and 2 are part of the quantity and should be kept with the m.

9. Rearrange $F = \frac{Gm_1m_2}{r^2}$ to make m_2 the subject.

10. Rearrange $F = \frac{Gm_1m_2}{r^2}$ to make r the subject.

Activity 14: Graphs

1. The cost of hiring a piece of equipment is given by the formula $C = 8d + 10$, where d is the number of days for which the equipment is hired and C (£) is the total cost of hire.

   Add a line to the graph to show this equation $C = 8d + 10$

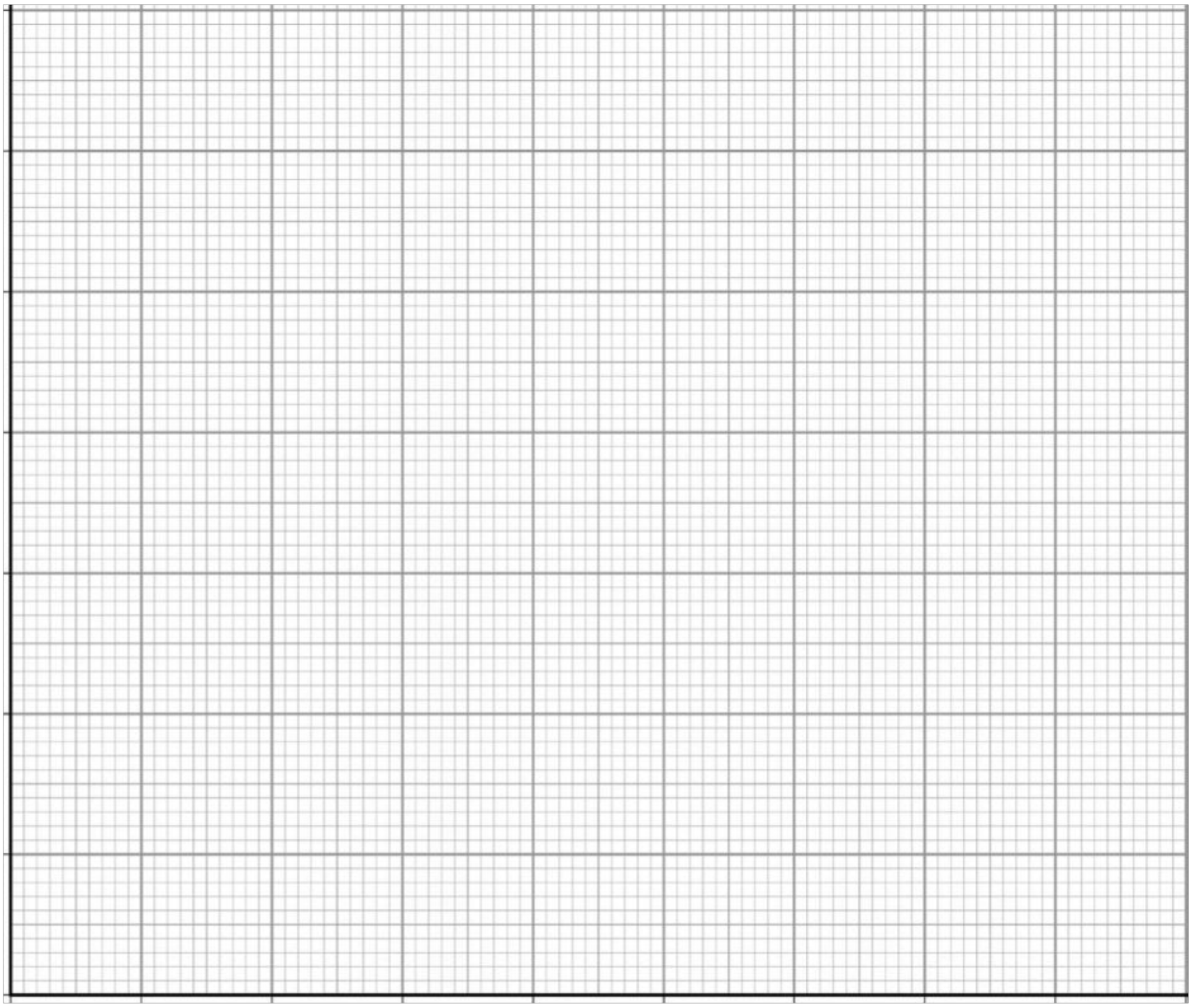
2. For the above graph, what was the deposit required for hiring the equipment?

3. Another shop hires out equipment where the cost of hire is given by the formula $C = 5d + 24$

   Josh says that the first supplier is always cheaper if you want to hire equipment.

   Add this formula to the graph.

   Is he correct? Give reasons for your answer.



Activity 14: Graphs (continued)

4. The cost of hiring a laser is worked out as follows:

   Fixed charge = £28

   Cost per day = £12

   Draw a graph to work out the cost of hiring the laser for 6 days.

5. Another firm hires out a laser machine for £22 fixed charge, plus the cost of the first 2 days at £20 per day, then £8 for each additional day.

   Draw a graph on the same axes as the one above to show the cost of hiring the laser for 6 days.

   Which firm would you use to hire the laser machine for 5 or more days?

   Give reasons for your answer.

Activity 14: Graphs (continued)

6. Draw graphs of the following functions from x = −3 to x = +3

   Choose axes that allow all values of all graphs to be shown.

   $y = x^2$, $y = x^3$ and $y = \sqrt{(x)}$ for positive numbers only .

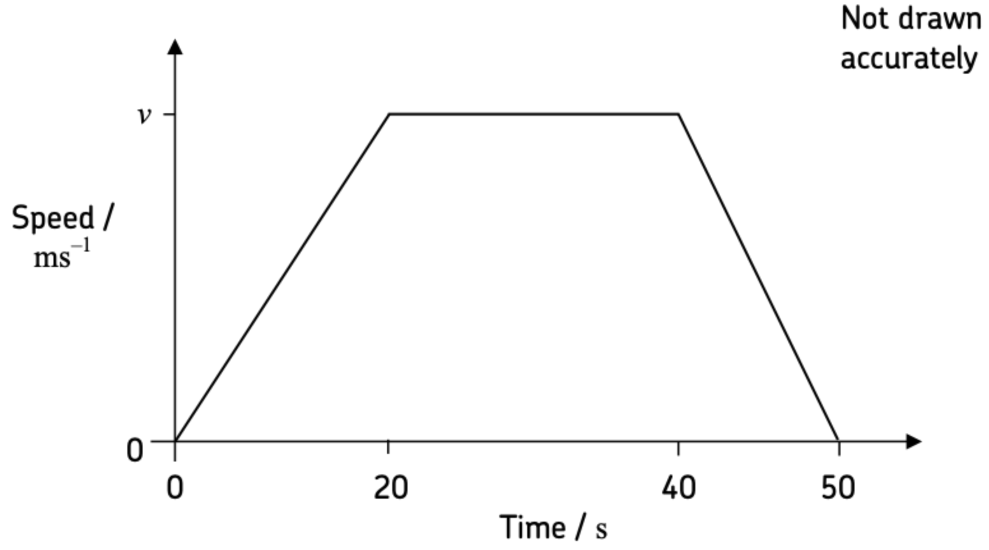
Activity 15: Gradients and areas

1. The graph shows the speed of a car between two sets of traffic lights.

   It achieves a maximum speed of v metres per second.

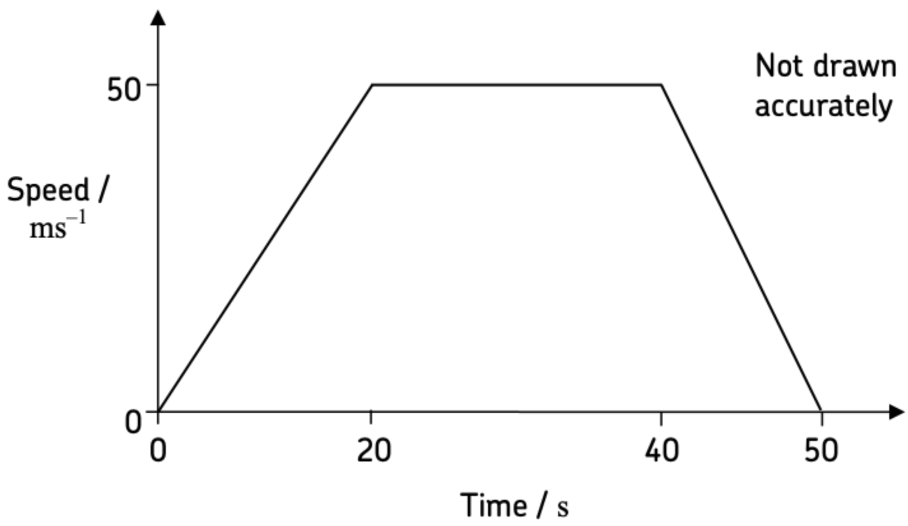
   It travels for 50 seconds.

   The distance between the traffic lights is 625 metres.



   Calculate the value of v

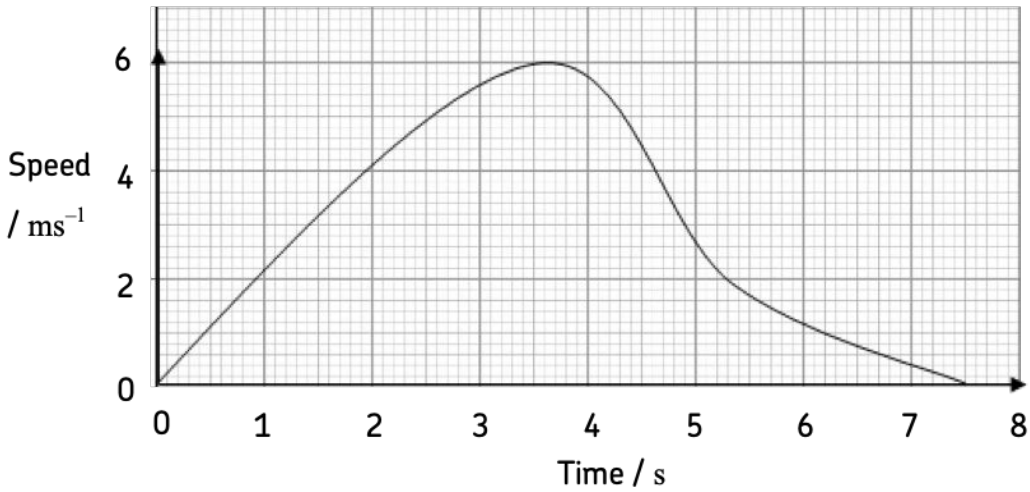
2. The graph shows the speed of a train between two stations.



   Calculate the distance between the stations.

Activity 16: Non-linear graphs

3 The graph shows the speed-time graph of a car.



Use the graph to work out:

a. The maximum speed of the car.

b. The total distance travelled.

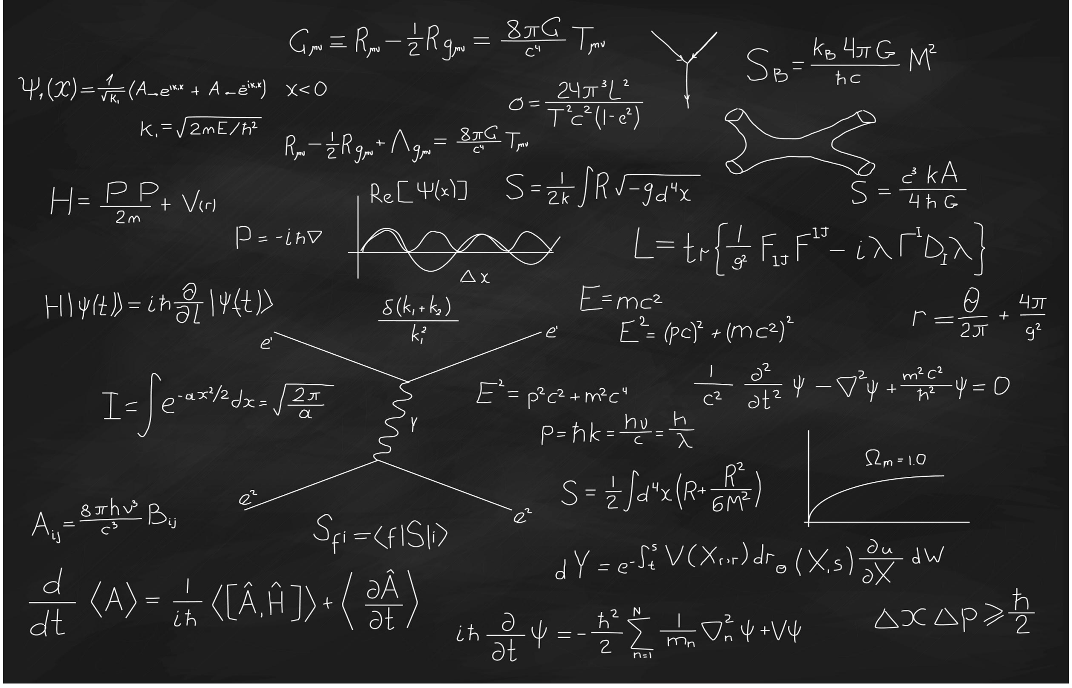
c. The average speed for the journey.

d. The deceleration of the car after 8 seconds.

There are a number of activities throughout this resource. The answers to some of the activities are available on our secure website, e-AQA. Your teacher will be able to provide you with these answers.

Data Sheet

Quantity	Symbol	Value	Units
speed of light in vacuo	c	3.00×10^{8}	$m\ s^{-1}$
permeability of free space	μ_0	$4\pi \times 10^{-7}$	$H\ m^{-1}$
permittivity of free space	ε_0	8.85×10^{-12}	$F\ m^{-1}$
magnitude of the charge of electron	e	1.60×10^{-19}	C
the Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	$N\ m^{2}\ kg^{-2}$
the Avogadro constant	N_A	6.02×10^{23}	mol^{-1}
electron rest mass	m_e	9.11×10^{-31}	kg
proton rest mass	m_p	$1.67(3) \times 10^{-27}$	kg
neutron rest mass	m_n	$1.67(5) \times 10^{-27}$	kg
gravitational field strength	g	9.81	$N\ kg^{-1}$
acceleration due to gravity	g	9.81	$m\ s^{-2}$
atomic mass unit	u	1.661×10^{-27}	kg
mass of the Sun		1.99×10^{30}	kg
mean radius of the Sun		6.96×10^{8}	m
mass of the Earth		5.98×10^{24}	kg
mean radius of the Earth		6.37×10^{6}	m



Part 3

Prerequisite knowledge check :

1. **Electricity**
2. **Force**
3. **Motion**
4. **Space & Radioactivity,**
5. **Energy & Waves.**

(Level: Standard demand)

Task: Answer all the questions on the above 5 topics.

Due date: 26th June 2020

Electricity

The questions below are intended to test your knowledge of key ideas covered in most GCSE specifications. Answers with brief explanations follow. You should revise any areas which you find difficult or do not score well on.

Conductors and insulators

1 Name three good electrical conductors, including one non-metal.

2 Name three electrical insulators.

3 What name is given to the property of a material that gives a measure of how easy it is for electrical current to flow through it?

4 Why does a circuit stop working when a switch is open?

Circuit symbols

5 Copy the table and complete the missing circuit symbols and their names.

symbol	name
	cell
	
	resistor
	
	bulb

Circuits

6 Draw a simple circuit containing a cell, bulb, ammeter and voltmeter.

7 Label the positive and negative sides of the cell symbol.

8 Copy and complete: An ammeter measures .... flowing in a circuit and is always placed in .... with components in the circuit.

9 Copy and complete: A voltmeter measures .... across a component and is always placed in .... with components in the circuit.

10 What changes and what remains the same as you move round a series circuit?

Safety

11 What are the colours of the mains wires in a plug?

12 Name what each wire is.

13 Explain how a fuse works.

14 If someone is electrocuted what is the first thing you should do?

Calculations

15 What is the total resistance when a 470 Ω resistor is placed in series with a 500 Ω resistor?

16 What is the voltage across a 24 Ω resistor if a current of 0.78 A flows through it? (Use $V = IR$)

17 What is the voltage across an 11 kΩ resistor if a current of 0.055 A flows through it? (Use $V = IR$)

18 Rearrange $V = IR$ so that current is the subject instead of voltage.

19 Calculate the resistance of a circuit if 1.2 A flows around it when the voltage of the supply is 12 V.

20 Calculate the resistance of a resistor if 0.22 A flows through it when the voltage across it is 230 V.

Forces

The questions below are intended to test your knowledge of key ideas covered in most GCSE specifications. Answers with brief explanations follow. You should revise any areas which you find difficult or do not score well on.

Examples of forces

1 What name is given to the force of gravity on an object?

2 What is the name of the force that makes raindrops and bubbles round?

3 What force between tyres and the surface of a road enables a car to corner?

4 What force causes some objects to float in water?

5 What name is given to the force acting along a rope that is pulled taut?

6 What name is given to the force on the wings of an aeroplane during flight?

7 Draw the forces acting on

a. a book on a table

b. a ball on the floor

c. a ball falling towards the ground

d. a boat on a still lake

Balanced and unbalanced forces

8 What is the name given to the force put on an object by the surface it rests on?

9 What is the same, and what is different, about a pair of forces if they are balanced with each other?

10 What does it mean to say a body is in equilibrium?

11 What does an unbalanced force do to an object's motion?

Newton's Laws of Motion

12 State Newton's First Law of Motion.

13 Write the formula for Newton's Second Law of Motion.

14 What 'saying' is a version of Newton's Third Law of Motion?

Pressure

15 a. State the equation for pressure in a liquid and name all the variables and their units.
b. Describe a situation where pressure is exerted on one object by another.

16 State the density of water.

17 a. Explain how pressure varies with varying depth and density in a liquid.
b. State the equation that shows the relationship between pressure, depth and density.

18 Calculate the pressure at a depth of 0.1 m in water.

19 Calculate the pressure in air of average density 0.6 kg m^{-3} at a depth of 18 km.

20 Calculate the pressure at a depth of 253 m in seawater with a density of 1030 kg m^{-3}.

Motion

The questions below are intended to test your knowledge of key ideas covered in most GCSE specifications. Answers with brief explanations follow. You should revise any areas which you find difficult or do not score well on.

Speed

1 Speed is a measure of how far an object travels in a given time. Write an equation that relates speed, distance and time.

2 What is the metric unit for speed?

3 What is the average speed of a sprinter, if they travel 200 metres in 19.2 seconds?

4 Calculate the average speed of a snail covering 1.6 metres in 26 minutes.

5 How far does sound travel in 10 seconds, if its speed in air is 330 $m s^{-1}$?

6 How long does it take a car travelling at 24 $m s^{-1}$ to cover a distance of 1.2 km?

Acceleration

7 Acceleration is the change in speed in a given time. The change in speed is the final speed minus the initial speed, so when the initial speed is zero (that is, when an object starts at rest), the change in speed is the same thing as the final speed. Write an equation that relates acceleration, speed and time.

8 Write the metric unit for acceleration.

9 If a cyclist reaches a speed of 5 $m s^{-1}$, after starting from rest, in 3 seconds, what is their acceleration?

10 A sprinter achieved a speed of 12 $m s^{-1}$, 1.4 seconds after the starter's gun was fired. What was their acceleration?

11 If an object starting at rest falls with an acceleration of 10 $m s^{-2}$, what is its speed at 8 seconds?

12 How long does it take for a rocket travelling at 100 $m s^{-1}$ to increase its speed to 150 $m s^{-1}$, if the rocket motor can produce an acceleration of 25 $m s^{-2}$?

Force and motion

13 Explain the difference between stopping distance, thinking distance and braking distance for vehicles on the road.

14 Give three factors that affect thinking distance.

15 Give three factors that affect braking distance.

16 Name two safety features modern cars have that are designed to reduce the size of forces on occupants during an impact.

17 Engine thrust acts forwards when a car is travelling on a road. This is opposed by drag (friction and air resistance) acting in the opposite direction to motion. What happens to these forces:

a. when the car accelerates?

b. when the car brakes?

Space and Radioactivity

The questions below are intended to test your knowledge of key ideas covered in most GCSE specifications. Answers with brief explanations follow. You should revise any areas which you find difficult or do not score well on.

Space

Earth and Moon

1 How long does it take for the Earth to rotate on its axis once?

2 How long does it take for the Moon to orbit the Earth once?

3 How many people have landed on the Moon?

4 Why do you need a space suit on the Moon?

5 Why is the strength of gravity lower on the Moon's surface than on Earth's?

6 What advantage do telescopes mounted on satellites in orbit have over ground-based telescopes?

Solar system

7 Who is credited with first suggesting that the Earth orbits the sun?

8 What name is given to the model of the solar system where planets orbit the sun?

9 List the four gas giant planets in our solar system in order of distance from the Sun.

10 Place the following planets in order of surface temperature from highest to lowest: Earth, Mars, Venus, Mercury.

Stars

11 What is the nearest star to the Earth?

12 Approximately how far, in light years, is the next nearest star?

13 What force causes stars to form?

14 What process powers stars?

15 What type of star do stars like the sun become as they start burning helium?

16 Very large stars end their short 'lives' in a huge explosion called a supernova. What extreme object can be formed from the core of the exploding star?

Radioactivity

Atoms and isotopes

17 Write the relative charges of the electron, proton and neutron.

18 Write the relative masses of the electron, proton and neutron.

19 Deuterium is an isotope of hydrogen. What is different between hydrogen and deuterium?

20 Carbon-12 has a nucleon number of 12 and a proton number of 6. How many neutrons does it have in its nucleus?

Alpha, beta and gamma

21 Write the relative charges of alpha, beta and gamma radiation.

22 Write the relative masses of alpha, beta and gamma radiation.

23 What happens to an isotope when it emits alpha or beta radiation?

24 Why can exposure to radiation be dangerous?

Sources and uses of radiation

25 Name three sources of background radiation.

26 Describe how radioactive tracers are used in medicine.

27 Explain why smoke detectors work with alpha radiation but why beta or gamma radiation would not be suitable.

28 What process happens in a nuclear power plant, and what is the usual fuel?

Energy and Waves

The questions below are intended to test your knowledge of key ideas covered in most GCSE specifications. Answers with brief explanations follow. You should revise any areas which you find difficult or do not score well on.

Energy

1 What is the metric unit for energy?

2 What is the name given to the energy of a moving object?

3 Give two examples of things that store chemical energy.

4 State the meaning of energy conservation.

Energy transfers

5 Describe the energy transfers occurring in a light bulb.

6 Why is uranium used in nuclear power plants?

7 Describe the energy transfers involved in converting coal into electricity.

8 Name two gases that are responsible for the greenhouse effect.

9 Name a renewable and a non-renewable energy source for generating electricity, neither one originating with the energy of the sun.

Heat and temperature

10 Why does a solid turn into a liquid when heated?

11 When ice melts in a hot room, why does the temperature of the ice remain constant for a time as it melts?

12 List the three methods of heat transfer.

13 Which of the methods of heat transfer is responsible for heat passing from the sun to the Earth?

14 Which contains more heat energy – a hot cup of tea or a warm bath of water?

Waves

Types of waves

15 List three examples of transverse waves.

16 Draw a diagram of a transverse wave.

a. Label the amplitude.

b. Label the wavelength.

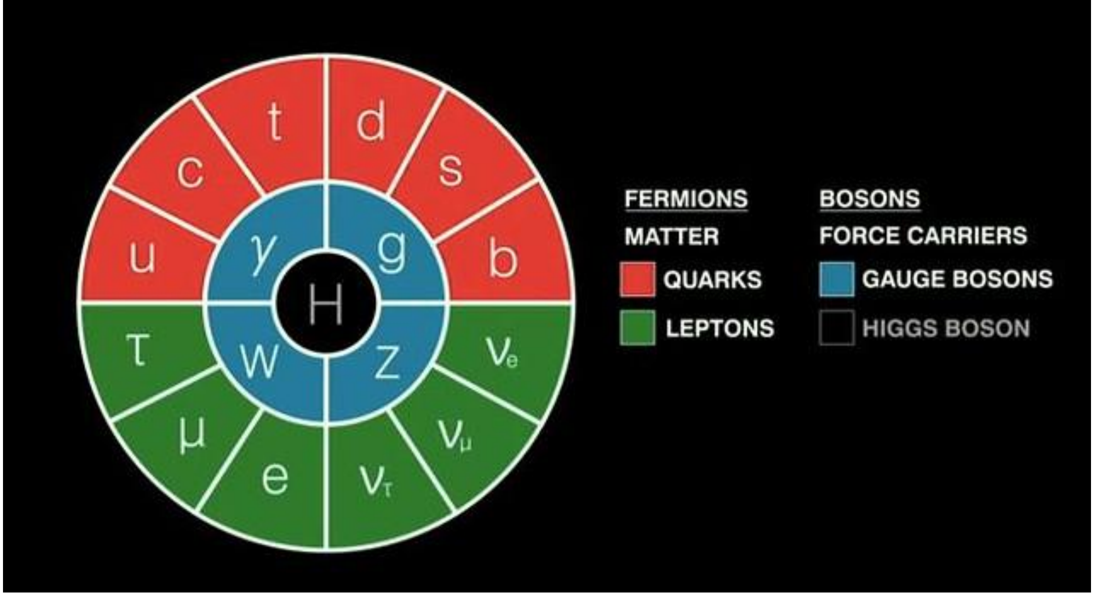
17 What type of wave is a sound wave?

Properties of waves

18 All waves can be reflected. Name two other ‘things’ all waves can do.

19 Draw a diagram to show a ray of light reflecting off of a plane mirror. Include the normal for the mirror.

20 In reflection, what is the relationship between the incident angle and the reflected angle?



Part 4

Learning Definitions, Key terms & more Maths Skills:

1. ***Practical Science****: Define terms*
2. ***Foundation Physics****: Learn and Recall answers.*
3. ***Maths****: Check your skills*

(Level: High demand)

Task: Follow the instruction given and do all the Practice questions

Due date: Sep 2020

Transition from GCSE to A Level

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

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

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

Learning objectives

After completing the worksheet you should be able to:

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

Retrieval questions

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

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

Practical science key terms

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

Foundations of Physics

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

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

Matter and radiation

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

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

Maths skills

1 Measurements

1.1 Base and derived SI units

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

Base units

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

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

Derived units

Example:

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

If a car travels 2 metres in 2 seconds:

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

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

Practice questions

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

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

1.2 Significant figures

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

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

3.62   25.4   271   0.0147   0.245   39 400

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

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

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

Standard form numbers with 3 significant figures:

9.42×10^{-5} 1.56×10^{8}

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

590 (to 3.s.f.) or 5.90×10^{2}

Practice questions

2 Give these measurements to 2 significant figures:

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

3 Use the equation:

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

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

1.3 Uncertainties

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

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

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

It is useful to quote these uncertainties as percentages.

For the above length, for example,

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

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

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

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

Practice questions

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

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

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

a 1200 W ± 10% **b** 330 000 Ω ± 0.5%

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

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

2 Standard form and prefixes

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

2.1 Standard form for large numbers

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

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

2.2 Prefixes for large numbers

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

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

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

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

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

Practice questions

1 Give these measurements in standard form:

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

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

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

2.3 Standard form and prefixes for small numbers

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

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

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

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

Practice questions

3 Give these measurements in standard form:

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

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

5 Write the following measurements using suitable prefixes.

a a microwave wavelength = 0.009 m

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

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

2.4 Powers of ten

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

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

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

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

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

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

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

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

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

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

Practice questions

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

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

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

c $2^3 \times 10^2$

d $10^5 \div 10^2$

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

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

b radio waves, wavelength 1000 m

c X-rays, wavelength 1.0×10^{-10} m.

3 Resolving vectors

3.1 Vectors and scalars

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

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

Practice questions

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

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

3.2 Drawing vectors

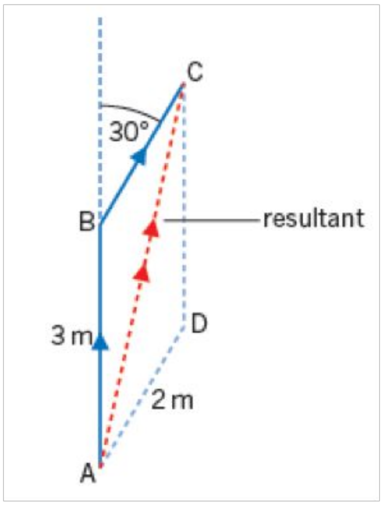
Vectors are shown on drawings by a straight arrow. The arrow starts from the point where the vector is acting and shows its direction. The length of the vector represents the magnitude.

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

The combined effect of the vectors is called the resultant.

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

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

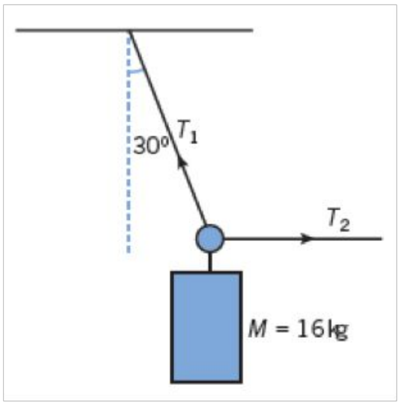


Practice questions

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

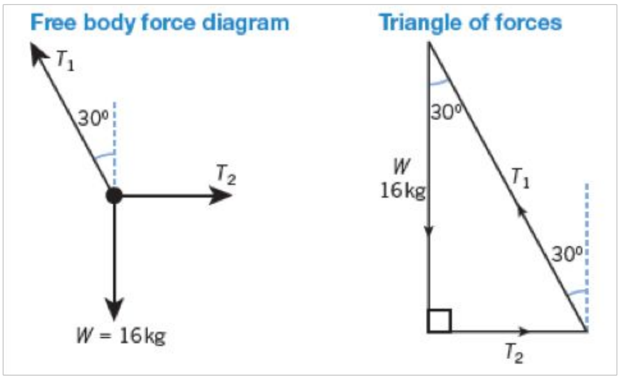
3.3 Free body force diagrams

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



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

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



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

Practice questions

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

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

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

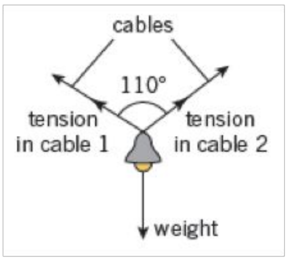


Figure 1

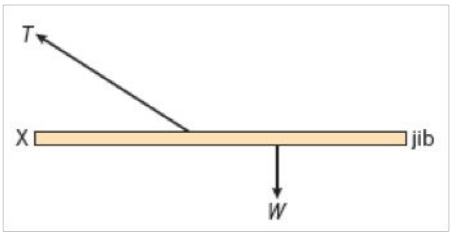


Figure 2

3.4 Calculating resultants

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

For a right-angled triangle as shown:

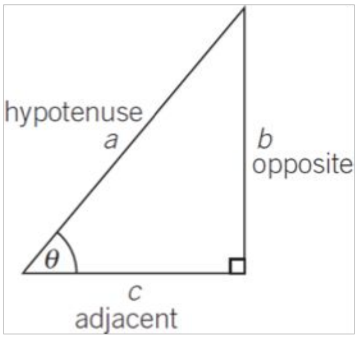
$h^2 = o^2 + a^2$

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

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

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

(soh-cah-toa).



Practice questions

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

7 Find the resultant force for the following pairs of forces at right angles to each other:
a 3.0 N and 4.0 N **b** 5.0 N and 12.0 N

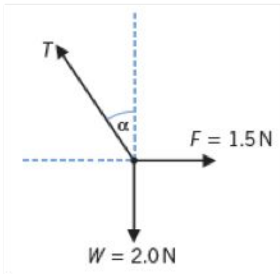


Figure 3

4 Rearranging equations

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

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

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

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

When you are solving a problem:

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

  or
- substitute the values and then rearrange the equation

4.1 Substitute and rearrange

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

Step 1: Known values are:

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

Step 2: Equation:

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

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

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

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

Step 3: Rearranging:

$-19.62\, s = -25$

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

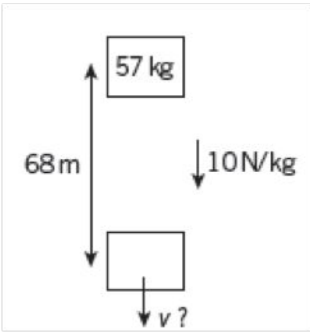
Practice questions

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

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

4.2 Rearrange and substitute

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



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

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

Step 2: There are three equations:

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

Step 3: Rearrange the equations before substituting into it.

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

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

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

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

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

Step 4: Substitute into the equation:

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

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

Practice questions

3 Calculate the specific latent heat of fusion for water from this data:
4.03×10^4 J of energy melted 120 g of ice.
Use the equation:

thermal energy for a change in state (J) = mass (kg) × specific latent heat (J kg^{-1})

Give your answer in J kg^{-1} in standard form.

5 Work done, power, and efficiency

5.1 Work done

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

work done = energy transferred = force × distance

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

Practice questions

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

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

5.2 Power

Power is the rate of work done.

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

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

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

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

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

Gravitational potential energy gained:

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

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

Practice questions

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

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

5.3 Efficiency

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

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

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

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

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

Practice questions

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

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

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

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

Part 5

So you are considering A Level Physics?

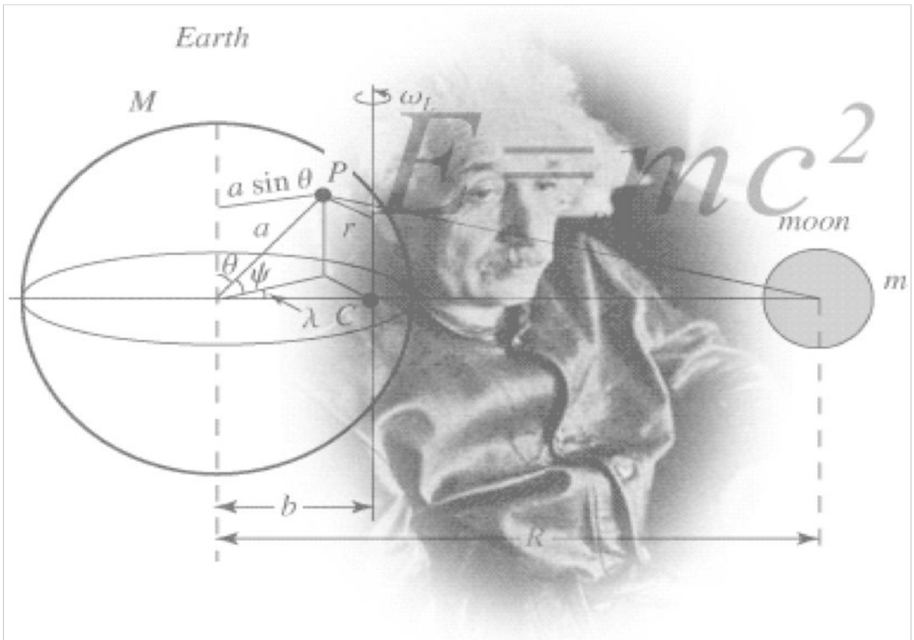


Figure 1 http://scienceworld.wolfram.com/physics/images/main-physics.gif

Physics Beyond A Level curriculum

Recommendation of books, videos and websites.

Welcome, Future Physicists

If you have been thinking about studying Physics then you must have an inquisitive mind and you may have been wondering or asking yourself questions like:

- Do heavy objects fall faster than lighter ones, and is it any different on the moon?
- If I get thrown out of a cannon can I figure out how high I will go and where I will land, and does it depend on my weight or my speed?
- How does the speed camera know how fast I am going, and the SatNav know where I am? And what safety features does my car have built in when I find myself in a jam?
- What makes Christmas tree lights flash on and off, and how can I make them brighter?
- How does a microwave do what it does, and why can I hear around corners?

We will be supplying the answers to questions like these and many many more in A-level physics.

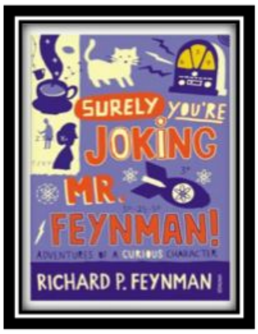
If you continue to pursue the subject at university you will find that **Physics graduates are in great demand, as pilots, engineers, consultant, accountants, management/computer analysts, in the City – anywhere that profound analytical skills are required.**

However, to satisfy your inquisitivity for now I have shared some recommendation of books, video, websites, interviews, **which will broaden your knowledge horizon and teach you to think out of the box.**

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**

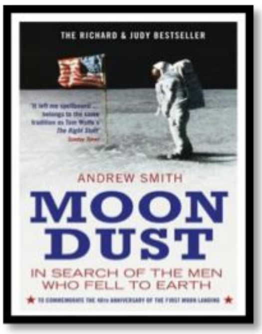


ISBN - 009917331X - Richard Feynman was a Nobel Prize winning Physicist. In my opinion he epitomises what a Physicist is. By reading this books you will get insight into his life's work including the creation of the first atomic bomb and his bongo playing adventures and his work in the field of particle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

(Also available on Audio book).

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

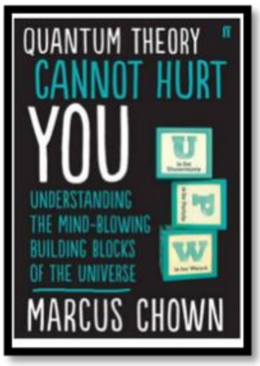
2. **Moondust: In Search of the Men Who Fell to Earth**



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

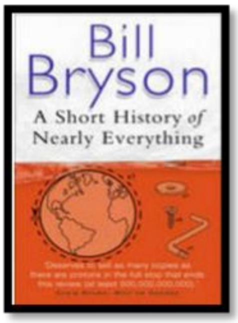
3. **Quantum Theory Cannot Hurt You: Understanding the Mind-Blowing Building Blocks of the Universe**



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

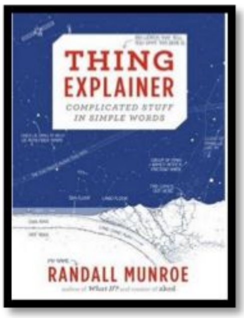
4. **A Short History of Nearly Everything**



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. **Feynman Lectures** - My favourite educator and Physicist Prof

https://www.microsoft.com/en-us/research/project/tuva-richard-feynman/?from=http://research.microsoft.com/apps/tools/tuva/

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.

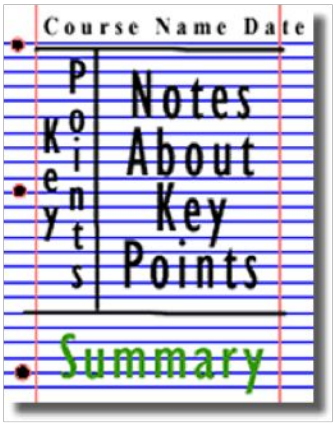


Figure 2: http://coe.jmu.edu/learningtoolbox/images/noteb4.gif