A LEVEL PHYSICS TRANSITION BOOKLET 2016-2017

STUDENT BOOKLET

NAME: ……………………………..

ACHIEVED GCSE GRADE: ……….

SECTIONS

SECTION 1: MATHS GUIDE

Congratulations on choosing A level physics! You will probably have heard that it is challenging or that there's 'lots of maths' in it. You might even know that the syllabus has changed in 2015 and there is now 'even more maths' in it. Many physics students are very competent at and interested in maths but, if that's not you, don't worry: it's true that there are several number-related skills to master to be good at physics (indeed, that's one of the reasons why physics graduates are in demand for all the best jobs) but you won't need most of the topics you studied for your maths GCSE.

Physics is about real-life, practical, useful things. We've discovered that many things in nature follow the same kinds of patterns: for example, you might have learned about electricity using an analogy about water flow or about radioactivity by rolling dice.

We use maths in physics because it's good for describing patterns clearly and because it lets us put a number on things: rather than just saying something increases we'd like to be able to say by how much.

So we tend to look at equations a bit differently than your maths teachers. We see our equations as pictures: pictures of the real life situation that the maths is describing. The other thing that makes our equations different is that, unlike the maths department, we almost never mean them to be exact. Nature is complex so most situations don't quite perfectly fit the patterns we have discovered and in any case we can never measure things perfectly. So all our equations are approximate to some extent, or only work in certain situations.

How to use maths in physics

The better you are able to visualise the patterns and understand the limits of equations in physics, the easier you will find it. This booklet aims to give you some pointers to, and some practice, in those bits of maths that come up a lot in A level physics. It also shows you the calculation skills you need to practise so that you can find answers quickly and check they are reasonable. They might seem daunting at first but don't be put off: like anything else that is worth doing, you will only get good at them through practice.

Standard Form, Units, Prefixes and Significant Figures

You will probably be familiar with these ideas from GCSE maths and science but you will meet more challenging examples at A level such as:

- Conversion of complex units such as those for density, for example from g cm-3 to kg m-3
- Using more unit prefixes e.g. nano-, giga- and micro-
- Learning more about measurements and significant figures (sf).

Tip: two voltmeter readings of, say, 0.935 V and 1.025 V are correctly recorded despite different sf as the meter resolution is ±0.005 V.

Worked example

An ultrasound pulse travels through a metal bar and reflects off a defect inside the bar. The time for the pulse echo to be detected is 12 μs. The speed of ultrasound in the bar is 1.1 km s^{-1}. Calculate the distance between the defect and the bar's surface in mm.

Answer

$d = vt$

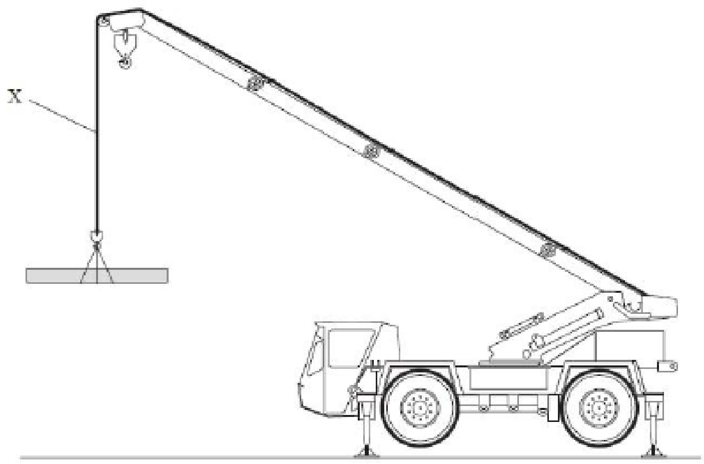
$= 1.1 \times 10^3 \times (½ \times 12 \times 10^{-6})$

$= 6.6 \times 10^{-3}$ m

$= 6.6$ mm

Practice question 1

The diagram shows a crane lifting a concrete beam.



Weight of beam = 13 kN diameter of steel cable = 1.1 cm

Show that the stress in the cable at point X is about 0.1 GPa.

As you will be using standard form all the time you really need to be an expert in using your calculator. On your calculator, do you know how to do the following?

(Key sequences in the text refer to the Casio FX-82ES.)

- Reset it back to 'normal' mode (SHIFT 9 3 = AC).
- Make sure × and ÷ happen in the right order, perhaps using brackets to make sure. (What is the value of $3.2 \times 10^7 \div 2.5 \times 10^4 + 3.0 \times 10^3$?)
- Enter standard form accurately (using EXP or X10X) including $X10^{-X}$.
- Convert answers so you can use prefixes like k, M, μ (the S<->D, ENG buttons).
- Change final answer to given sf using the SCI mode or similar.
- Change to and from radian mode.
- Use a single button to do one-over (1/x or X^{-1}).

Tip: standard form has a single digit before the decimal point. However, enter numbers with unit prefixes as they occur i.e. enter 650 nm as 6 5 0 EXP – 9 rather than converting to standard form first. Let the calculator do the work

Considering the units of quantities will help both in certain exam questions such as the example below but also in problem solving where the units of the answer can show you how to get started with the problem (see later).

Tip: think of the **number of** electrons, photons etc. like a unit – that way electrons and anything else that is **per electron** will cancel. Never write them as if they are a unit however because they are not part of SI and therefore technically not correct as units.

Worked example

The current I in a length of aluminium of cross-sectional area A is given by the formula

$$I = nevA$$

where e is the charge on an electron.

Show that the units on the left-hand side of the equation are consistent with those on the right-hand side.

Answer

Write out the units for each quantity. In this example we're thinking of the ones as being electrons (but not writing it this way).

$$nevA = \frac{\cancel{1}}{\cancel{m^3}}\,\frac{C}{\cancel{1}}\,\frac{\cancel{m}}{s}\,\cancel{m^2}$$

$$= C\,s^{-1}$$

$$= A$$

When converting unfamiliar units it might help you to think of a conversion factor having two units: for example, there are 1000 m per km so it's 1000 m km^{-1}. Then when you multiply km by km^{-1} (or if you divide m by m) they cancel.

Worked example

The specific heat capacity of aluminium is 900 J kg^{-1} K^{-1}.

Convert this to kJ mol^{-1} K^{-1} (M_r aluminium is 27 g mol^{-1}).

Answer

M_r is 27 g mol^{-1} = 27 $\cancel{g}\,mol^{-1} \div 1000\,\cancel{g}\,kg^{-1}$ = 0.027 kg mol^{-1}

For kJ the conversion is 1000 J kJ^{-1}

Specific heat capacity = 900 J kg^{-1} K^{-1}

$$= (900\,\cancel{J}\,\cancel{kg}^{-1}\,K^{-1} \div 1000\,\cancel{J}\,kJ^{-1}) \times 0.027\,\cancel{kg}\,mol^{-1}$$

$$= 0.0243\ kJ\,mol^{-1}\,K^{-1}$$

Practice question 2

A submarine has a volume of 7100 m^3. Calculate the upthrust force.

Density of sea water = 1.03 g cm^{-3}

It is useful to be able to do a sum roughly in your head to make sure the answer is sensible and that you didn't make a calculator error. You will find this hard at first, but keep practising: your physics teacher is probably very good at it following many years of practice! Using standard form, do all the numbers roughly first, then work out the powers separately: finally change the answer to standard form. For example:

$$\frac{1.60 \times 10^{-19}}{9.11 \times 10^{-31}} \approx \frac{2}{10} \times 10^{(-19 - -31)} = 0.2 \times 10^{12} = 2 \times 10^{11}$$

Transformation of Formulae

In maths this is called 'changing the subject of a formula'. You might have used the 'magic triangle' approach before, but for A level you will meet more complex formulae and you will need to learn the 'proper' maths technique now. Practice makes perfect!

Tip: when a new formula is introduced, practise transposing it to make each variable the subject

One situation you might find confusing is if you have a fraction on the bottom of a fraction. For example:

$$\frac{14.6}{\frac{7.3}{2}}$$

In this situation just move the bottom of the bottom to the top – in other words:

$$\frac{2 \times 14.6}{7.3}$$

Practice question

Calculate the angular velocity of a satellite that makes 8 complete orbits in 3 days.

Estimation

The new exams might ask you to estimate the value of a familiar quantity such as the volume of a house. This kind of question can be daunting at first but you will find it becomes easier with practice and it can be fun to make up questions of your own.

To become good at estimating you need to be able to make assumptions to simplify the problem, to have a rough idea of the sizes of some everyday things (at least the nearest factor of 10) and to be able to combine those using physics ideas.

For example, to estimate the weight of the air in an average house we might use.

$$\text{mass} = \text{density} \times \text{volume}$$

A useful number to know is the density of air: about 1 kg m^{-3} (it's actually 1.2 but that doesn't matter). What about the volume? If we assume the house is a cube we know it's bigger than 1 m on a side but probably not as much as 10 m on a side. Assuming it's a 5 m cube is near enough; so the volume is 125 m^3.

So the answer to the question is probably about 1300 N (did you remember we wanted weight?).

Practice question

Estimate:

- the number of photocopies made in your school in a year
- the sea level rise caused if the entire world's population went swimming
- the rate at which rubber wears off the tyres of a family car (in $mm^3\ s^{-1}$).

Proportion, Percentage Change and Uncertainty

Proportional reasoning is a skill we use as physicists all the time: when this thing doubles, this other thing doubles (or halves, or quadruples…). It saves time in recalculating if we can see the answer using a pattern. This skill appears often in A level questions but rarely at GCSE so it is worth practising. Questions can be set using numbers: in these questions you can just recalculate with the new value, but this is much slower than using proportion.

Worked example

The current through a bulb connected to a 6 V cell is 2 A. The bulb is replaced with one of half the original resistance. Calculate the new current.

The long way (by calculation)

Resistance of original bulb, using Ohm's law, $R = \frac{V}{I} = \frac{6}{2} = 3\ \Omega$.

Therefore new bulb has resistance 1.5 Ω.

New current, using Ohm's law, $I = \frac{V}{R} = \frac{6}{1.5} = 4$ A.

Using proportion

Ohm's law tells us $I \propto \frac{1}{R}$ (if V constant) so if R halves then I doubles.

So the answer is 4 A.

Practice question 1

A football has a diameter of 22.5 cm. It contains air at a temperature of 20°C and a pressure of 1.65×10^5 Pa. When the football is left in direct sunlight, the temperature of the air in the football increases to 40°C.

Show that the new pressure exerted by the air in the football is about 2×10^5 Pa. Assume that the volume of the football remains constant.

Questions can also be set with letters (algebraic symbols) rather than values: in this case you can only use proportion.

Practice question 2

Two protons, separated by a distance *x*, experience a repulsive force *F*.

If the separation is reduced to $\frac{x}{3}$ the force between the protons will be:

A $\frac{F}{9}$ **B** $\frac{F}{3}$ **C** $3F$ **D** $9F$

Another common question type asks you to check whether some experimental results are in direct or inverse proportion (or sometimes inverse square or exponential relationships). These can be tested by checking that the data values multiply or divide to give a constant.

If two things are proportional, y α x, then y = constant × x and so x/ y is constant.

y/cm	1.2	2.9	3.4	4.6
x/V	0.245	0.579	0.684	0.922
$\frac{y}{x}$	4.90	5.01	4.97	4.99

Calculate x /y for each pair of values (as shown above). This gives the same answer (to within the uncertainty in your experiment) so we conclude that y α x.

Practice question 3

A wire carries a constant current. A Hall probe is used to investigate how the magnetic flux density produced by the wire varies with distance from the wire.

r/cm	V/V
1.0	0.725
1.5	0.483
2.0	0.363
2.5	0.29
3.0	0.242
3.5	0.21

The potential difference V was recorded for a range of distances r.

It is suggested that V and r are related by the equation

$$V = \frac{k}{r}$$

where k is a constant.

Determine by calculation whether this suggestion is valid.

At A level you will also learn about how to combine experimental uncertainties. Imagine you have made measurements of a and b. If a were actually 1% bigger and b 2% bigger than measured, then the product increases by about 3%.

We can show this by writing:
$1.01a \times 1.02b = (1 + 0.01)(1 + 0.02)ab = (1 + 0.01 + 0.02 + \ldots)ab \approx 1.03ab$

Where the three dots (…) show we have ignored some very small values. This is useful in questions where you are asked what happens when one quantity changes by a small amount.

Worked example

A 1 m length of wire of cross-section 1.00×10^{-2} mm^2 has resistance 2.00 Ω.

a Calculate the resistivity of the material.

b What is the effect on the resistance of a 2% increase in diameter?

Answer

a $\rho = \frac{RA}{l} = \frac{2 \times 1 \times 10^{-2} \times 10^{-6}}{1} = 2 \times 10^{-8}\ \Omega\,\text{m}$

b

Expert teacher solution

$R \propto \frac{1}{d^2}$ so increasing d by 2% makes R decrease by 4%.

So the answer is 96% of 2 Ω which is 1.92 Ω to 3 sf.

Transitioning student's solution

$R = \frac{\rho l}{A} = \frac{2 \times 10^{-8} \times 1}{A}$

$A = \pi(\frac{d}{2})^2$ so $d = 2\sqrt{\frac{A}{\pi}} = 0.113$ mm

So new $d = 0.115$ mm, $A = 1.04 \times 10^{-2}$ mm^2

So $R = \frac{2 \times 10^{-8} \times 1}{1.04 \times 10^{-2}} = 1.92\ \Omega$ (3 sf)

Vectors

Physics makes use of the idea of a vector to show direction. Lots of quantities in physics have an associated direction (quantities like time or mass that don't have direction are called scalars.) You will be used to this from studying forces at GCSE.

You will also be familiar with writing column vectors from maths but, for A level physics, the idea of writing a vector in this column notation is not so important. Instead, it is more important to be able to add two vectors (at right angles) and carry out the reverse process (to split a single vector into two components at right angles). You will remember that to do this you need to use Pythagoras' theorem and a bit of trigonometry.

Although this is the same as the ideas you've met in maths, students often say that it doesn't look the same when you first meet it in physics.

Practice question 1

Which set of quantities is all scalar?

A acceleration, displacement, velocity

B energy, mass, power

C extension, force, gravitational potential energy

D weight, kinetic energy, work

Practice question 2

A model boat is crossing a stream. The stream is travelling east at a speed of 1.5 m s^{-1}.

The boat is heading north at a speed of 0.5 m s^{-1}.

The magnitude of the resultant velocity is:

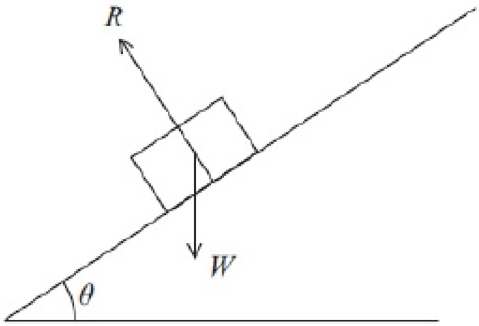
A $(1.5 + 0.5)$ m s^{-1}

B $(1.5^2 + 0.5^2)$ m s^{-1}

C $\sqrt{1.5 + 0.5}$ m s^{-1}

D $\sqrt{(1.5^2 + 0.5)^2}$ m s^{-1}

Practice question 3



The diagram shows an object on an inclined surface.

The component of the weight *W* parallel to the surface is

A 0

B 1

C $W \cos \theta$

D $W \sin \theta$

Practice question 4

Films made to be watched in three dimensions (3D) are produced by projecting two slightly different images on to the screen, one to be seen by each eye.

In one technique the images are polarised. The viewers wear special glasses where the lenses are replaced by two separate plane polarising filters.

The light from the screen reaching each eye passes through a different filter so each eye sees a different image. The filter for one eye has a plane of polarisation of 45° and the filter for the other eye has a plane of polarisation of 135°.

Explain this choice of angles.

Rate

The idea of rate occurs in several places in physics as well as in the other subjects you are probably studying.

Examples: reaction rate in chemistry, photosynthesis rate in biology, GDP growth in economics, attrition rate in a psychological study.

Rate tells us how quickly something is changing compared to another, which is related to the gradient of a graph (and to ideas in calculus if you study this in maths). For example, acceleration tells us how much the speed is changing in a given time; or absorption rate tells us how the number of beta particles changes as they pass through different thicknesses of absorbing material.

It is very rare to have a question specifically about rate but many questions expect you to be able to recognise it and understand that we are really talking about the gradient of a graph. This can be tricky when the word rate does not appear: for example, acceleration and power both have the idea of rate built in to their definition. This leads to a common calculation mistake we see in exams, confusing power in watts and energy in joules.

Problem Solving

It's quite hard to define what we mean by problem solving. Sometimes it's hard to see how to connect what you know with the way the examiner has phrased the question.
How do you get from what you know to what they want? That's a good enough definition of problem solving as far as it applies to A level physics.

There are two general tips you can use to tackle these questions.

Tip: draw a detailed diagram with all the information on it.

This puts all the information into a visual form and sometimes helps you to see which part of physics the question is about. This might lead you to a plan of attack or at least to a principle you need to use, such as the principle of moments.

Tip: start with what you need and work backwards.

Usually the problem will only require two steps (maybe using two formulae or a principle that isn't given to you in the question, like energy conservation). That means there's probably only 'one degree of separation' between what you know and what's required so you just need to find that missing link.

Worked example

A bulb of resistance 12 Ω is connected to a 6 V battery. Calculate the charge passing through the bulb in 1 minute.

Answer

The current would tell us how much charge passes in given time ($Q = It$).

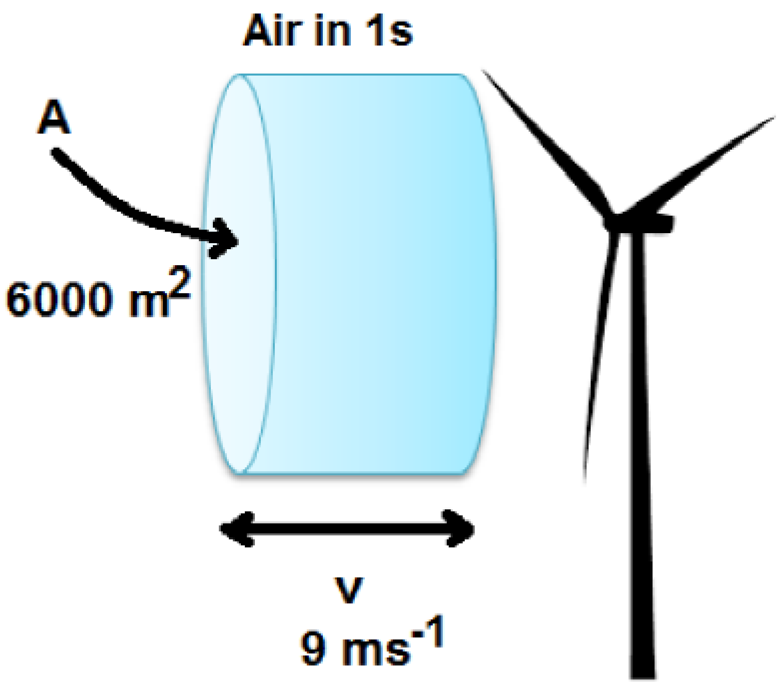
We can find current from the information we have using Ohm's law ($V = IR$).

$$I = \frac{6}{12} = 0.5 \text{ A}$$

$$Q = 0.5 \times 60 = 30 \text{ C}$$

Worked example

Kinetic energy of wind is transferred to electrical energy by a wind turbine as the blades rotate.



The area swept out by one blade, as it turns through 360°, is 6000 m^2. Wind at a speed of 9 m s^{-1} passes the turbine.

Calculate the maximum power available to the wind turbine.

density of air = 1.2 kg m^{-3}

Answer

We need to find power. $P = \frac{E}{t}$

The energy transfer is from the wind's KE to the turbine's.

So we need the KE available from the wind in 1 s. $KE = ½mv^2$

We don't know *m* but we know how much wind passes through the turbine in 1 s from our diagram: it is *Aρx*. *x* is the distance the wind goes in 1 s so that's *v*.

So the power is the wind's KE available in 1 s which is $½(A\rho v)v^2$.

So the answer is 2.62 MW.

Practice question 1

The heating element of an electric shower has a power of 6.0 kW.

Water enters the shower at a temperature of 7.5°C.

Calculate the water flow rate required to give an output temperature of 37.5°C.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}

Practice question 2

A CCD sensor of area 1 mm^2 is illuminated with light of wavelength 700 nm and intensity 2.84 mW m^{-2}. The quantum efficiency of the CCD is 70%. Find the rate at which electrons are released in the sensor.

SECTION 2: PRACTICAL GUIDE

Physics is a practical subject, which means that whatever anybody thinks – hypothesis – it is only by testing the idea – carrying out an investigation – that we can come to conclusion about whether the idea might be a reasonable explanation of the world (or universe) around us. Practical skills are central to the work of a physicist and the A level course is built around the development of those skills.

At GCSE you might have seen a Geiger counter measuring the emissions from a radioactive source, by putting different materials between source and detector you were able to tell whether the radiation was alpha, beta or gamma. All the ideas and principles in physics have been tested like this and this early investigation of the nucleus led, over a hundred years, to the investigations at CERN.

It is really important to remember that the term 'practical skills' covers a very wide range of requirements at A level. It does not mean just the ability to handle equipment in a school laboratory or know how to use some particular piece of apparatus. It ranges from using mathematics in a practical context to understanding how scientists investigate ideas, how they analyse their data and how they use that data when drawing conclusions. This guide will explain each of these in more detail.

By carrying out a programme of practical work you will develop the skills that a student must have if he or she is to be regarded as a competent practical physicist. You will have to be able to work safely in the laboratory and to manage your time so as to complete your work in the time allowed. Normally you will be given written instructions so you must be able to follow these carefully.

Over the two years of your A level course your teacher will assess your competence as a practical physicist by letting you carry out core practicals. At the end of the course your teacher will list some of the practical work you have carried out and decide if you have passed as a competent practical physicist. If you pass, then this will be recorded on your A level certificate.

How is this different from GCSE?
First of all you will be doing most of the practical work, occasionally working with one or more other people you will develop a wide range of skills. You will need to keep asking 'How do we know that?' You will also realise that, even at A level, you will only have part of the story and that science is constantly changing. It is not a pile of 'facts' it is just the best model we have at the present, in as far as we can test it.

By the end of the course you will have a mastery of practical work which means you will be consistently and routinely competent and therefore happy to have a go at a huge range of physics in the laboratory.

Developing independent thinking
An investigation is more than simply finding a value for something or verifying the behaviour of a system. In the same way a practical mastery is more than the sum of the parts, more than all the practical skills lumped together. The 'extra ingredient' is independent thinking. For example knowing which instruments to use and knowing how to use them is a key part of planning, using them correctly and being able to get accurate and precise readings is carrying out your investigation.

Completing the work is to present your data and your conclusions supported by some analysis. Thinking independently means being able to make the right decisions about what you know and making them at the right time. Perhaps there is more to an investigation, there is the 'I wonder...', 'what would happen if I did this?' and 'how do we know that?' – an enquiring mind.

All of this makes a good physicist but physicists seldom work alone. Modern projects such as CERN or the Very Large Telescope in Atacama require literally thousands of highly trained specialists to make them work. So although the spark of an idea starts in one head – think of Peter Higgs and his boson – the investigation is usually a collaboration.

Physics is about describing the world around us, perhaps predicting what it might do next but not really explaining it, that is left for the philosophers. Creating models and then testing them is the way physicists do this and the models evolve all the time. Communicating that spreading understanding is then another aspect of the work.

Finally physicists are very careful about claiming to have proved something and they are more likely to talk of developing the current model.

Thinking independently is about the creativity of the individual working within the framework of the subject and its other skilled practitioners.

Writing Investigations

Some of the core practicals offer you the opportunity to go beyond simply learning a technique by applying your knowledge to the design of an investigation. You will have met some of the requirements at GCSE level but during the two years of your A level course you will be expected to gain a deeper understanding of the details.

You might start as follows.

- **Is the hypothesis clear?**
- **Exactly what is to be measured? Is this the correct dependent variable, does it match the hypothesis and how can it be measured as accurately as possible?**
- **Are there any other variables that I need to control? What can I do about ones I cannot control?**
- **How much data will be needed to come to some meaningful conclusions?**

For example in a required practical you will investigate the effect of length, tension and mass per unit length on the frequency of vibration of a string or wire. You might think of a guitar, adjusting the frequency means tuning it or playing it – and each of the six strings has a different composition. How will you plan your investigation? You must start with your own hypothesis and run through the questions above. You will need a framework for you practical investigation. You can probably add questions to the list – but don't make it too complicated, you are aiming to test your hypothesis.

Instruments

You will choose which instruments you are going to use for each of your measurements and explain why they are appropriate; this is probably due to their resolution – smallest measuring division – but also their range. If the instruments are electrical then it is the range that you must specify, for example a voltmeter on its 20 V range. You should also detail any additional apparatus you will need such as retort stands, beakers or perhaps a bench pulley.

It is a really good idea to draw a diagram of how you will set up your apparatus. This should be labelled, large and drawn with a pencil and ruler. This process will help you think more clearly about what you are about to do. Key dimensions should be indicated on your diagram, these are lengths you will measure.

Question A

You are given two samples of a metal and told that they might both be aluminium. One is in the form of a sheet of kitchen foil and one is a cylindrical block with a mass of approximately 1 kg. In order to test the suggestion you decide to measure the density of the metal of each. What instruments would you use? Justify your choices.

Method
This can be bullet points but should include everything you will need to do including a risk analysis of your activity, this should include the equipment and other people in the room. You should discuss repeat readings and the range you are expecting to cover.

Techniques
You should also describe any techniques you will employ to improve accuracy. For example, a timing marker if the experiment concerns oscillations or zero errors on almost any instrument. This helps you to think more clearly about what you will actually do. You might think about holding your head perpendicular to the scale to get a more accurate reading, on a thermometer for instance.

Question B

Describe how you would use the micrometer in Question A to measure the thickness of the foil with as good a resolution as possible.

Planning should be detailed but concise, in an investigation it is to help you test the right thing in the right way.

Recording
When recording your data you should always use a table with headings which include the quantity and its unit, write the unit that you read from the instrument. You might read a metre rule in centimetres, so head the column of length L say as L/cm, you should also record the resolution of the instrument as ±0.1 cm in the case of the rule.

Use the number of significant figures (SF) that the instrument gives, so a small length might be 6.4 cm and a longer one 25.6 cm. Recording to the resolution of the instrument is more important than having the same number of SF.

Be careful that your recorded figure represents what you think you measured. For example if you record values for mass and write down M = 1.00 kg you are recording the mass to the nearest 10 g, the resolution is much nearer 1 g so you should write M = 1.000 kg.

When you record the period of 10 oscillations using a timer with a resolution of 0.01 s you might record 10T = 14.52 s, this gives you T = 1.452 s and the resolution of your measurement has improved because you recorded a longer time interval.

Make sure you record enough data and not too much. Keep your eye on the dependent variable and if it is changing slowly increase the increments in the independent variable. You should be flexible and not stick rigidly to your plan if nothing much is changing. Write your readings straight into your table and record everything you measure.

Question C

A student records the following values for the diameter of a piece of wire

d/mm	0.27, 0.29, 0.27, 0.77, 0.26

Calculate a mean value for the diameter and explain your choice.

Graphs

Almost every physics experiment will display data in graphical form and physicists always use a form of their data that produces a straight line – if all goes well with the data. There is usually a mathematical model for the data and it is this that can be manipulated to give a straight line on the graph. This will happen when the model has been manipulated to be similar to y = mx + c.

Some examples are shown in the table.

Mathematical Model	*x*-axis	*y*-axis	gradient	intercept
$V = IR$	I	V	R	Zero
$v^2 = u^2 + 2as$	s	v^2	$2a$	u^2
$I = I_0 \exp^{(\frac{-t}{RC})}$	t	$\ln I$	$\frac{-1}{RC}$	$\ln I_0$
$T = kx^p$	$\ln x$	$\ln T$	p	$\ln k$
$I = I_0 \exp^{(\frac{b}{T})}$				
$T = f^2\lambda^2\mu$				

Question D

Complete the bottom two lines in order to determine a value for b in the first one where the variables are I and T and a value for μ in the bottom line where the variables are T and f.

The axes should be labelled with a unit such as s/m or ln(T/s) – in this way the plots have no units. The scale should stretch the plots over at last half the graph paper in each direction but should not be difficult to read i.e. multiples of 7s or 3s – take care when plotting time in seconds. The plots should be accurate to 1 mm and the line of best fit should have plots above it and below. Always tabulate the numbers you are going to use for your graph alongside your data. A graph in physics is always a scatter graph with a line of best fit shown.

You should plot error bars on your data and these should come from the spread in your repeated readings – it is usual to use half the spread as the size of the error bar. This will enable you to draw different lines of fit and hence estimate the uncertainty in your gradient, which is almost always a key aspect of the investigation.

Analysing

Investigations might be to verify the behaviour of a system or to calculate a value for some aspect of it. In the first case you will be commenting on the goodness of fit of your best fit line. In the second you will be doing further numerical analysis. In both cases you should record what was easy and what was difficult about your practical work, if your method was easy to carry out you might expect plots close to a straight line whereas difficulties might explain a spread of readings. If you were expecting a straight line but got a curve there might be a reason for that too. For example if you are measuring the period of a pendulum and varying the length then plotting T^2 against l should give a straight line from

$$T = 2\pi(\frac{l}{g})^{\frac{1}{2}}$$

But if your oscillations are too large so that this is not the correct mathematical model then that explains the curve you might get on your graph.

In the practical to determine a value for g and if your experimental value turns out to be 9.25 N kg^{-1} then you can use a percentage difference to gauge the error.

Percentage difference = 100 × (your value – accepted value) ÷ accepted value
Here that gives %D = 100 × (9.81 – 9.25) ÷ 9.81 = 5.7% – not a bad result.
A properly plotted graph can tell you a very great deal about your experiment and always repays close attention.

Question E

You measure a value for Young modulus of copper and obtain a value of 1.32×10^{11} Pa. The accepted value is 1.17×10^{11} Pa. Calculate the percentage difference between the two values.

Use of Mathematics
Nearly all the mathematical requirements are those of GCSE Maths at Higher Level. But of course at top marks, the topics are relatively easy but the precision is 100% - in other words you have to get GCSE Maths right when you use it. Although this might sound worrying you should find that as you practice over the course and keep ticking over with the maths you improve, just as you do with everything else. The only difference is the use of logarithms and exponentials.

Evaluating uncertainties
Uncertainties give you a degree of confidence in your results so that if your uncertainties are large, say 25%, then you might find little confidence in your conclusion but if they are small, say 2%, then you might think your results are valid i.e. you have measured what you were supposed to be measuring.

In your investigation you will want to derive an uncertainty in your final value, this will depend on the difficulty you experienced taking the readings, the spread in your repeated readings and other factors too.

In some experiments you will be comparing your final value to an accepted value. Your value for g was 5.7% different from he accepted value, if your uncertainty was 9% then your result might be valid because the percentage difference can be explained by the percentage uncertainty. If your percentage uncertainty was 3% then the difference is not explained by the uncertainty and your experiment was flawed in some way.

When evaluating the result of your investigation as well as considering percentages, as above, you should consider your graph and the readings it shows as well as the difficulties you felt you had in taking accurate readings. As part of this you might consider whether a different method would produce a better result.

Your report should end with a conclusion supported by numbers and an evaluation based on the evidence you have assembled.

Question F

A wave crosses a tray, reflects off the far side and returns after a time *t*. A student measures the distance *d* across the tray as 33.4 cm with an uncertainty of 0.2 cm.

She then measures *t* = 0.92 s with an uncertainty of 0.03 s.

(i) Use these measurements to calculate *v*, the velocity of the wave.

(ii) Estimate the percentage uncertainty in your value for *v*.

Question G

A student records measurements of a metre rule. She repeats these from several positions along the rule.

Width/mm 28.2, 29.3, 28.9, 29.0, 29.1

Thickness/mm 6.04, 5.94, 5.97, 6.01, 5.99

Mass/g = 106.4

(i) Use these measurements to calculate a value for the density of the rule.

(ii) Calculate the uncertainty in your value for the density.

Question H

A student takes measurements to determine the resistivity of constantan in the form of a wire. He measures the diameter and the resistance of a length of wire. He records:

Diameter = 0.559 mm ±0.010 mm

Resistance 1.15 Ω ±0.02 Ω

Length = 0.600 m ±0.003 m

Ii) Calculate the resistivity of the constantan.

(ii) Calculate the percentage uncertainty in your value for the resistivity

(iii) The accepted value for the resistivity of constantan is 4.9×10^{-7} Ω m. Comment on the result of using the student's measurements.

SECTION 3: PHYSICS GUIDE

AQA A-level Physics should be a natural progression from the GCSE course and there are many familiar topics that are taken a stage further. Some topics, such as electricity, are studied in greater detail while others, such as energy transfer, broaden the GCSE experience and include a greater use of mathematics so that the qualitative understanding becomes quantitative. A large change at A-level is the inclusion of optional topics, all of which build on familiar topics from GCSE and give students the chance to study in areas they have a specific interest in, and is the first step towards specialising towards a particular career.
In the following section, you can see how the knowledge learnt at GCSE is used at A-Level and how it is built upon.

Content

Kinetic theory

GCSE specification reference: 1.1.2

A-level specification reference: 6.2.2 (Ideal gases) and 6.2.3 (Molecular kinetic theory model).

There is no quantitative work at GCSE, just an appreciation of the basic model of constantly moving atoms, molecules and particles, as well as the different energy states of solid, liquid and gases.

The kinetic theory at A-level is described by assumptions and mathematical interpretation linking micro and macro to generate, for gases, PV = nRT(as well as pV = NkT) , moles, work done, Avogadro constant, NA, Boltzmann's constant k and absolute temperature, (T). Link between $(KE)_{av}$ and T is also covered at A-level.

Energy transfer by heating

GCSE specification reference: 1.1.3

A-level specification reference: 6.2.1 (Thermal energy transfer).

There is use of $Q = mc\Delta T$ in both the GCSE and A-level specifications. Definition of c and measurement as well as ideas about cooling by evaporation also appear in both.

A-level also deals with quantitative appreciation of latent heat and Q = mL for fusion and evaporation.

Energy and efficiency

GCSE specification reference: 1.2.1

A-level specification reference: 4.1.8 (Conservation of energy).

Both GCSE and A-level have definitions of efficiency and assumed principles of conservation of energy.

At A-level the use of efficiency is restricted to transformers in section 7.4.6 (the operation of a transformer).

Transferring electrical energy

GCSE specification reference: 1.3.1

A-level specification reference: 5.1.4 (Circuits).

GCSE and A-level have common equations for power and energy. At GCSE the equation is restricted to P=IV, and knowledge of kW, kWh.

At A-level the power equation is also defined as $P=I^2R$ and $P= V^2/R$.

Generating electricity/The National Grid

GCSE specification reference: 1.4.1 and 1.4.2

A-level specification reference: 5 (Electricity) and 7.4 (Magnetic fields).

Knowledge of National Grid and use of transformers is assumed at A-level and the transmission of energy by power lines is common to both GCSE and A-level.

A-level develops an equation for generating of an AC voltage (rotating coil), includes the transformer and deals quantitatively with power loss in transmission lines.

General properties of waves

GCSE specification reference: 1.5.1

A-level specification reference: 3 (Waves)

Both GCSE and A-level require a basic knowledge of longitudinal and transverse waves, their nature and properties, including speed of electromagnetic waves in a vacuum. Also common are the wave equations (using different symbols for velocity) i.e. $v = f\lambda$ and $c = f\lambda$.

At A-level, the oscillation of particles in a medium and the idea of phase difference is introduced with a formal definition of frequency (f=1/T), and polarisation.

Refraction of waves at an interface and diffraction are treated qualitatively at GCSE. At A-level refractive index/Snell's law and total internal reflection (critical angle) are treated quantitatively and their application in fibre optics is introduced.

At A-level single slit diffraction, Young's slits and the diffraction grating are explained mathematically through superposition and interference.

Sound

GCSE specification reference: 1.5.3

A-level specification reference: 3.1.1 (Progressive waves) to 3.2.1 (Interference).

Implied knowledge of longitudinal nature and the requirement of a medium is included in both GCSE and A-level specifications.

At A-level, the concept of stationary waves, superposition, interference and the determination of the speed of sound is included.

Resultant forces

GCSE specification reference: 2.1.1

A-level specification reference: 4.1.1 (Scalars and vectors).

The outcome of resultant forces through vector addition and the concept of equilibrium (resultant force=zero) is common to both GCSE and A-level for parallel forces, including acceleration in the direction of the resultant force.

At A-level, the calculation of the resultant of two forces at 90° and resolution of forces are treated mathematically.

Forces and motion

GCSE specification reference: 2.1.2

A-level specification reference: 4.1.3 (Motion along a straight line), 4.1.4 (Projectile motion), 4.1.5 (Newton's laws of motion) and 4.1.6 (Momentum).

Both GCSE and A-level assume knowledge of F = ma, but at A-level all three of Newton's laws are required. GCSE content is restricted to motion in a straight line and definitions of velocity and acceleration, including graphical representation for uniform straight line motion to determine acceleration and distance travelled.

At A-level, all SUVAT equations and displacement are defined and the use of Δ for changes in V=ΔsΔt is introduced, including non-uniform acceleration. The acceleration due to gravity (g) and its measurement is an A-level requirement. Projectile motion is analysed mathematically taking account of air resistance.

Forces and Terminal velocity

GCSE specification reference: 2.1.4

A-level specification reference: 4.1.4 (Projectile motion).

This builds on the idea of equilibrium (balanced forces: mg and resistive forces). Both GCSE and A-level require a knowledge of why there is a terminal speed (velocity), that fluid resistance depends on speed and how drag forces can be useful. Interpretation of υ-t graphs for objects falling under gravity with drag forces present is also included.

Lift forces are considered only at A-level.

Forces and elasticity

GCSE specification reference: 2.1.5

A-level specification reference: 4.2.1 (Bulk properties of solids) and 4.2.2 (The Young modulus).

Both GCSE and A-level include an understanding of Hooke's law and expressions in terms of a spring constant, k (or stiffness at A-level). Mathematical expressions of force and extension: F=ke (GCSE) and F=kΔL (A-level) including elastic, strain and potential energy stored are also included.

At A-level the concept of elastic limit, plastic behaviour, breaking stress, fracture and brittle behaviour are included with the use of stress and strain graphs. The area under a force-extension graph is equated to energy stored as E=FΔL and also the transformation of energy in a mass and spring system between KE and PE. Use of stress and strain curves to determine the Young modulus and its measurement is at A-level only.

Both specifications require knowledge of the terms work, energy and power (including the Joule and kW) as well as the conservation of energy including the equation for work done. Both specifications involve a definition of power in terms of energy/work transformed per second and the equations for PE and KE.

A-level also considers work done against resistive forces. For 'non parallel force and displacement' A-level considers when work is done or not done by a force (W = Fs cosθ) and power in respect of force and velocity (P=ΔWΔt= Fv), and that the area under a force-displacement graph is work done for both constant and variable forces.

Momentum

GCSE specification reference: 2.2.2

A-level specification reference: 4.1.6 (Momentum).

Both GCSE and A-level define momentum and conservation of momentum, including the concept of a 'closed system', for collisions and explosions.

At A-level, linear momentum in one dimension is specified and involves the understanding that force results from a momentum change per second. The idea of impulse ('force × time') including an appreciation of impact forces and contact times is introduced and for constant and variable forces, the area under a force-time graph is used for momentum change. There is also consideration at A-level for both elastic (conservation of KE) and inelastic collisions, with calculations.

Electrical circuits

GCSE specification reference: 2.3.2

A-level specification reference: 5 (Electricity).

Both GCSE and A-level include circuit symbols; the terms, I, Q, V; and the definitions of current, voltage (PD), and work done in a circuit. The concept of resistance (R=VI), and I-V characteristics for ohmic and non ohmic components, and series/parallel circuits is common to both.

At A-level, the potential divider/potentiometer is introduced as a control mechanism, as are cells in series and parallel. Conservation of charge and energy in a DC circuit and the equation for resistors in parallel are considered only at A-level, as is resistivity and superconductors.

Atomic structure

GCSE specification reference: 2.5.1

A-level specification reference: 2 (Particles and radiation), 8 (Nuclear physics).

Simple 'Bohr model' of an atom in terms of protons, neutrons, electrons, and the relative masses of these particles is common to both GCSE and A-level. The idea of neutrality (number of electrons = number of protons) and ions and isotopes. 'Atomic number' is used at GCSE and 'proton number, Z' is used at A-level. 'Mass number' is referred to in GCSE and 'nucleon number' in A-level.

For A-level only, evidence for the nucleus (Rutherford) and specific charge of nuclei, ions and protons/electrons and the concept of a nuclide with symbolic representation.

Atoms and radiation

GCSE specification reference: 2.5.2

A-level specification reference: 2 (Particles and radiation), 8 (Nuclear physics) and 9.2.3 (Classification by temperature, black body radiation-Astrophysics option).

A general appreciation of radioactive substances, the three types of radiation and their properties, safety, hazards, background and half-life is assumed at A-level. At GCSE (higher), only the nuclear equation for α–decay is required. At A-level, the equation for β–decay (including the neutrino) is also required. A-level requires more detail about the reasons for instability, including the N against Z curve, and the forces involved in decay such as the strong nuclear force and short range attractive.

The experimental investigation of evidence for α, β and γ is required at A-level, along with the inverse square law for γ. Count rate (elimination of background), mathematical definition of half-life and manipulation of exponential decay equations are all required at A-level, along with knowledge of natural logs.

Nuclear fission and Nuclear fusion

GCSE specification reference: 2.6.1 and 2

A-level specification reference: 8.1.6 (Mass and energy) and 8.1.7 (Induced fission).

Knowledge of the fissile substances used in thermal reactors and that the process involves the nucleus and neutrons is common to both GCSE and A-level, as is the fact that fusion involves nuclei 'joining' at high temperatures.

At A-level, the concepts of binding energy and use of $E = mc^2$ for calculations of mass difference and energy are required. An understanding of critical mass, moderator, control rods and coolant in a thermal reactor is necessary.

Other applications using light

GCSE specification reference: 3.1.5

A-level specification reference: 3.2.3 (Refraction at a plane surface).

Most specification content is common so that an appreciation of total internal reflection, optical fibres and lasers is assumed.

At A-level the critical angle is related to refractive index by $\sin\theta_c$ = ratio of two refractive indices. A-level deals in slightly more detail for optical fibres with a step index.

Centre of mass

GCSE specification reference: 3.2.1

A-level specification reference: 4.1.2 (Moments) and 6.1.2 (Simple harmonic motion).

The definition of centre of mass and stability in general is assumed as are the general properties of a simple pendulum.

At A-level there is analysis of the simple pendulum time period equation.

Moments

GCSE specification reference: 3.2.2

A-level specification reference: 4.1.2 (Moments).

Both GCSE and A-level specifications require the definition of a moment and the principle of moments, including the idea of equilibrium/stability.

A-level introduces the concept of parallel opposite forces forming a couple.

Circular motion

GCSE specification reference: 3.2.4

A-level specification reference: 6.1.1 (Circular motion).

Both GCSE and A-level require knowledge of centripetal forces, their origins and how these forces depend on mass, speed and radius.

The equation $F = mv^2/r$ and the link $v = \omega r$ are only required at A-level.

The motor effect

GCSE specification reference: 3.3.1

A-level specification reference: 7.4 (Magnetic fields).

An understanding of how current-carrying conductors react in magnetic fields is included for both specifications. In particular, Fleming's left hand rule is required for currents and fields at 90°.

A-level considers the concept of B (flux density) and moving charges with equations for F used to explain how a current balance works and the circular motion of particles, e.g. in a cyclotron.

Transformers

GCSE specification reference: 3.3.2

A-level specification reference: 7.4.6 (The operation of a transformer).

The concept of electrical induction, including simple experiments, is expected at both GCSE and A-level, as is the structure of a transformer, its turns ratio and power ratio for an ideal transformer.

A-level requires an understanding of Lenz's and Faraday's laws for induction, flux and flux linkage (topic 7.4.4), leading to an appreciation of energy losses in a transformer – Eddy currents/laminations. Calculations are included at A-level on transformers with efficiency below 100%.

In the following section there are practice questions on key concepts in physics which you can attempt to familiarise yourself with the A Level Physics course.

1. Vectors and Scalars

1 Which of the following is a scalar quantity?

Place a cross (☒) in the box next to your answer.

A acceleration ☐

B displacement ☐

C force ☐

D work ☐

(1 mark)

2 A cyclist travelling at a speed of 4.2 m s^{-1} accelerates at 1.1 m s^{-2}. In a time of 7.4 s what is the distance travelled?

Place a cross (☒) in the box next to your answer.

A 30 m ☐

B 35 m ☐

C 61 m ☐

D 91 m ☐

(1 mark)

3 Complete the sentence by putting a cross (☒) in the box next to your answer.

A building has 5 floors. The windows on successive floors are separated by the same vertical distance.

A brick is dropped from a window on each floor at the same time. The bricks should hit the ground at...

A decreasing time intervals ☐

B equal time intervals ☐

C increasing time intervals ☐

D the same time ☐

(1 mark)

4 **a** Explain the difference between scalar and vector quantities.

(1 mark)

b When asked to run one complete lap around a track, a student says, 'However fast I run, my average velocity for the lap will be zero.'

Comment on his statement.

(3 marks)

5 This photograph shows an athlete performing a long jump.

At take-off his horizontal speed is 8.0 m s^{-1} and his vertical speed is 2.8 m s^{-1}.

a Show that the total time the athlete spends in the air is about 0.6 s.

Assume that his centre of gravity is at the same height at take-off and landing.

(3 marks)

b Calculate the horizontal distance jumped by the athlete.

(2 marks)

c In reality, when the athlete lands his centre of gravity is 50 cm lower than its position at take-off.

Calculate the extra horizontal distance this enables the athlete to jump.

(4 marks)

2. Motion Graphs

1 Complete the sentence by putting a cross (☒) in the box next to your answer.

Distance travelled can be found from the...

A area under a velocity-time graph ☐

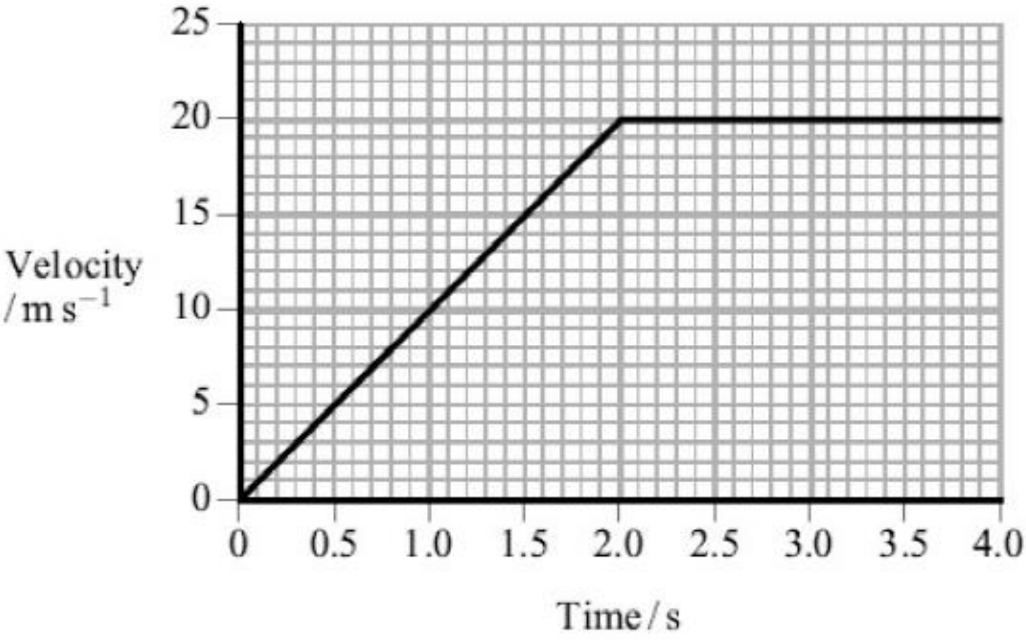
B area under an acceleration-time graph ☐

C gradient of a force-time graph ☐

D gradient of a velocity-time graph ☐

(1 mark)

2 Complete the sentence by putting a cross (☒) in the box next to your answer.



The graph shows how velocity varies with time for an object.

The acceleration at 3 s is...

A 10 m s^{-2} ☐

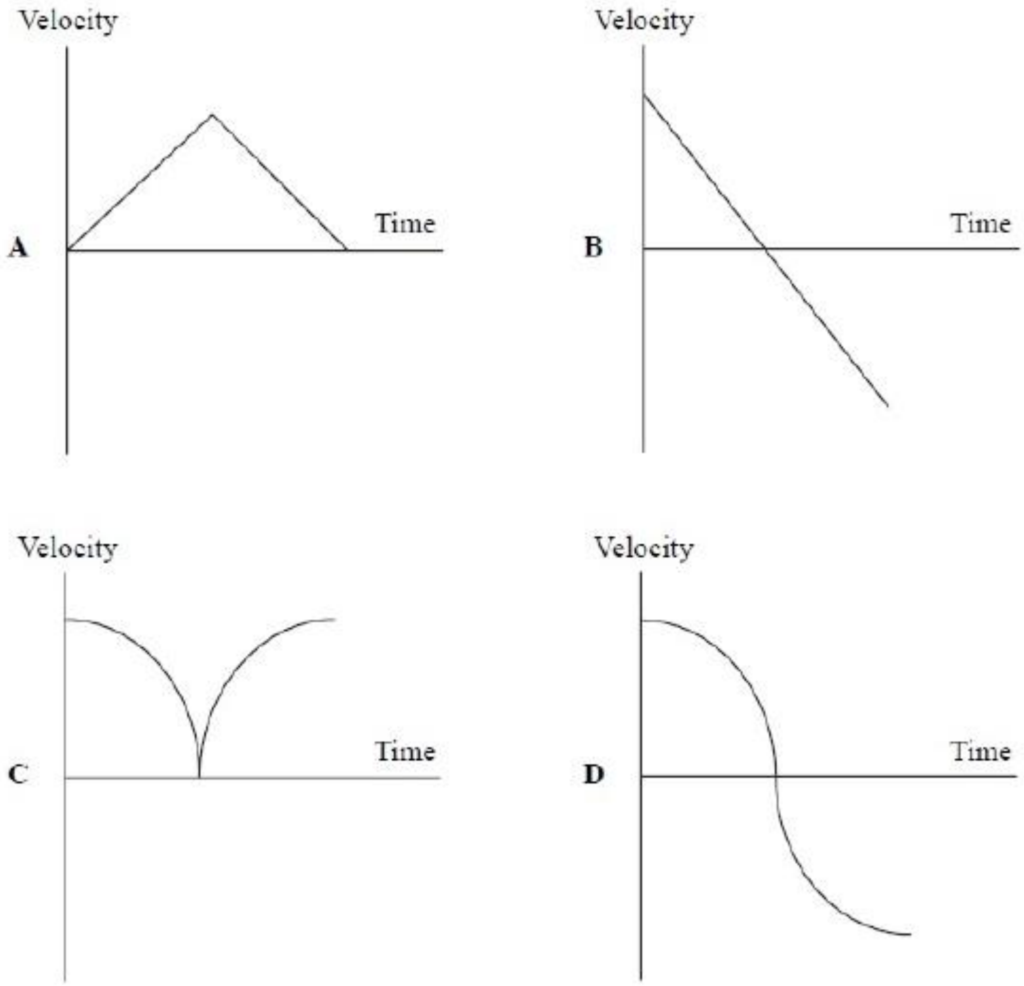
B 7 m s^{-2} ☐

C 5 m s^{-2} ☐

D 0 m s^{-2} ☐

(1 mark)

3 A ball is thrown straight up in the air and caught when it comes down. Which graph best shows the velocity of the ball from the moment it is released until just before it is caught?



Select one answer from A to D and put a cross in the box (☒).

A ☒

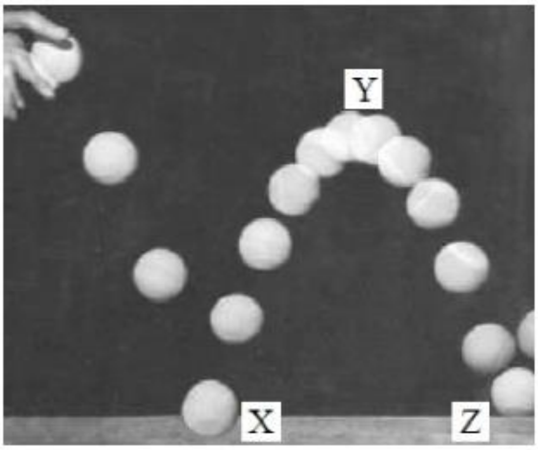
B ☒

C ☒

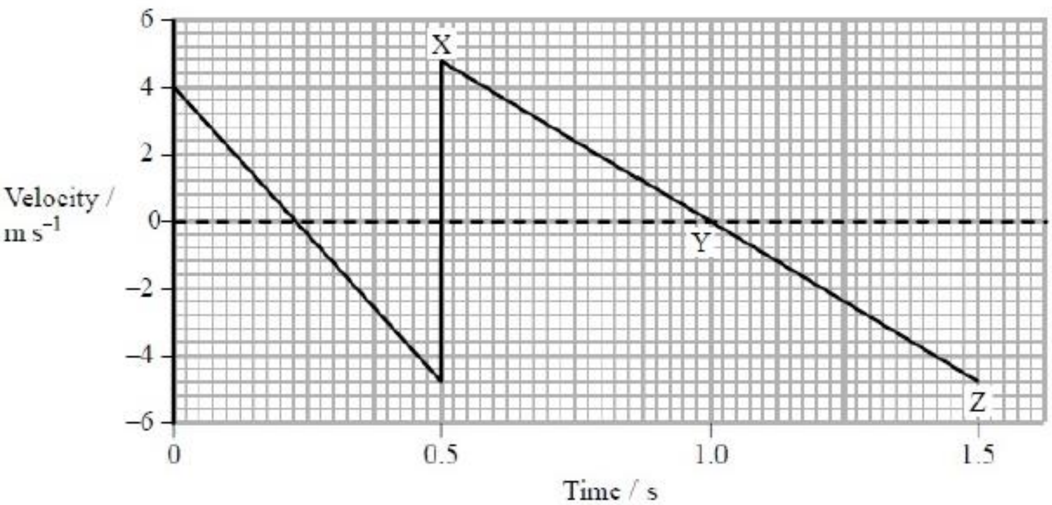
D ☒

(1 mark)

4 The photograph shows a sequence of images of a bouncing tennis ball.



A student plots the following graph and claims that it shows the vertical motion of the ball in the photograph.



a Without carrying out any calculations describe how the following can be found from the graph:

i the vertical distance travelled by the ball between 0.5 s and 1.0 s

ii the acceleration at Y.

(2 marks)

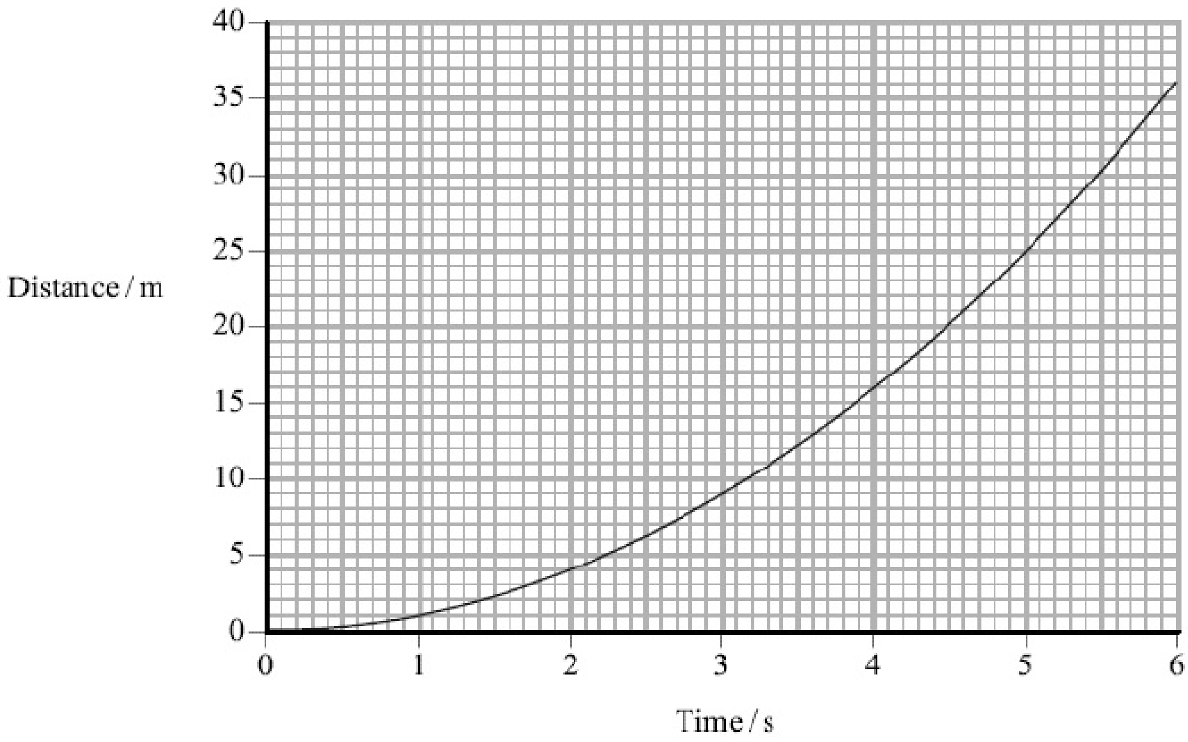
b The graph contains several errors in its representation of the motion of the ball. Explain two of these errors.

Error 1

Error 2

(4 marks)

5 The graph shows how displacement varies with time for an object which starts from rest with constant acceleration.



a Use the distance-time graph to determine the speed of the object at a time of 4.0 s.

(3 marks)

b Calculate the acceleration.

(2 marks)

3. Weight and Mass

1 Complete the sentence by putting a cross (☒) in the box next to your answer.

On a newly discovered planet, an object of mass 8.0 kg has a weight of 60 N.
The gravitational field strength on this planet is…

A 0.13 N kg^{-1} ☒

B 7.5 N kg^{-1} ☒

C 9.8 N kg^{-1} ☒

D 480 N kg^{-1} ☒

(1 mark)

2 A person weighing 100 N stands on some bathroom scales in a lift. If the scales show a reading of 110 N, which answer could describe the motion of the lift?

Select one answer from A to D and put a cross in the box (☒).

A Moving downwards and decelerating. ☒

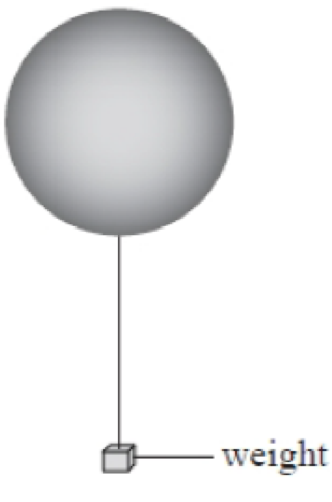
B Moving downwards with a constant velocity. ☒

C Moving upwards and decelerating. ☒

D Moving upwards with a constant velocity. ☒

(1 mark)

3 A student is asked to calculate the magnitude of a weight required to keep a spherical helium filled balloon stationary in the air.



The only measurement taken is the diameter d of the balloon. The student is given the values of the density of air ρ_a, the density of helium ρ_h and gravitational field strength g.

a Using the symbols given, write an expression for:

i the volume *V* of the balloon

(1 mark)

ii the mass of the helium inside the balloon

(1 mark)

iii the mass of the air displaced by the balloon

(1 mark)

iv the upthrust on the balloon.

(1 mark)

b Assuming the weight of the balloon and string are negligible, write an expression for the magnitude of the required weight.

(1 mark)

4 You are asked to determine the acceleration of free fall at the surface of the Earth, g, using a free fall method in the laboratory.

a Describe the apparatus you would use, the measurements you would take and explain how you would use them to determine g.

(6 marks)

b Give **one** precaution you would take to ensure the accuracy of your measurements.

(1 mark)

4. Series Circuit

1 Complete the sentence by putting a cross (☒) in the box next to your answer.

The unit of potential difference can be expressed as...

A C s^{-1} ☒

B J C^{-1} ☒

C A Ω^{-1} ☒

D J A^{-1} ☒

(1 mark)

2 Complete the sentence by putting a cross (☒) in the box next to your answer.

A rechargeable cell stores a maximum energy of 4200 J. The cell has an e.m.f. of 1.5 V and after 2.0 hours use the cell is completely discharged.

Assuming the e.m.f. stays constant, the charge passing through the cell during this time is...

A 1400 C ☒

B 2800 C ☒

C 5600 C ☒

D 6300 C ☒

(1 mark)

3 An electric torch uses two 1.5 V cells. The torch bulb is marked 2.4 V, 270 mA.

What is the resistance of the torch bulb?

Put a cross (☒) in the box next to your answer.

A 0.81 Ω ☒

B 0.65 Ω ☒

C 8.9 Ω ☒

D 11 Ω ☒

(1 mark)

4 A student is taking measurements in order to determine the resistance of a component in a circuit. He connects a voltmeter in parallel with the component and an ammeter in series with the component.

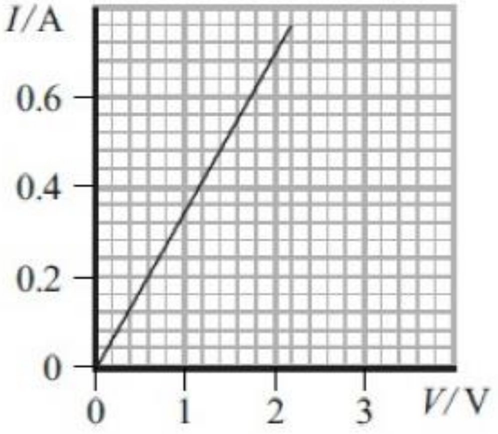
Explain why the voltmeter should have a very high resistance.

(2 marks)

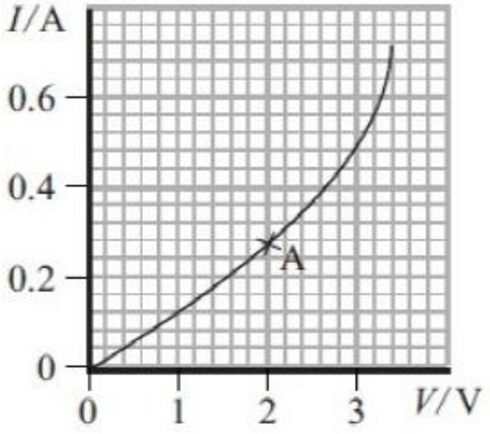
5 a Show how the ohm is derived.

(1 mark)

b The graphs show the current-potential difference (*I*-*V*) characteristics for a metal conductor and for a thermistor.



Metal conductor



Thermistor

i Calculate the resistance of the thermistor at point A.

(2 marks)

ii Use the graphs to describe how the resistance varies with potential difference for each component.

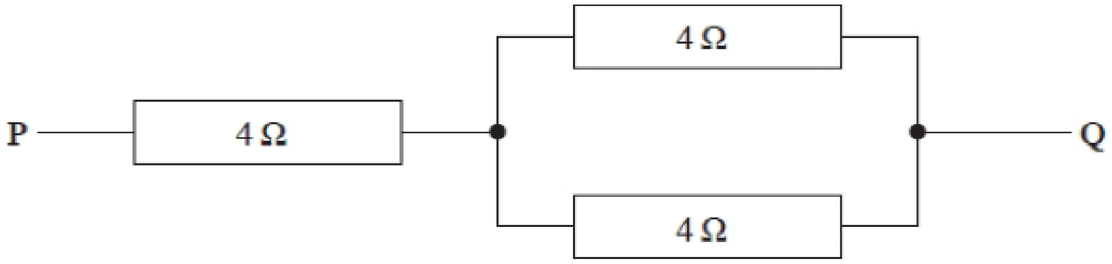
(2 marks)

iii Explain, in terms of electrons, why the thermistor behaves in this way.

(2 marks)

5. Parallel Circuits

1 The diagram shows a combination of three identical resistors.



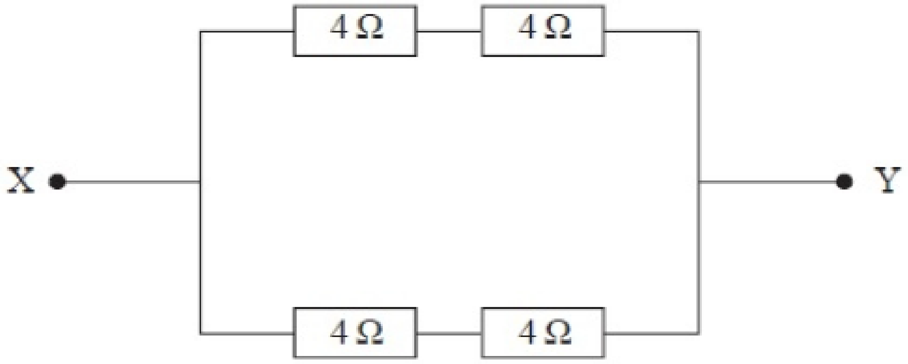
What is the combined resistance between P and Q?

Put a cross (☒) in the box next to your answer.

A 4 Ω ☐
B 6 Ω ☐
C 8 Ω ☐
D 12 Ω ☐

(1 mark)

2 The diagram shows a resistor network.



Complete the sentence by putting a cross (☒) in the box next to your answer.

The total resistance between points X and Y is...

A 0.25 Ω ☐
B 1.0 Ω ☐
C 4.0 Ω ☐
D 16 Ω ☐

(1 mark)

3 Complete the sentence by putting a cross (☒) in the box next to your answer.

Two identical resistors connected in series have a total resistance of 8 Ω.
The same two resistors when connected in parallel have a total resistance of…

A 0.5 Ω ☒

B 2 Ω ☒

C 4 Ω ☒

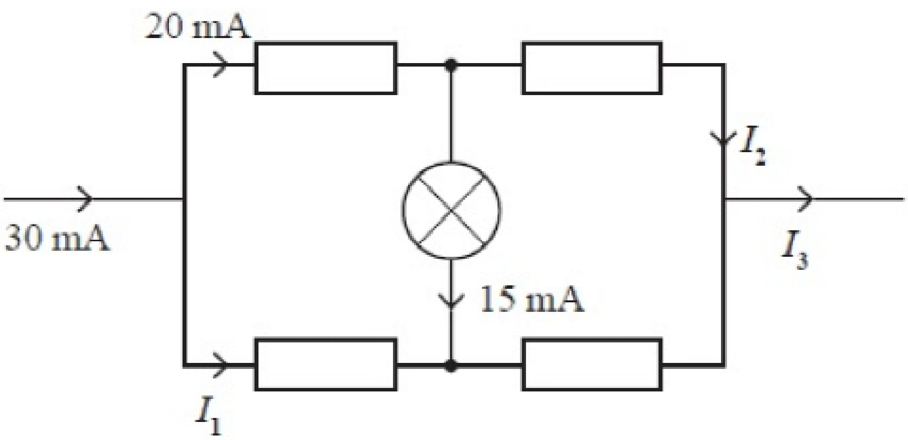
D 8 Ω ☒

(1 mark)

4 **a** What is the coulomb in base units?

(1 mark)

b The diagram shows part of an electrical circuit.



Determine the magnitudes of the currents I_1, I_2 and I_3.

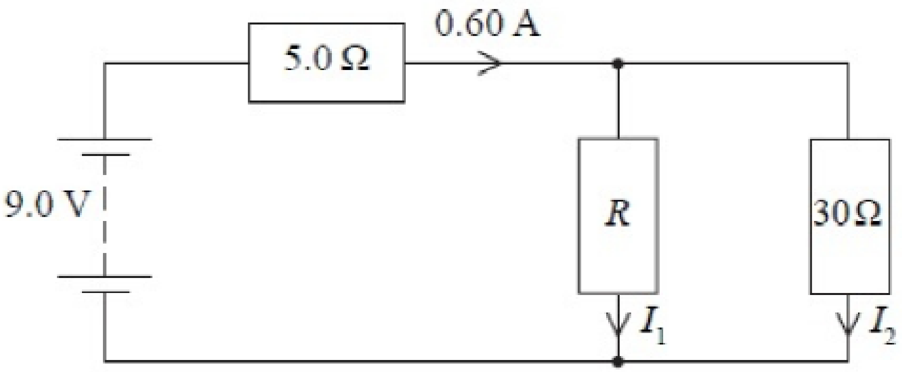
I_1 =

I_2 =

I_3 =

(3 marks)

5 The circuit diagram shows a battery of negligible internal resistance connected to three resistors.



a Calculate the potential difference across the 5 Ω resistor.

(2 marks)

b Calculate the current I_2.

(2 marks)

c Calculate the resistance R.

(2 marks)

SECTION 4: BASELINE ASSESSMENT

It is expected that you complete the baseline assessment to hand in on the first lesson of the course when you return to your studies in Year 12.

NAME: ………………

ACHIEVED GCSE GRADE: ………..

Question	Marks
1	/5
2	/6
3	/10
4	/8
Motion total	/29
1	/6
2	/6
3	/12
Electricity total	/24
Grand Total	/53
%	
Grade	

Target grade

- ☐ **OT**
- ☐ **BT**
- ☐ **AT**

Targets for improvement

- ☐
- ☐
- ☐
- ☐
- ☐
- ☐
- ☐

Motion

1 A car is travelling along a level road.

a The car travels at constant velocity. It covers 250 m in 40 s. Calculate the average velocity during this time.

(2 marks)

b The car now accelerates in a straight line.
Its average acceleration is 12 m/s^2.
Calculate the increase in velocity of the car in 4.0 s.

(3 marks)

2 The graph shows a velocity-time graph for a cyclist over a time of 60 s.

a i When is the cyclist travelling with greatest velocity?

Place a cross (☒) in the box next to your answer.

A for the first 15 seconds ☐

B between 15 and 40 seconds ☐

C between 40 and 50 seconds ☐

D for the last 10 seconds ☐

(1 mark)

ii Calculate how long the cyclist is stationary for in seconds.

(1 mark)

iii Calculate how far the cyclist travels in metres during the first 40 seconds.

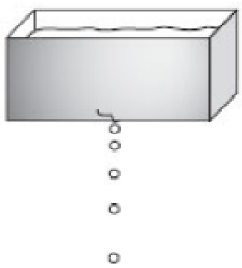
(1 mark)

b A different cyclist accelerates for 8 s. During this time they accelerate from 3 m/s to 14.2 m/s.

Calculate the acceleration during this time.

(3 marks)

3 A water tank drips water.



a Scientists could use four quantities to describe the movement of the water drops.

Three of these quantities are vectors.

The other quantity is a scalar.

acceleration	force	mass	velocity

i Complete the sentence by putting a cross (☒) in the box next to your answer.

The scalar quantity is...

A acceleration ☒

B force ☒

C mass ☒

D velocity ☒

(1 mark)

ii State any vector quantity **not** listed above.

(1 mark)

iii Complete the following sentence using one of the quantities from the word box above.

In a vacuum, all bodies falling towards the Earth's surface have the same

________________________.

(1 mark)

b The mass of one water drop is 0.00008 kg.
Calculate its weight in Newtons.
(Gravitational field strength is 10 N/kg)

(2 marks)

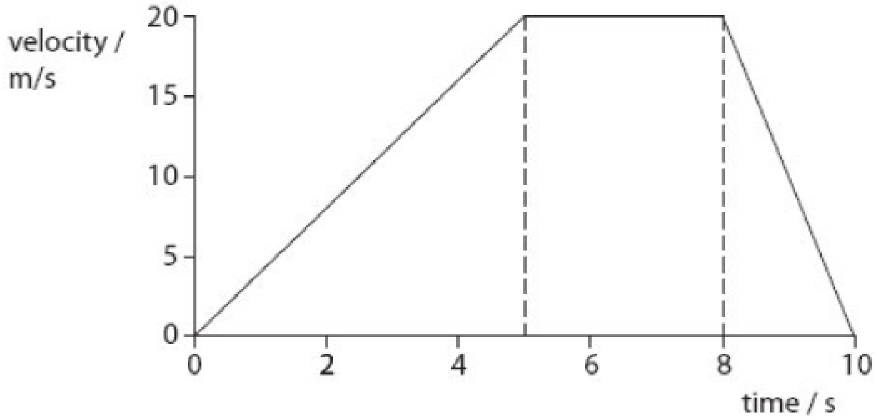
c The water drop falls to the ground, 13 m below, in 1.7 s.
Calculate the average speed in m/s of the drop while it is falling.

(2 marks)

d Assuming the droplet starts at rest calculate the velocity just before it hits the ground. Ignore air resistance.
($g = 10 m/s^2$)

(3 marks)

4 The graph shows how the velocity of a small car changes with time.



a Use the graph to estimate the velocity of the car at three seconds.

(1 mark)

b Calculate the acceleration in m/s^2 of the car when it is speeding up.

(2 marks)

c Explain why the units of acceleration are m/s^2.

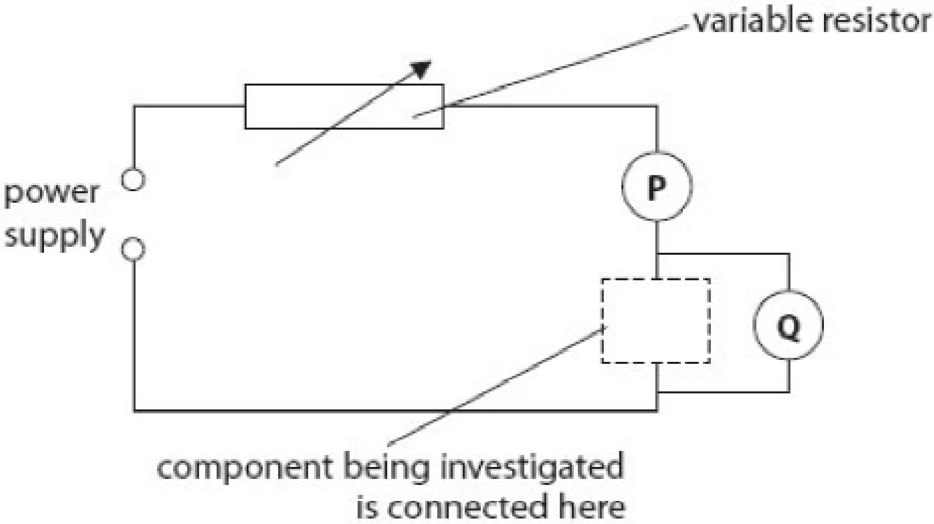
(2 marks)

d Show that the car travels further at a constant velocity than it does when it is slowing down.

(3 marks)

Electricity

1 Some students investigate the electrical resistance of different components using this circuit.



a Which row of the table is correct for both meters P and Q?

Place a cross (☒) in the box next to your answer.

		meter P is	**meter Q is**
A	☒	an ammeter	an ammeter
B	☒	an ammeter	a voltmeter
C	☒	a voltmeter	a voltmeter
D	☒	a voltmeter	an ammeter

(1 mark)

b One of the components being investigated is a 12 ohm resistor.

When it is in the circuit, the ammeter reading is 0.50 A.

Calculate the voltmeter reading.

(2 marks)

c The students reduce the resistance of the variable resistor.

State what happens to the readings on each of the meters P and Q. Explain what happens to P.

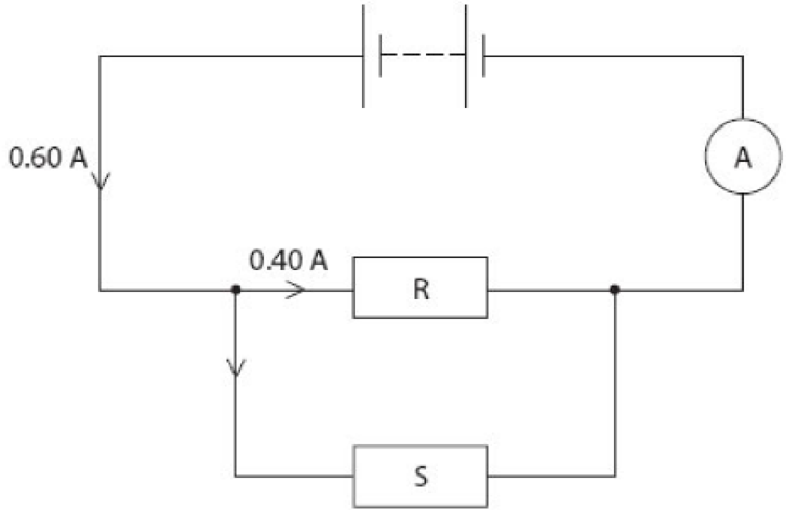
(2 marks)

d The students then reduce the voltage of the power supply.

State what happens to the current in the circuit.

(1 mark)

2 a The diagram shows an electric circuit with two resistors, R and S.



i R has a resistance of 11 ohms.

Calculate the potential difference across R.

(2 marks)

ii Use information from the diagram to calculate the current in S.

(1 mark)

iii Calculate the resistance of S.

(2 marks)

b Complete the sentence by putting a cross (☒) in the box next to your answer.

A student wants to measure the battery voltage with a voltmeter.
The voltmeter should be placed...

A in series with the battery ☒

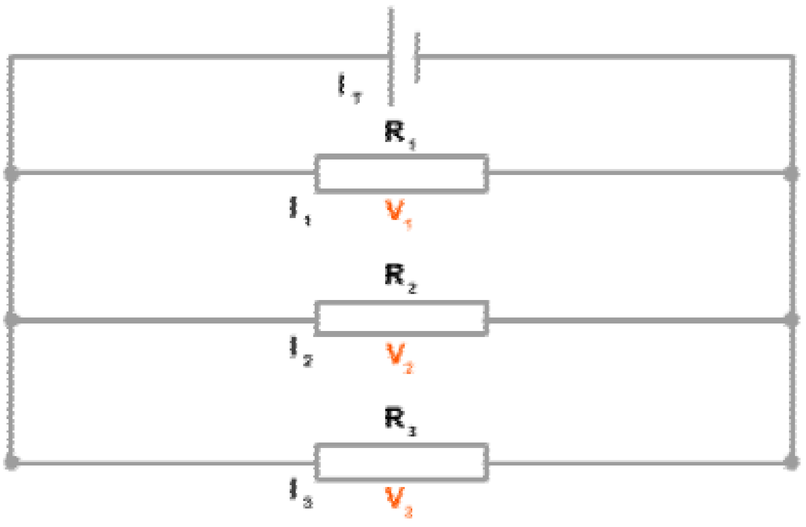
B in parallel with the battery ☒

C in parallel with the ammeter ☒

D in series with either resistor R or S ☒

(1 mark)

3 The diagram shows an electric circuit with three resistors, R_1, R_2 and R_3.



a **i** R_1 has a resistance of 5 ohms. The current flowing in it is 2A.
Calculate the potential difference across R_1.

(2 marks)

ii State the voltage provided by the battery

(1 mark)

b **i** The resistance of R_2 is 10 ohms and R_3 is 4 ohms. Calculate the combined resistance of R_1, R_2 and R_3 in this arrangement.

(4 marks)

ii Calculate the current being produced by the battery.

(2 marks)

c Calculate the current flowing in:

i R_2

ii R_3

(3 marks for **i** and **ii** combined)