PG ONLINE

ClearRevise

Illustrated revision and practice

AQA GCSE
Physics

8463 / 8464

Foundation & Higher

ClearRevise™

AQA GCSE
Physics 8463 / 8464

Illustrated revision and practice

Foundation and Higher
Physics and Trilogy Courses

Published by
PG Online Limited
The Old Coach House
35 Main Road
Tolpuddle
Dorset
DT2 7EW
United Kingdom

sales@pgonline.co.uk
www.clearrevise.com
www.pgonline.co.uk
2021

PREFACE

Absolute clarity! That's the aim.

This is everything you need to ace the examined component in this course and beam with pride. Each topic is laid out in a beautifully illustrated format that is clear, approachable and as concise and simple as possible.

Each section of the specification is clearly indicated to help you cross-reference your revision. The checklist on the contents pages will help you keep track of what you have already worked through and what's left before the big day.

We have included worked exam-style questions with answers for almost every topic. This helps you understand where marks are coming from and to see the theory at work for yourself in an exam situation. There is also a set of exam-style questions at the end of each section for you to practise writing answers for. You can check your answers against those given at the end of the book.

LEVELS OF LEARNING

Based on the degree to which you are able to truly understand a new topic, we recommend that you work in stages. Start by reading a short explanation of something, then try and recall what you've just read. This has limited effect if you stop there but it aids the next stage. Question everything. Write down your own summary and then complete and mark a related exam-style question. Cover up the answers if necessary but learn from them once you've seen them. Lastly, teach someone else. Explain the topic in a way that they can understand. Have a go at the different practice questions – they offer an insight into how and where marks are awarded.

ACKNOWLEDGEMENTS

The questions in the ClearRevise textbook are the sole responsibility of the authors and have neither been provided nor approved by the examination board.

Every effort has been made to trace and acknowledge ownership of copyright. The publishers will be happy to make any future amendments with copyright owners that it has not been possible to contact. The publisher would like to thank the following companies and individuals who granted permission for the use of their images in this textbook.

Design and artwork: Jessica Webb & Mike Bloys / PG Online Ltd
Insulation image: Martyn F Chillmaid/Science Photo Library. Sciencephotos / Alamy Stock Photo.
Resistance experiment image: © iStock. Frictionless ramp image: © Adobe Stock. Icons: Icons8.com
All other images: © Shutterstock
Contributor: Helen Sayers
Editing: Jim Newall

First edition 2021. 10 9 8 7 6 5 4 3 2 1
A catalogue entry for this book is available from the British Library
ISBN: 978-1-910523-33-9

Printed on FSC certified paper by Bell and Bain Ltd, Glasgow, UK.

MIX
Paper from responsible sources
FSC® C007785

THE SCIENCE OF REVISION

Illustrations and words

Research has shown that revising with words and pictures doubles the quality of responses by students.[1] This is known as 'dual-coding' because it provides two ways of fetching the information from our brain. The improvement in responses is particularly apparent in students when asked to apply their knowledge to different problems. Recall, application and judgement are all specifically and carefully assessed in public examination questions.

Retrieval of information

Retrieval practice encourages students to come up with answers to questions.[2] The closer the question is to one you might see in a real examination, the better. Also, the closer the environment in which a student revises is to the 'examination environment', the better. Students who had a test 2–7 days away did 30% better using retrieval practice than students who simply read, or repeatedly reread material. Students who were expected to teach the content to someone else after their revision period did better still.[3] What was found to be most interesting in other studies is that students using retrieval methods and testing for revision were also more resilient to the introduction of stress.[4]

Ebbinghaus' forgetting curve and spaced learning

Ebbinghaus' 140-year-old study examined the rate in which we forget things over time. The findings still hold power. However, the act of forgetting things and relearning them is what cements things into the brain.[5] Spacing out revision is more effective than cramming – we know that, but students should also know that the space between revisiting material should vary depending on how far away the examination is. A cyclical approach is required. An examination 12 months away necessitates revisiting covered material about once a month. A test in 30 days should have topics revisited every 3 days – intervals of roughly a tenth of the time available.[6]

Summary

Students: the more tests and past questions you do, in an environment as close to examination conditions as possible, the better you are likely to perform on the day. If you prefer to listen to music while you revise, tunes without lyrics will be far less detrimental to your memory and retention. Silence is most effective.[5] If you choose to study with friends, choose carefully – effort is contagious.[7]

1. Mayer, R. E., & Anderson, R. B. (1991). Animations need narrations: An experimental test of dual-coding hypothesis. *Journal of Education Psychology*, (83)4, 484–490.
2. Roediger III, H. L., & Karpicke, J.D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science*, 17(3), 249–255.
3. Nestojko, J., Bui, D., Kornell, N. & Bjork, E. (2014). Expecting to teach enhances learning and organisation of knowledge in free recall of text passages. *Memory and Cognition*, 42(7), 1038–1048.
4. Smith, A. M., Floerke, V. A., & Thomas, A. K. (2016) Retrieval practice protects memory against acute stress. *Science*, 354(6315), 1046–1048.
5. Perham, N., & Currie, H. (2014). Does listening to preferred music improve comprehension performance? *Applied Cognitive Psychology*, 28(2), 279–284.
6. Cepeda, N. J., Vul, E., Rohrer, D., Wixted, J. T. & Pashler, H. (2008). Spacing effects in learning a temporal ridgeline of optimal retention. *Psychological Science*, 19(11), 1095–1102.
7. Busch, B. & Watson, E. (2019), *The Science of Learning*, 1st ed. Routledge.

CONTENTS

Paper 1

Topic 1 Energy

Topic 2 Electricity

Topic 3 Particle model of matter

Topic 4 Atomic structure

Paper 2

Topic 5 Forces

Topic 6 Waves

Topic 7 Magnetism and electromagnetism

Topic 8 Space physics

MARK ALLOCATIONS

Green mark allocations[1] on answers to in-text questions throughout this guide help to indicate where marks are gained within the answers. A bracketed '1' e.g.[1] = one valid point worthy of a mark. In longer answer questions, a mark is given based on the whole response. In these answers, a tick mark[✓] indicates that a valid point has been made. There are often many more points to make than there are marks available so you have more opportunity to max out your answers than you may think.

TOPICS FOR PAPER 1

Energy, electricity, particle model of matter and atomic structure

Information about Paper 1:

Separate Physics 8461:

Written exam: 1 hour 45 minutes
Foundation and Higher Tier
100 marks
50% of the qualification grade
All questions are mandatory

Trilogy 8464:

Written exam: 1 hour 15 minutes
Foundation and Higher Tier
70 marks
16.7% of the qualification grade
All questions are mandatory

Specification coverage

The content for this assessment will be drawn from Topics 1–4 Energy; Electricity; Particle model of matter; and Atomic structure.

Questions

A mix of calculations, multiple-choice, closed short answer and open response questions assessing knowledge, understanding and skills.

Questions assess skills, knowledge and understanding of Physics.

ENERGY STORES AND SYSTEMS

Energy is stored in **systems**. A system is an object or a group of objects.

Common energy stores

Common energy stores are: **chemical**, **kinetic**, **elastic potential**, **gravitational potential** and **thermal**. Further stores are **magnetic**, **electrostatic** and **nuclear**. When a system changes, the way the energy is stored in the system changes.

Scenario	Store that decreases	Store that increases
An object thrown upwards	Kinetic	Gravitational potential
A moving object hitting a wall	Kinetic	Thermal
A bow releasing an arrow	Elastic potential	Kinetic
A vehicle slowing down when braking	Kinetic	Thermal (caused by friction)
Heating water on a camping stove	Chemical (in gas)	Thermal
Using a battery-operated fan	Chemical (in battery)	Kinetic and thermal (of the motor and surroundings)

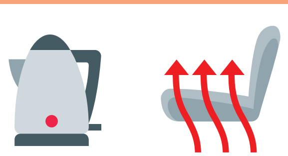
Change in systems

Systems can be changed by:

Heating

Work done by forces

Work done when current flows



1. Complete the sentences using answers from below.

   chemical **elastic potential** **gravitational potential** **kinetic** **thermal**

   (a) A cyclist accelerates. Energy is transferred from a chemical store to a ________________ store. [1]

   (b) When a stone falls from a cliff, energy is transferred from a ________________ store to a ________________ store. [2]

2. A fully charged electric scooter is ridden down a street at a constant speed. Explain how the energy stores change in this system. [3]

1. (a) kinetic[1], (b) gravitational potential[1], kinetic[1]

2. Three points from: Chemical energy[1] stored in the battery is transferred to the thermal energy[1] store of the scooter and then to the thermal energy[1] store of the surroundings due to air resistance and friction between the wheels and the ground[1].

KINETIC ENERGY (E_k)

Calculating kinetic energy

A moving object has a store of **kinetic energy**. The kinetic energy of a moving object can be calculated using the equation:

Kinetic energy = 0.5 × mass × (speed)^2, or $E_k = \frac{1}{2}mv^2$

You need to be able to recall and apply this equation.

E_k = kinetic energy in joules, J m = mass in kg v = velocity (speed) in metres per second.

The equation can be rearranged to calculate mass and speed.

1. A cyclist and bike have a combined mass of 75 kg. The cyclist is moving at 10 m/s. Calculate the kinetic energy of the cyclist and bike. [2]
2. A ball has a mass of 400 g. The ball moves with a speed of 2 m/s.

   Calculate the kinetic energy of the ball. Give the unit. [4]
3. **Higher only:** The mass of a runner is 70 kg. The kinetic energy of the runner is 875 J.

   Calculate the speed of the runner in m/s. [3]

1. $E_k = \frac{1}{2}mv^2$

   $= 0.5 \times 75 \times 10^2$ [1]

   $= 3750$ J [1]

2. $m = 400$ g $= 0.4$ kg [1]

   $E_k = \frac{1}{2}mv^2$

   $= 0.5 \times 0.4 \times 2^2$ [1]

   $= 0.8$ [1] J [1]

3. $E_k = \frac{1}{2}mv^2$

   $875 = 0.5 \times 70 \times v^2$ [1]

   $v = \sqrt{\frac{2 \times 875}{70}}$ [1]

   $v = 5$ m/s [1]

Remember to convert any values that have been given in different units.

For example:

1 MJ = 1 000 000 J

0.1 kg = 100 g

1 km = 1000 m; 1 cm = 0.01 m

1 minute = 60 seconds;
1 hour = 60 × 60 = 3600 seconds.

ELASTIC POTENTIAL ENERGY (E_e)

A stretched object, such as a spring or an elastic band under tension, stores **elastic potential energy**.

Calculating elastic potential energy

The elastic potential energy of an object can be calculated using the equation:

elastic potential energy = 0.5 × spring constant × (extension)^2

$$E_e = \frac{1}{2} ke^2$$

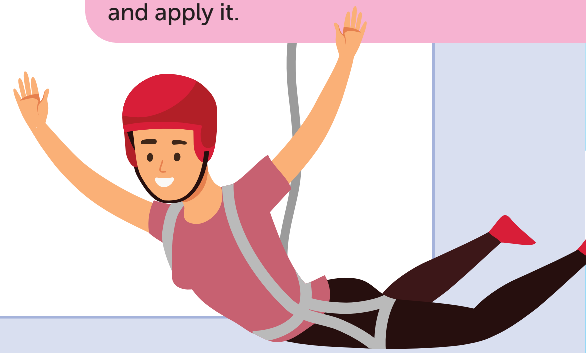
E_e = elastic energy in joules, J

k = spring constant in newtons per metre, N/m

e = extension in metres, m

The equation can be rearranged to calculate the spring constant and extension.

You need to be able to select this equation from the equation sheet and apply it.



A spring also has a store of elastic potential energy if it is squashed. The amount of energy can be calculated using the same equation, but with compression replacing extension.

The limit of proportionality

The **limit of proportionality** refers to the point at which an object will no longer return to its original shape or length when stretched or squashed. Beyond this point, you cannot calculate the elastic potential energy. See **page 72**.

1. A toy pops out on a compressed spring when a box is opened.
   (a) Describe the change in energy stores as the box opens. [2]
   (b) The spring extends by 0.1 m when the box opens. The spring constant is 4.0 N/m . Calculate the elastic potential energy, E_e, (J) stored in the spring when it is inside the box. [2]
2. **Higher only:** A training band stretched by 0.05 m has an elastic potential energy store of 0.02 J. Calculate the spring constant of the band in N/m. [3]

1. (a) Elastic potential energy[1] is transferred to kinetic energy[1].

(b) $E_e = \frac{1}{2} ke^2$

$= 0.5 \times 4.0 \times 0.1^2$ [1] $= 0.02$ J [1]

2. $E_e = \frac{1}{2} ke^2$

$0.02 = 0.5 \times k \times 0.05^2$ [1]

$k = \frac{2 \times 0.02}{0.05^2}$ [1]

$= 16$ N/m [1]

EXAMINATION PRACTICE

01 Choose the correct equation to calculate kinetic energy. Tick (✓) **one** box. [1]

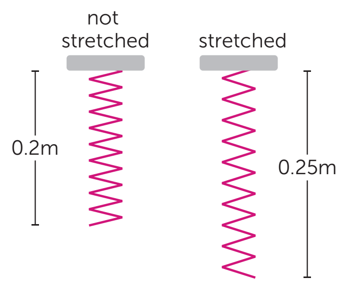
☐ $E_k = \frac{1}{2}mv^2$

☐ $E_k = ke^2$

☐ $E_k = \frac{1}{2}ke$

02 The diagram shows a spring before and after it is stretched.

Calculate the value of *e*, the spring extension, when it is stretched. [1]



03 Calculate the kinetic energy store of a bird with a mass of 0.4 kg flying at 8 m/s. Give the unit. [3]

04 A mountain biker rides along a path and jumps into the air. The cyclist and bike have a total mass of 85 kg.

04.1 Calculate the gravitational potential energy when the cyclist has jumped 2 m above the ground. Use g = 9.8 N/kg. [2]

04.2 Describe the energy transfers as the bike falls and then hits the ground. [2]

04.3 **Higher Tier only:** The cyclist does another jump and has a maximum gravitational potential energy of 680 J. Calculate the speed at which the cyclist hits the ground.

Assume that there are no energy transfers due to friction or other forces. [3]

POWER

The power transfer in any component or appliance is proportional to the potential difference across it and the current through it.

Power, potential difference and current

Power, potential difference and current are linked by the equation:

power = potential difference × current

$$P = V \times I$$

P = power in watts, W

V = potential difference in volts, V

I = current in amperes (amps), A

Remember these definitions of power from **page 7**.

$$\text{power} = \frac{\text{energy transferred}}{\text{time}} = \frac{\text{work done}}{\text{time}}$$

You need to be able to recall and apply both these equations.

Power, current and resistance

Power, current and resistance are linked by the equation:

power = (current)^2 × resistance

$$P = I^2 R$$

P = power in watts, W

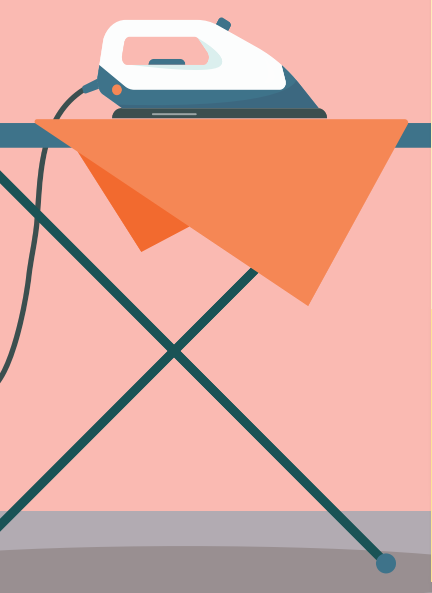
I = current in amperes (amps), A

R = resistance in ohms, Ω

- As $V = I \times R$, substitute $I \times R$ for V in the equation $P = V \times I$
- current^2 = current × current

Large powers are given in kW.

1 kW = 1000 W



1. Convert 72.61 kW to W. Tick **one** box. [1]

   ☐ 0.07261 W ☐ 7261 W ☐ 72 610 W ☐ 726 100 W

2. Calculate the power, in kW, of an electric iron with a current in it of 11.3 A and a potential difference across it of 230 V. [2]
3. There is a potential difference of 1.5 V across a 7.5 Ω resistor. The current through the resistor is 0.2 A. Show **two** different calculations to confirm that the power of the resistor is 0.3 W. [2]
4. **Higher Tier only:** A 5.0 Ω resistor has a power rating of 12.0W. Calculate the current, in amps, in the resistor. [3]

1. 72 610 W[1]

2. $P = V \times I$
$= 230 \times 11.3$[1]
$= 2.60$ kW[1]

3. $P = V \times I$
$= 1.5\ \text{V} \times 0.2\ \text{A} = 0.3\ \text{W}$[1]
$P = I^2R$
$0.2\ \text{A} \times 0.2\ \text{A} \times 7.5\ \Omega = 0.3\ \text{W}$[1]

4. $P = I^2R$
$12 = I^2 \times 5$[1]
$I = \sqrt{\frac{12}{5}}$[1] $= 1.5$ A[1]

THE NATIONAL GRID

Electrical power is transferred from power stations to consumers using the **National Grid**.

The National Grid is the system of cables and transformers in the UK that links power stations to consumers.

Step-up transformers are used to increase the potential difference (pd) from the power stations. The pd is increased from about 25 kV to values up to 400 kV.

Step-down transformers are used to decrease the pd from the transmission cables to a much lower pd of 230 V for use in homes.

The current heating effect means that the current in the transmission cables heats up the cables, dissipating energy to the surroundings. This reduces the amount of useful energy transferred and makes the system less efficient.

The electrical power transferred by the cables is given by the equation:

$$\text{power} = \text{pd} \times \text{current}$$

So for the same power, when the pd is increased, the current decreases.

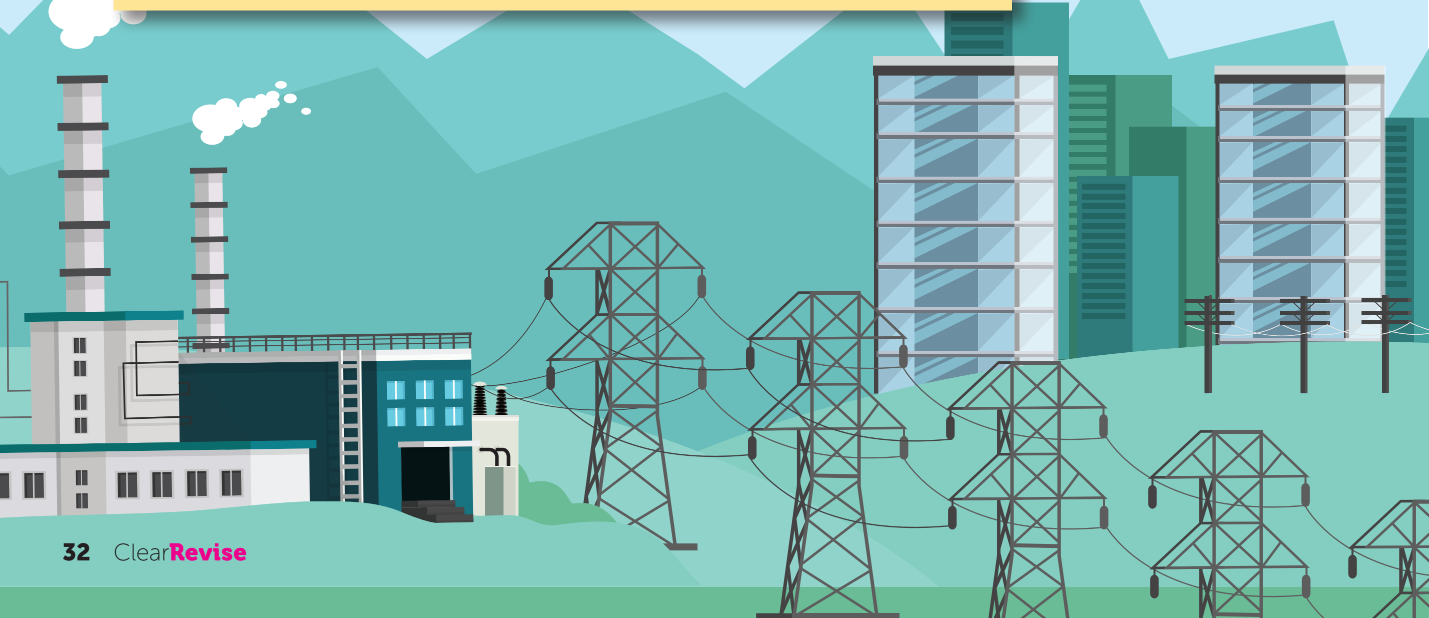
The electrical power dissipated by the cables is given by the equation:

$$\text{power} = (\text{current})^2 \times \text{resistance}$$

So by reducing the current, and using wires with a low resistance, the electrical power dissipated by the current heating effect is minimised.

Explain why the National Grid system is an efficient way to transfer energy. [6]

The power dissipated in the transmission cables is given by the equation $P = I^2R$.[1] In the National Grid, a step up transformer[1] steps up the pd and reduces the current[1]. So, reducing the current, reduces the energy dissipated[1] by the current heating effect[1]. In addition, wires with low resistance are also used to help minimise the energy dissipated.[1]

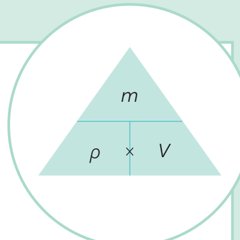


REQUIRED PRACTICAL 5 (17)

Determining the densities of liquids, regular solids and irregular solids

This practical activity helps you develop your ability to measure length, mass and volume accurately, and then determine densities.

Density, mass and volume



To determine density, the mass and volume of a subject needs to be measured.

Use **density** = $\dfrac{\text{mass}}{\text{volume}}$

Mass is measured using an electronic balance. The mass of a solid can be measured directly by placing it onto a balance. A liquid can be put into a container with a known mass.

The mass of the liquid = (mass of liquid and container) – (mass of empty container)

Volume is measured in different ways depending on both the state and shape of the substance.

Liquids

In a classroom laboratory, the most accurate container for measuring the volume of a liquid is a **measuring cylinder**. For accuracy, choose one with the smallest graduations that will contain the volume of liquid.

Example: For an approximate volume of 4 cm^3, use a 5 cm^3 cylinder with graduations of 0.1 cm^3 instead of a 10 cm^3 cylinder with graduations of 0.2 cm^3.

Liquid volume is also measured in ml. (1 cm^3 = 1 ml)

Regular shaped solids

The volume of a **regular shape** can be found by measuring the quantities that are needed to calculate the volume from the mathematical formula for that shape. This usually includes **length**.

Example:
Volume of a cuboid = length × height × width

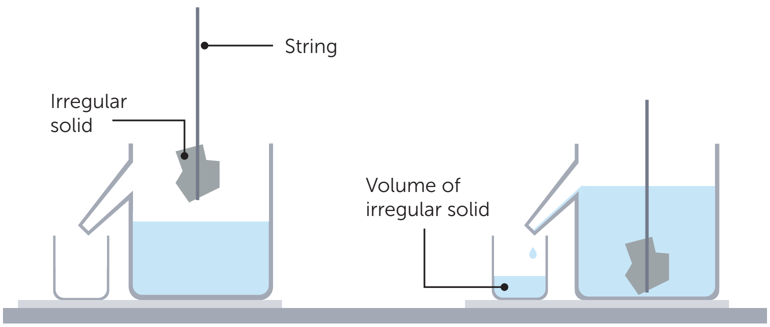
Measure the three lengths using a **ruler** or **Vernier callipers**.

Irregular shaped solids

The volume of an irregular shape can be found by displacement. The solid is carefully lowered into a liquid, usually water. The solid will displace the same volume of the liquid and this volume can then be measured. The solid must be fully submerged to obtain its volume.

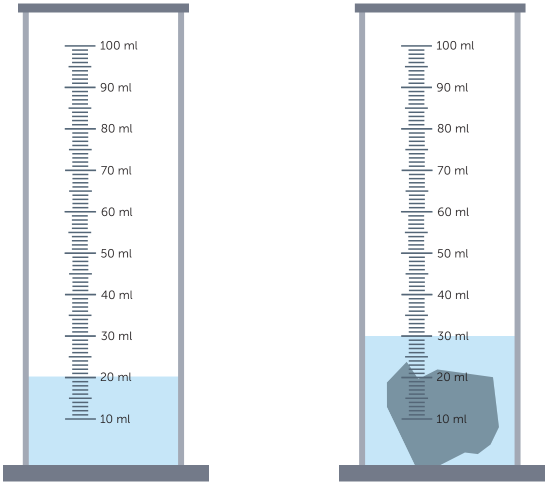
1. Using a eureka can

The can is filled up to the spout with water and the solid lowered in. The displaced water is collected in a measuring cylinder. The displaced water has the same volume as the irregular solid. Because a liquid takes the shape of a container, the volume can be easily measured.



2. Direct measurement in a measuring cylinder

Record the volume of the water in the measuring cylinder. Carefully lower the solid into the water and record the new volume. volume of object = (volume with object) – (volume without object)



What potential sources of error are there in the two methods described above? [3]

Not lowering in the object carefully so that water splashes out of the measuring cylinder.[1]
Not reading the scale on the measuring cylinder at eye level.[1]
Level of water in the eureka can is below the level of the spout when the object is lowered into it.[1]

INCREASING THE PRESSURE OF A GAS

Work is the transfer of energy by a force.

Doing work on a gas increases the internal energy (the total kinetic and potential energy of the particles) of the gas. This can cause the temperature of the gas to increase because the temperature of a gas is related to the average kinetic energy of the particles.

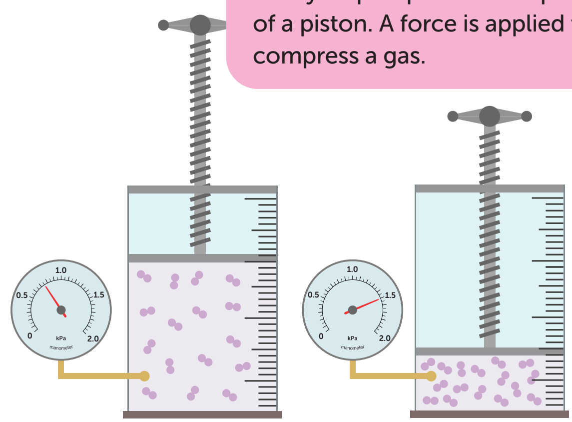
Applying a force to compress a gas increases the pressure of the gas.

Doing work on a gas

A person presses a piston down on a column of gas contained within the piston. The force moves the piston, and the gas is compressed. Work is done on the gas which means there is an energy transfer. Mechanical work has transferred energy from the person's chemical energy store to the internal energy store of the gas.

The amount of work done, or energy transferred, depends on the magnitude of the force and the distance the piston moves.

A bicycle pump is an example of a piston. A force is applied to compress a gas.



Explain why a bicycle pump gets warm when it is used to inflate a tyre. [3]

Work is done to compress the air in the bike pump[1] *so energy is transferred to the air. This increases the internal energy of the air particles*[1] *so the temperature of the air increases*[1]*. Or:*

The volume of the air in the pump decreases[1] *so the pressure increases*[1]*. This increases the internal energy of the gas particles so the temperature increases.*[1]

RADIOACTIVE CONTAMINATION

Exposure to radioactive materials can be harmful. Measures need to be taken to minimise the risk. There are two types of exposure to consider.

Contamination and irradiation

Radioactive contamination

Contamination involves unwanted direct contact with materials containing radioactive atoms. The exposed object also becomes radioactive. It is the decay of the radioactive atoms that causes the hazard. The level of danger is determined by the type of radiation emitted, its ionising power, and its ability to penetrate air and other materials.

Compare the hazards associated with radioactive contamination and irradiation. [6]

Contamination is the unwanted presence of radioactive particles on other objects after they and a radioactive material have come into direct contact with each other.[✓] The object then becomes radioactive as well so will emit radiation[✓] until all the particles have decayed[✓]. The longer the half-life of the radioactive particles, the longer this takes.[✓] Irradiation occurs when an object is exposed to a source.[✓] The greater the distance from the source, the weaker the irradiation.[✓] The shorter the time spent near the source, the lower the irradiation.[✓] Removing the object from the source stops the irradiation.[✓] The type of radiation affects the damage it can cause[✓]. The more ionising the radiation, the more tissue damage.[✓] Contamination with alpha particles inside a body is particularly dangerous[✓] because alpha particles are highly ionising[✓]. Being exposed to alpha particles outside the body is less harmful as they cannot penetrate skin.[✓] Beta particles and gamma rays can penetrate skin.[✓] Wearing protective clothing can reduce the risks from both contamination and irradiation.[✓]

This question should be marked with reference to the levels of response guidance on *page 170.*

Irradiation

Irradiation is the process of exposing an object to nuclear radiation. The irradiated object does not become radioactive. For example, fresh fruit is irradiated to destroy bacteria on it and preserve the fruit for longer. The fruit does not become radioactive.

Humans are often irradiated deliberately for medical reasons with a controlled dose of radiation.

Suitable precautions must be taken to protect against any hazard. This includes wearing protective clothing, minimising unnecessary exposure and handling radioactive materials with tongs. Using tongs prevents contamination by stopping hands touching the radioactive material. They also reduce the rate of irradiation by increasing the distance of the hands from the radioactive source.

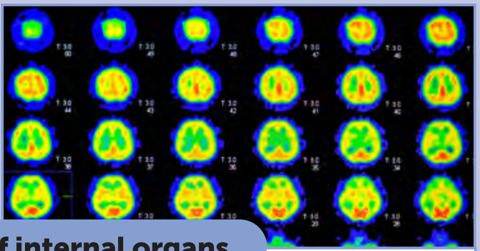
The effect of radiation on humans is studied globally. It is important to publish the findings so that other scientists can rigorously check them and confirm or challenge the evidence. This process is known as **peer review**.

USES OF NUCLEAR RADIATION

There are many uses of nuclear radiation.

Diagnostic medicine and treatments

The half-life and toxicity of an isotope used for medical reasons needs to be considered, as well as the type of radiation emitted in terms of ionisation and penetration.



Medical contamination for the exploration of internal organs

Radioactive sources are used as **tracers** to look at soft tissues and to find areas of blockage. Sources emitting gamma rays can be injected into the body and detected by medical imaging processes.

This involves using non-poisonous isotopes with half-lives long enough for the isotope to produce enough measurements, but short enough so that the activity decays to safe levels quickly and the exposure of the patient to ionising radiation is minimised. They are usually emitters of gamma rays.

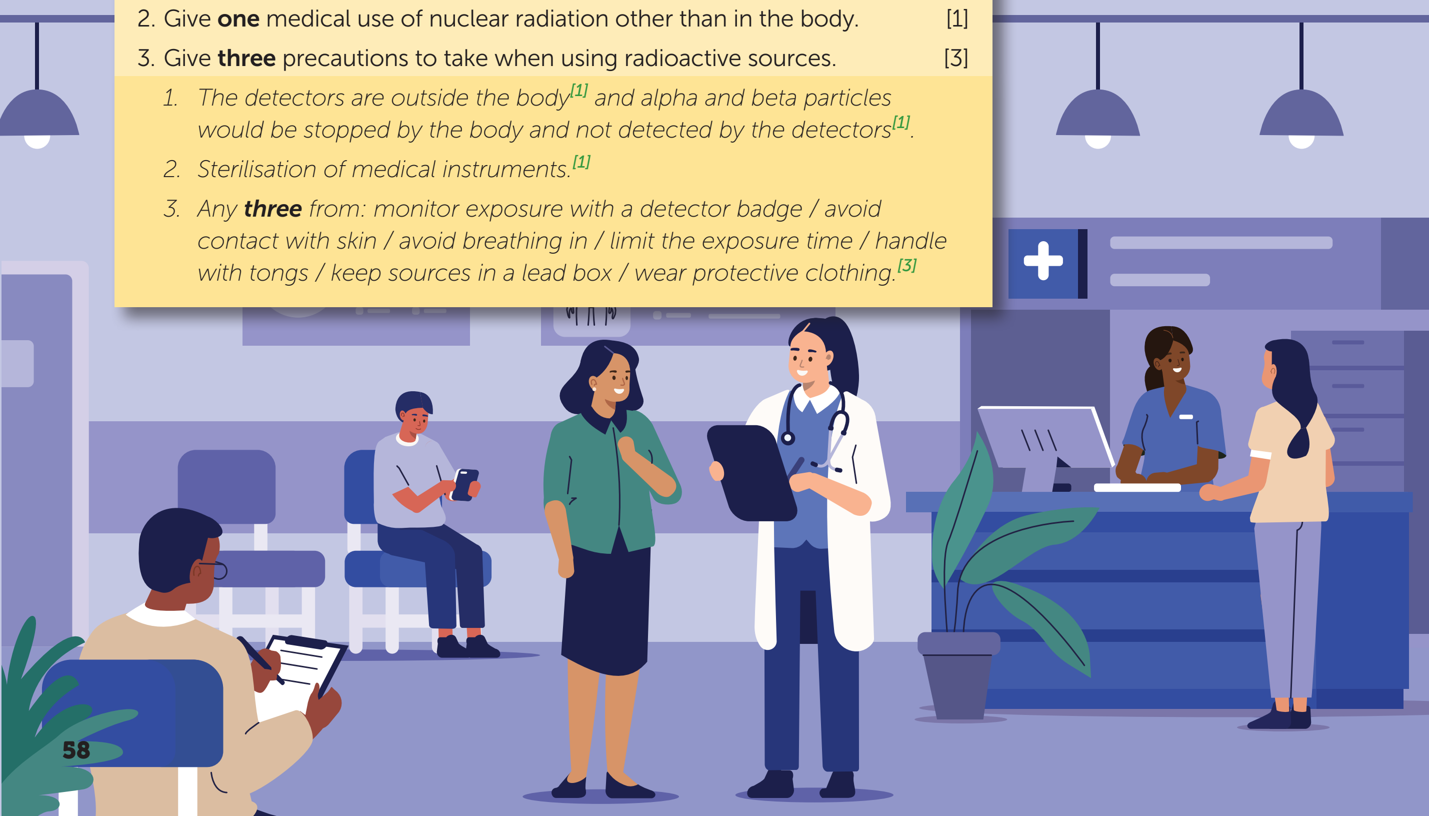
Medical irradiation for the control or destruction of unwanted tissue

Nuclear radiation can damage or destroy cells which can be controlled for medical advantage.

Gamma rays can be used to kill cells in cancerous tumours deep inside the body. The dose is maximised by targeting the beam at different angles, and minimising damage to healthy tissue.

1. Suggest why tracers are usually emitters of gamma rays. [2]
2. Give **one** medical use of nuclear radiation other than in the body. [1]
3. Give **three** precautions to take when using radioactive sources. [3]

1. *The detectors are outside the body*[1] *and alpha and beta particles would be stopped by the body and not detected by the detectors*[1].
2. *Sterilisation of medical instruments.*[1]
3. *Any* ***three*** *from: monitor exposure with a detector badge / avoid contact with skin / avoid breathing in / limit the exposure time / handle with tongs / keep sources in a lead box / wear protective clothing.*[3]



TOPICS FOR PAPER 2

Information about Paper 2:

Separate Physics 8461:

Written exam: 1 hour 45 minutes
Foundation and Higher Tier
100 marks
50% of the qualification grade
All questions are mandatory

Trilogy 8464:

Written exam: 1 hour 15 minutes
Foundation and Higher Tier
70 marks
16.7% of the qualification grade
All questions are mandatory

Specification coverage

The content for this assessment will be drawn from Topics 5–8. Forces; Waves; Magnetism and electromagnetism; and Space physics.

Questions

A mix of calculations, multiple-choice, closed short answer and open response questions assessing knowledge, understanding and skills.

Questions assess skills, knowledge and understanding of Physics.

CONTACT AND NON-CONTACT FORCES

Forces are pushes and pulls that act on an object due to an interaction with another object.

Types of force

Force is a vector quantity, so it has size and direction. Forces are represented by arrows, often drawn to scale. The longer the arrow, the larger the force.

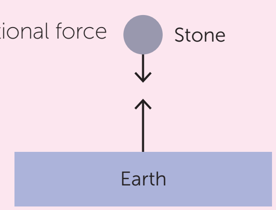
The size and direction of a force is determined by the force that is acting and how it is acting.

There are two types of forces:

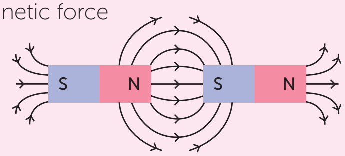
- **Contact forces** – when objects are touching.
- **Non-contact forces** – when objects are not touching or are separated.

Non-contact forces

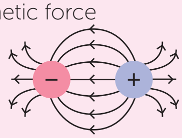
Gravitational force



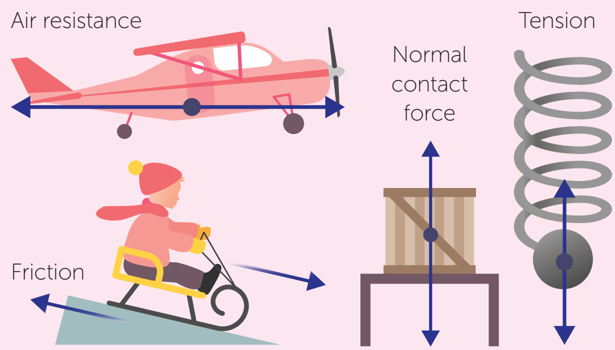
Magnetic force



Electromagnetic force



Contact forces

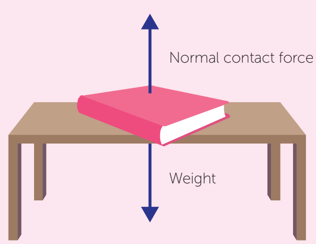


3. Explain the difference between a gravitational force and a magnetic force. [2]

3. A gravitational force always attracts[1] but a magnetic force can attract or repel.[1]

Interaction pairs

A book is sitting on a table. The weight of the book is balanced by the reaction force from the table. This force is at right angles to the surface and is called the **normal contact force** from the table. There is an interaction between the two objects which produces a force on each object. 'Normal' means at 90°.



1. Explain why an electrostatic force is a non-contact force. [2]
2. Identify the other force in each of the interaction pairs shown in the contact force diagrams. [4]

1. There will be a force between two charged objects when they are brought close together but not touching.[1] The objects do not have to be touching for the force to be exerted.[1]

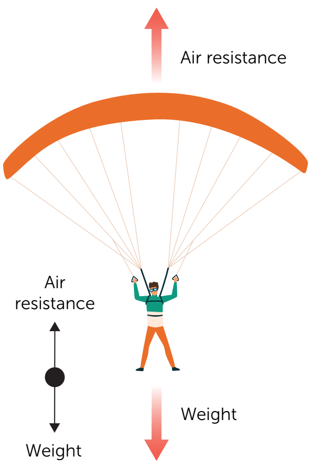
2. Tension: weight[1]; Air resistance: pushing force or thrust[1]; Friction: pushing force[1]; Normal contact force: weight[1].

FREE BODY DIAGRAMS

A **free body force diagram** is a simplified diagram showing the forces acting on an object shown as a simple box or a dot. The force arrows act away from the centre of the box or dot.

Balanced forces

The air resistance is equal and opposite to the weight of the parachutist so there is no net force on the parachutist and the forces are balanced.

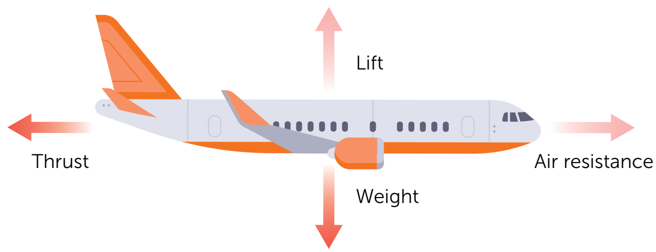


Unbalanced forces

The weight of the aeroplane is equal and opposite to the lift of the plane. So there is no net vertical force.

The thrust from the engines of the aeroplane is greater than the air resistance. So the horizontal forces are unbalanced and there is a resultant force to the left.

The same force can sometimes be described using different words. For example, **drag** and **air resistance**; **forward force** and **thrust**. The situation of the object, and the direction of the force arrow, will make what the force represents clearer.



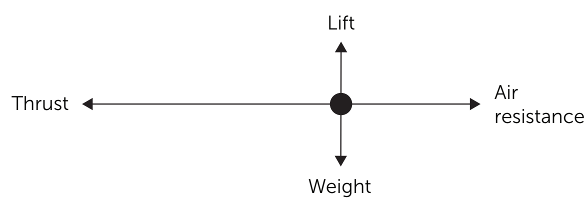
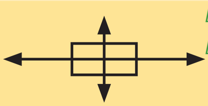
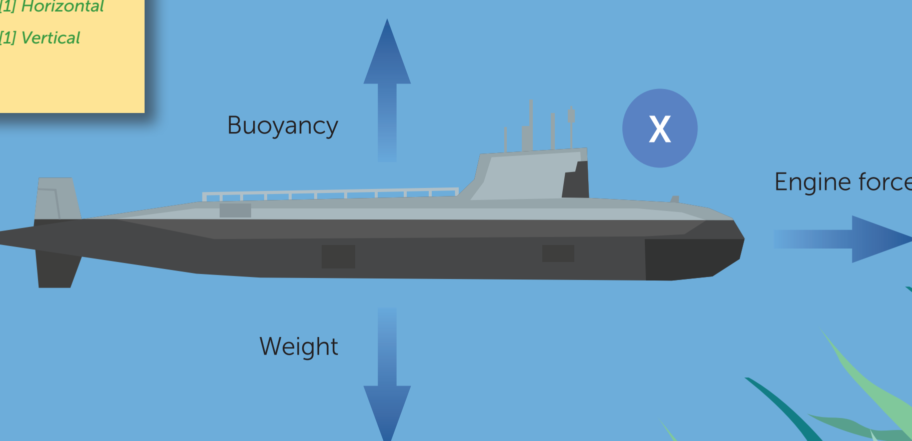


Figure X, below, shows a submarine moving forward at a constant depth.
Draw a free body diagram of this submarine. [2]



[1] Horizontal
[1] Vertical

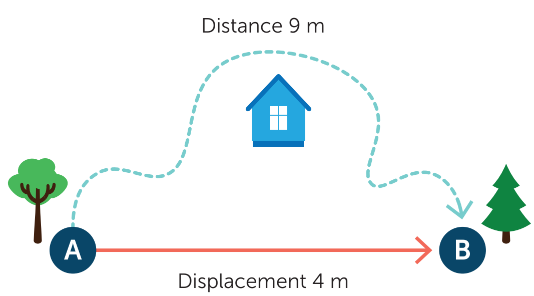


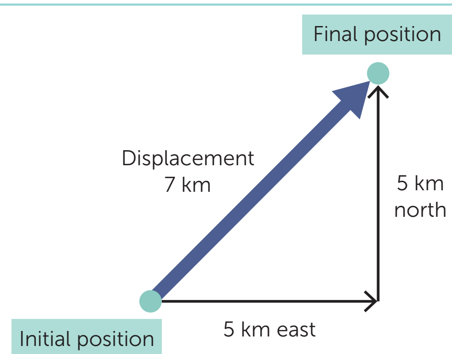
DISTANCE AND DISPLACEMENT

Distance and **displacement** are both ways of describing how far an object has moved from its starting point.

Properties of distance and displacement

Distance	Displacement
The total length of the path travelled by a moving object from start to finish	The shortest distance between the start and finish points of a moving object
Any shape line	Straight line
Scalar quantity	Vector quantity
No direction	The direction of the straight line is described in terms of an angle or a point of the compass
Measured in metres, m	Measured in metres, m
Will always have a positive value	Values can be positive or negative depending on the direction moved
Will still be total distance moved when an object has moved from one point and returned to the same place	Will be zero when an object starts and finishes at the same place





1. Describe the difference between displacement and distance. [1]
2. Describe the displacement of the object above right. [1]

1. Distance only has magnitude, displacement has a magnitude and a direction.[1]

2. The displacement is 7 km north east.[1]

VELOCITY-TIME GRAPHS

You can use a velocity-time graph to calculate acceleration and distance travelled.

Calculating acceleration

The acceleration of an object can be determined from a velocity–time graph.

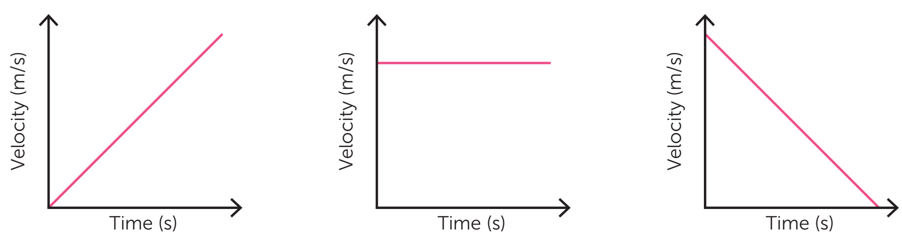
- A velocity-time graph shows how the velocity of an object changes over time
- The **gradient** of the graph equals the **acceleration** of the object

Using the gradient

- Gradient = Δv / Δt
- The gradient equals acceleration because $a = \Delta v / t$
- The steeper the line, the greater the acceleration

Deceleration is negative acceleration.

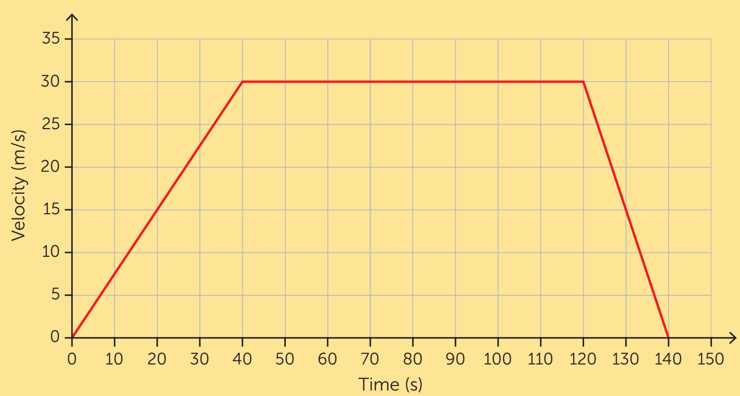
Constant acceleration | Constant velocity | Constant deceleration



A straight line upwards represents **constant acceleration** as it has a positive gradient.
A horizontal line shows **constant velocity** and zero acceleration as the gradient is zero.
A straight line downwards represents **constant deceleration** as it has a negative gradient.

1. A train starts from stationary and accelerates at a constant rate for 40 s. It then travels at a constant velocity of 30 m/s for 80s. It slows down to a stop with a constant deceleration for 20 s.
   Draw a velocity-time graph for this train journey. [3]

1. *Line from (0,0) to (40,30).*[1] *Line from (40,30) to (120, 30).*[1] *Line from (120,30) to (140, 0).*[1]



Determining distance — Higher Tier

Velocity-time graphs can also be used to determine the **distance travelled** by (or displacement of) an object on a journey. The distance travelled over a period of time equals the **area under the velocity-time graph** for that period of time.

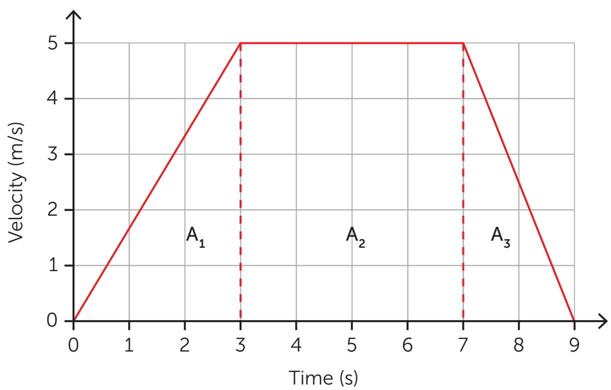
The area, and hence the distance travelled, can be calculated by using the values of time and velocity from the graph. Because the graph lines will be horizontal, or sloping up and down, the area under the graph will be a **triangle** or **rectangle** shape, or a combination.

Area of a rectangle = width × height

Area of a triangle = ½ × base × height

Area under a distance-time graph

Calculate the distance travelled shown in the velocity-time graph by calculating the area under the graph.



Check that the units match for both axes.

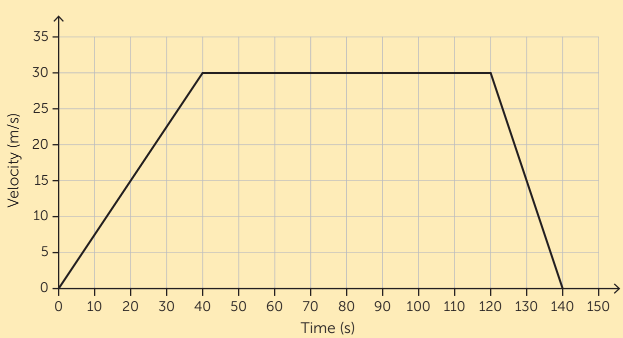
In this case area = s × m/s so the distance travelled is in m.

You could also calculate the distance by finding the area of a trapezium.

Counting squares

You can also find the distance, or the area under the graph by **counting squares** under the graph line. This is straightforward when they are all whole squares, and more likely to be an estimate when there are several part squares under the line.

2. This is a velocity-time graph for a train journey.
   Calculate the total distance travelled by the train. [1]



2. distance = $(\frac{1}{2} \times 40 \times 30) + (80 \times 30) + (\frac{1}{2} \times 20 \times 30)$
   $= 600 + 2400 + 300$[1] $= 3300$ m[1]

CONSERVATION OF MOMENTUM CALCULATIONS

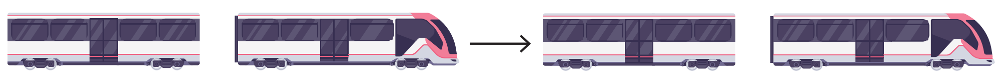
When the momentum before or after an event is known, along with some of the masses and velocities, an unknown value for mass or velocity can be calculated using the conservation of momentum.

Check the values you calculate for unknown mass and velocity make sense in terms of the known values.

Collision between two objects

Consider a collision between two objects. When the two objects remain separate, then their individual momentums before and after the collision can be calculated when you know the velocity of one of the objects after the collision.

Before collision **After collision**

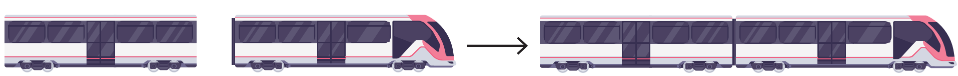


m_1v_1 m_2v_2 m_1v_3 m_2v_4

$$m_1v_1 + m_2v_2 = m_1v_3 + m_2v_4$$

If two objects stick together after a collision, then the new mass is the total of the two colliding masses.

Before collision **After collision**



m_1v_1 m_2v_2 $(m_1 + m_2)\,v_3$

$$m_1v_1 + m_2v_2 = (m_1 + m_2)\,v_3$$

Write out the equation in full for the momentum before and after to isolate and calculate the unknown value.

1. A supermarket trolley with a mass of 14.0 kg moves at a velocity of 2.1 m/s. It hits an identical trolley moving at a velocity of 1.5 m/s in the same direction. The two trolleys move off together. Calculate the velocity of the two trolleys as they move together. [3]
2. Ice skater 1 has a mass of 60 kg and skates in a straight line with a velocity of 3 m/s. Ice skater 1 bumps into stationary ice skater 2. Ice skater 2 moves forward with a velocity of 2 m/s. Ice skater 1 continues to move forward with a velocity of 0.5 m/s. Calculate the mass of ice skater 2. [3]

1. $m_1v_1 + m_2v_2 = (m_1 + m_2)v_3$ $(14 \times 2.1) + (14 \times 1.5) = (14 + 14)v_3$[1] $v = (29.4 + 21) / 28$[1] $= 1.8$ m/s[1]

2. $m_1v_1 + m_2v_2 = m_1v_3 + m_2v_4$ $(60 \times 3) + (75 \times 0) = (60 \times 0.5) + (m \times 2)$[1] $v = (180 - 30) / 2$[1] $= 75$ kg[1]

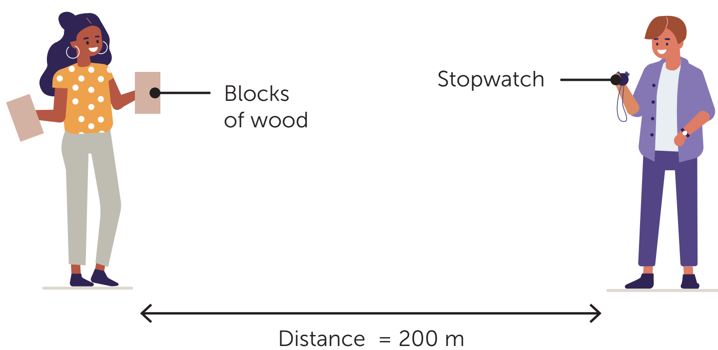
MEASURING WAVE SPEED

There are various methods for measuring the speed of sound in air and the speed of ripples on the surface of water.

Measuring the speed of sound in air

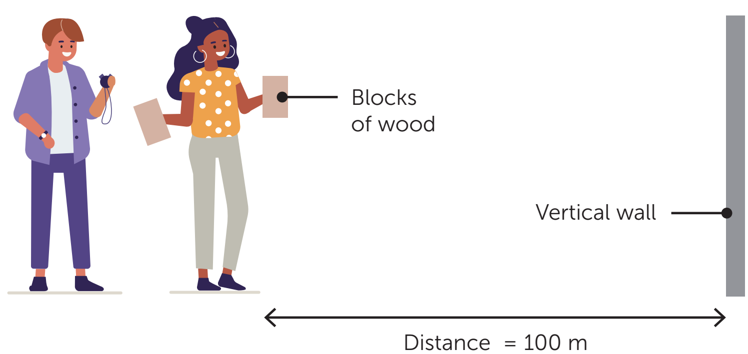
One possible method is:

- A person makes a loud noise (e.g. banging together blocks of wood) and indicates as they make the sound.
- A second person stands 100–200 m away and starts a stopwatch when they see the visual sound indication.
- They stop the watch when they hear the sound and record the time taken.



The sound is seen being made before it is heard because light travels much faster than sound in air (3×10^8 m/s, and 330 m/s)

An alternative method is to record the time taken to hear an echo from a wall (the sound travels to the wall and back). This has the advantage of a greater distance, so the time taken for the sound wave to travel will be longer and easier to measure. Also, the person with the stopwatch stands next to the person making the sound which may mean the stopwatch is started more accurately.



Measuring the speed of waves and ripples on a water surface

One possible method is to time how long it takes a water wave to travel a known distance such as along a sea wall. A ripple tank can also be used for this.
See the next page for more details. **RPA 8 (20)**.

1. Explain how the reaction time of the person timing affects the measurement of the speed of sound using a wall. [2]
2. You are going to measure the speed of a water wave by timing how long it takes to travel a known distance along a sea wall.
   Describe how you would take your measurements. [3]

1. The reaction time of the person timing introduces an error which makes the time longer than the true value.[1] This has the effect of calculating the speed to be lower than its true value.[1]

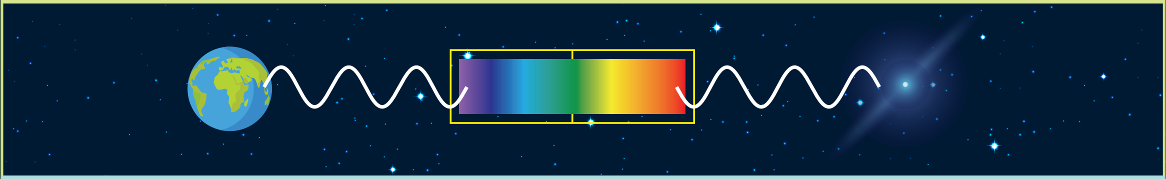
2. Identify two obvious features or points on the sea wall that you can use for timing the waves.[1] Measure the distance between these two points.[1] Time how long it takes several waves to travel between these two points.[1]

You can see a lightning flash before you hear the clap of thunder. The light from the flash travels at the speed of light, whereas the sound from the clap of thunder travels at the speed of sound. You can use this information to calculate how far away the lightning flash was.

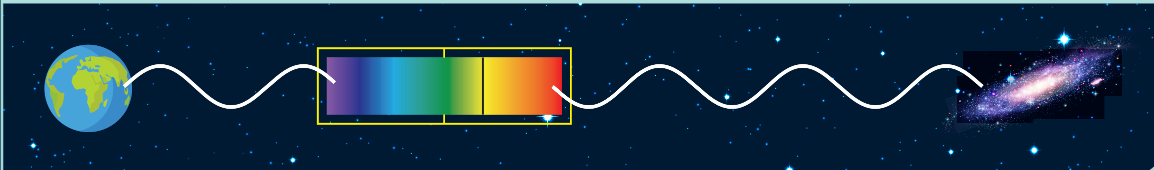
RED-SHIFT

Red-shift is the observed increase in the wavelength of light from most distant galaxies. When the spectrum of light from stars is examined, there are black lines where wavelengths have been absorbed. The light waves coming from a distance galaxy appear to be stretched so the observed **wavelength** is **increased**. This moves the black line towards the red part of the spectrum.

Spectrum from a nearby star

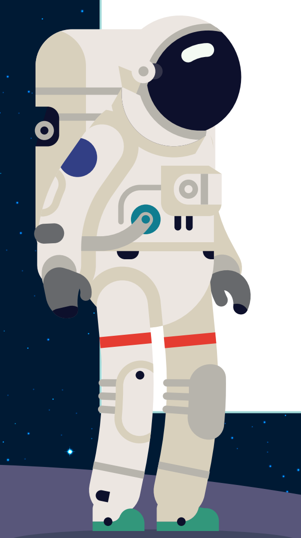


Spectrum from a galaxy that is far away



The **further away** the galaxy is, the greater the observed increase in wavelength, which means the galaxy is **receding faster**.

The **Big Bang theory** suggests that the universe began as an extremely small, hot, dense region which started to expand. Red-shift provides evidence for this theory and supports the idea that the universe expanded and continues to expand.



Theory suggests that the rate of expansion should slow down because of gravity. However, since 1998, observations of supernovae suggest that the rate that distant galaxies are receding is actually increasing. This could be explained by the existence of **dark mass** and **dark energy** which is not yet fully understood.

Tick **one** box in each row to show whether each statement is true or false. [3]

Evidence from red-shift	True	False
The universe is expanding		
The Big Bang theory is definitely correct		
All galaxies travel at the same speed		
Red-shift is smaller for galaxies that are further away		
The further away a galaxy is the faster it moves		
The faster a galaxy moves the greater the red-shift		

T, F, F, F, T, T.[3] (5 correct.[2] 4 correct.[1])

EXAMINATION PRACTICE ANSWERS

Topic 1

01 $E_k = \frac{1}{2}mv^2$ [1]

02\. 0.05m [1]

03\. $E_k = \frac{1}{2}mv^2 = 0.5 \times 0.4 \times 8^2$ [1] = 12.8 [1] J [1] [3]

04.1 $E_p = mgh = 85 \times 9.8 \times 2$ [1] = 1666 J [1] [2]

04.2 As the cyclist falls, energy is transferred from the gravitational potential energy store to the kinetic energy store, [1] and as the cyclist hits the ground the kinetic energy is transferred to the thermal energy store of the air in the tyre, and the surroundings and/or elastic potential energy store of the tyres [1]. [2]

04.3 **Higher Tier only:** $E_p = E_k$ so $E_k = 0.5 \times 85 \times v^2 = 680$ J [1] $v = \sqrt{[680 / (0.5 \times 85)]}$ [1] = 4.0 m/s² [1] [3]

05 Trend: The number of diesel cars sales went down 2018-19. [1]

Reason: Any one from: diesel is a known air pollutant / some places are banning diesel cars from city centres / Government targets to ban production of new fossil fuel cars by 2030. [1]

Trend: The number of electric car sales went up 2018-19. [1]

Reason: Any one from: becoming more available / prices are starting to come down / they are becoming cheaper to run / increase in electric car charging points ; no car tax / people are encouraged to buy them as they contribute less to carbon dioxide emissions. [1] [4]

06 Advantage: (any one from) does not emit carbon dioxide / sulfur dioxide / contribute to global warming. [1]

Disadvantage: (any one from) hugely expensive to build/decommission the power station; disposal of radioactive waste; risk of catastrophic accident. [1] [2]

07 Air is a better insulator than brick [1] so having a layer of air reduces the rate that thermal energy can transfer through the walls [1] increasing the thickness of the wall by having two layers also reduces the rate of energy transfer [1]. [3]

08 Efficiency = useful power output / total power input; 0.45 = useful power output / 30;
useful power output = 0.45 × 30 [1] = 13.5W [1] $E = Pt = 13.5 \times 20 = 270$ J [1] [3]

09 The same amount of energy needs to be supplied by both heaters (to warm up the room) [1] and the more powerful heater transfers that energy more quickly [1]. [2]

10.1 The amount of energy in joules needed to raise the temperature of 1 kg of water by 1°C. [1]

10.2 The time the heater is on. [1]

10.3 Thermal energy from the heater was also transferred to heat up the air/beaker/surroundings [1] so reduce this loss by increasing the insulation of the container [1]. [2]

10.4 **Higher Tier only:** 250 g = 0.25 kg [1]; $\Delta E = mc\Delta\theta$; $2100 = 0.25 \times 4200 \times \Delta\theta$ [1]; $\Delta\theta = 2100 / (0.25 \times 4200)$ [1] = 2 °C [1] [4]

11 ***Suggested method: This is an extended response question that should be marked in accordance with the levels based mark scheme on page 170.*** [6]

Indicative content:
Put 80cm³ hot water from a kettle into a 100cm³ beaker.[✓]
Take care with hot water[✓]
Place a cardboard lid on the beaker with a hole for a thermometer.[✓]
Insert the thermometer through the lid into the hot water.[✓]
Record the temperature of the water and start the stopwatch.[✓]
Record the temperature of the water every 3 minutes for 15 minutes.[✓]
Repeat for 2 layers of newspaper around the beaker[✓] held in place with an elastic band [✓].
Aim to have the same starting temperature of the hot water.[✓]
Then also repeat for 4, 6 and 8 layers of newspaper.[✓]
Draw cooling curves for each different number of layers.[✓]
The smaller the temperature drop the better the insulation.[✓]

LEVELS BASED MARK SCHEME FOR EXTENDED RESPONSE QUESTIONS

What are extended response questions?

Extended response questions are worth 4, 5 or 6 marks. These questions are likely to have command words such as 'compare', describe', 'explain' or 'evaluate'. You need to write in continuous **prose** when you answer one of these questions. This means you must write in full sentences, not bullet points, and organise your answer into paragraphs.

You may need to bring together skills, knowledge and understanding from two or more areas of the specification. To gain full marks, your answer needs to be logically organised, and ideas linked to give a sustained line of reasoning.

Some extended response questions may involve calculations. These need two or more steps that must be done in the right order. These questions will include the command words 'calculate' or 'determine'.

Marking

Written answers are marked using 'levels of response' mark schemes. Examiners look for relevant points (indicative content) and also use a best fit approach. This is based on your answer's overall quality and its fit to descriptors for each level. Extended response calculations give marks for each step shown.

Example level descriptors

Level descriptors vary, depending on the question being asked. Level 3 is the highest level and Level 1 is the lowest level. No marks are awarded for an answer with no relevant content. The table gives examples of the typical features that examiners look for.

Level	Marks	Descriptors for a method	Descriptors for an evaluation
3	5–6	The method would lead to a valid outcome. All the key steps are given, and they are ordered in a logical way.	The answer is detailed and clear. It includes a range of relevant points that are linked logically. The answer uses relevant data that may be given in the question. A conclusion is made that matches the reasoning in the answer.
2	3–4	The method might not lead to a valid outcome. Most of the key steps are given, but the order is not completely logical.	The answer is mostly detailed but not always clear. It includes some relevant points with an attempt at linking them logically. Data may not be used fully. A conclusion is given that may not fully match the reasoning given.
1	1–2	The method would not lead to a valid outcome. Some key steps are given, but they are not linked in a clear way.	The answer gives separate, relevant points. Uses little or no data that may be given in the question. The points made may be unclear. If a conclusion is given, it may not match the reasoning given in the answer.

COMMAND WORDS

A **command word** in a question tells you what you are expected to do.

The structure of a question

You should see one command word per sentence, with the command word coming at the start. A command word might not be used, however, if a question is easier to follow without one. In these cases, you are likely to see:

- What ...?
- Why ...?
- How ...?

Command word	What you need to do
Balance	Add correct balancing numbers to a nuclear equation.
Calculate	Use the numbers given to work out an answer.
Choose	Select from a range of options.
Compare	Write about **all** the similarities and/or differences between things.
Complete	Complete sentences by adding your answers in the spaces provided.
Define	Give the meaning of something.
Describe	Recall a fact, event or process accurately.
Design	Describe how something will be done, such as a practical method.
Determine	Use the data or information given to you to obtain an answer.
Draw	Produce a diagram, or complete an existing diagram.
Estimate	Work out an approximate value.
Evaluate	Use your knowledge and understanding, and the information supplied, to consider evidence for and against something. You must include a reasoned judgement in your answer.
Explain	Give the reasons why something happens, or make something clear.
Give, name, write	Only write a short answer, commonly just a single word, phrase or sentence.
Identify	Name or point out something.
Justify	Support your answer using evidence from the information given to you.
Label	Add the correct words or names to a diagram.
Measure	Use a ruler or protractor to obtain information from a photo or diagram.
Plan	Write a method.
Plot	Mark data points on a graph.
Predict	Write a likely outcome of something.
Show	Give structured evidence to come to a conclusion.
Sketch	Make an approximate drawing, such as a graph without axis units.
Suggest	Apply your knowledge and understanding to a new situation.
Use	You **must** base your answer on information given to you, otherwise you will not get any marks for the question. You might also need to use your own knowledge and understanding.

PHYSICS EQUATIONS

Mathematical skills account for at least 30% of the marks in the Physics exams and 20% overall in Trilogy.

Calculation questions in physics usually involve an equation. Most equations need to be learnt and then recalled and applied in the exam. Others need to be selected from a sheet given in the exam.

Some equations are **higher tier only** and some are **physics only**.

All the equations you are expected to learn, select and apply are given here.

Physics only P

Higher only H

Select and apply

Word equation	Symbol equation
pressure due to column of liquid = height of column × density of liquid × gravitational field strength (g)	$p = h \rho g$ P H
(final velocity)^2 – (initial velocity)^2 = 2 × acceleration × distance	$v^2 - u^2 = 2as$
force = $\frac{\text{change in momentum}}{\text{time taken}}$	$F = \frac{m \Delta v}{\Delta t}$ P H
elastic potential energy = 0.5 × spring constant × (extension)^2	$E_e = \frac{1}{2} k e^2$
change in thermal energy = mass × specific heat capacity × temperature change	$\Delta E = m c \Delta \theta$
period = $\frac{1}{\text{frequency}}$	$T = \frac{1}{f}$
magnification = $\frac{\text{image height}}{\text{object height}}$	P
force on a conductor (at right angles to a magnetic field) carrying a current = magnetic flux density	$F = B I l$ H
thermal energy for a change of state = mass × specific latent heat	$E = m L$
$\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$	$\frac{V_p}{V_s} = \frac{n_p}{n_s}$ P H
potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil	$V_p I_p = V_s I_s$ H
For gases: pressure × volume = constant	$p V = constant$ P

Recall and apply

Word equation	Symbol equation
weight = mass × gravitational field strength (*g*)	$W = m\,g$
work done = force × distance (along the line of action of the force)	$W = F\,s$
force applied to a spring = spring constant × extension	$F = k\,e$
moment of a force = force × distance (normal to the direction of force)	$M = F\,d$ **P**
pressure = $\frac{\text{force normal to a surface}}{\text{area of that surface}}$	$p = \frac{F}{A}$ **P**
distance travelled = speed × time	$s = v\,t$
acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$	$a = \frac{\Delta v}{t}$
resultant force = mass × acceleration	$F = m\,a$
momentum = mass × velocity	$p = m\,v$ **H**
kinetic energy = 0.5 × mass × $(\text{speed})^2$	$E_k = \frac{1}{2}m\,v^2$
gravitational potential energy = mass × gravitational field strength (*g*) × height	$E_p = m\,g\,h$
power = $\frac{\text{energy transferred}}{\text{time}}$	$P = \frac{E}{t}$
power = $\frac{\text{work done}}{\text{time}}$	$P = \frac{W}{t}$
efficiency = $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$	
efficiency = $\frac{\text{useful power output}}{\text{total power input}}$	
wave speed = frequency × wavelength	$v = f\,\lambda$
charge flow = current × time	$Q = I\,t$
potential difference = current × resistance	$V = I\,R$
power = potential difference × current	$P = V\,I$
power = $(\text{current})^2$ × resistance	$P = I^2\,R$
energy transferred = power × time	$E = P\,t$
energy transferred = charge flow × potential difference	$E = Q\,V$
density = $\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{V}$

MATHS SKILLS FOR SCIENCE

Standard form

Standard form is a way of writing very large or very small numbers and is written as:

$$A \times 10^B$$

- A is a number greater than or equal to 1 and less than 10
- B is any integer (negative or positive whole number)

Examples

Number	Standard form
0.0050 61	5.61×10^{-3}
170 000 000	1.7×10^{8}
0.012 03	1.203×10^{-2}
8 040 000	8.04×10^{6}

Rounding to *n* decimal places

When rounding to *n* decimal places (dp):

- look at the nth decimal place
- if the next digit is 5 or more, round up by increasing the preceding digit by one
- if it is 4 or less, keep the preceding digit the same

For example, 0.365 rounded to 2 dp is 0.364 is 0.36.

0.8675 rounded to 1 dp is 0.9

Rounding to *n* significant figures

- Look at the first non-zero digit, go $n - 1$ digits to the right, and follow the rules for rounding to *n* decimal places
- Fill any places after it with a zero and stop when you reach the decimal point.

Examples

	1 sf	2 sf	3 sf
9375	9000	9400	9380
56.27	60	56	56.3
0.003684	0.004	0.0037	0.00368

Units and conversions

Quantities in one unit can be converted into a different unit and the size of the measurement will still be the same.

Units need to be correct when using equations, it is usually the SI unit.

A common conversion is to change time from hours and minutes to the SI unit of seconds:

seconds = hours × 60 × 60

seconds = minutes × 60

Other conversions depend on the prefix of the unit

Common prefixes

	10^B	Prefix	Symbol
1 000 000 000	10^{9}	Giga-	G
1 000 000	10^{6}	Mega-	M
1 000	10^{3}	Kilo-	k
0.01	10^{-2}	Centi-	c
0.001	10^{-3}	Milli-	m
0.000 001	10^{-6}	Micro-	μ
0.000 000 001	10^{-9}	Nano-	n

Example conversions for the SI unit of metres (m)

Multiply to convert bigger units to smaller units →

km		m		cm		mm
	× 1000		× 100		× 10	

Divide to convert smaller units to bigger units →

mm		cm		m		km
	÷ 10		÷ 100		÷ 1000	

Using data

The **mean** is an average of a set of values.

To calculate the mean, add up all the values and divide this total by the number of values there are.

$$\text{mean} = \frac{\text{total sum of the values}}{\text{how many values there}}$$

Graphs

The most commonly used graph in physics is a **line graph** although you could see **bar** charts and **pie** charts too.

A line graph shows the relationship between two **continuous** variables.

- the **independent** variable is plotted on the horizontal ***x*-axis**.
- the **dependent** variable is plotted on the vertical ***y*-axis**.

Plotting a line graph

- Look at the **range** of values you need to plot on each axis.
- Choose appropriate **scales** for the small and large squares.
- Intervals such as 1, 2, 5, and multiples such as 10 or 100 are good to use. Do not use other intervals such as 3, 6 or 9.
- Make sure each axis uses at least half of the height or width of any given grid.
- Label both axes with the correct variable and unit.
- To plot (x, y) find the value on the x-axis, then go up to the value on the y-axis.
- Use a sharp pencil to plot each point as a small x, accurate to $\pm$ 1 small square.

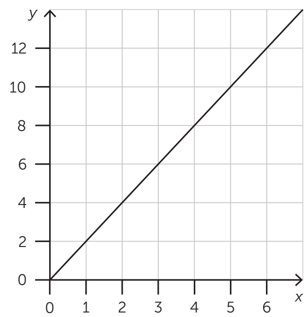
Drawing a line of best fit

A line of best fit is an indication of the relationship between two variables from experimental data. Lines of best fit can be **straight** or **curved**.

- Ignore any clearly **anomalous** points.
- Use a sharp pencil.
- Draw the line of best fit through most of the points with equal numbers of points above and below the line.
- Use a transparent ruler for **straight** lines so you can see all the points.
- Draw a **curved** line free hand as a smooth curve, not dot to dot with a ruler.
- Avoid drawing double lines.

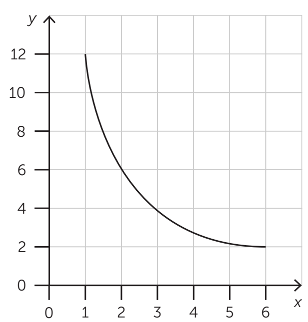
Information from graphs

Directly proportional



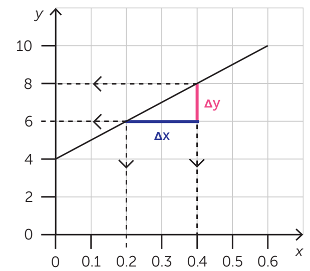
- Straight line graph
- Through the origin
- When x doubles, y doubles
- So x and y are directly proportional to each other

Inversely proportional



- Curved graph
- When x doubles, y halves
- So x and y are inversely proportional to each other.

Determining a gradient from a straight line graph



- Choose 2 points on the line which have easy to read values.
- Draw a right-angled triangle from these 2 points
- Determine the values of Δy and Δx
- Gradient = Δy / Δx
- $y = mx + c$ where m is the gradient and c is the point the line intercepts the y axis

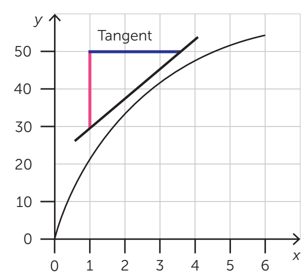
Example

$\Delta y = 8 - 6 = 2$ $\Delta x = 0.4 - 0.2 = 0.2$

gradient = 2 / 0.2 = 10 $y = 10x + 4$

Determining a gradient from a curved graph

Higher Tier only



- A **tangent** is a straight line that touches a curve at one point
- Draw a tangent at the point (e.g. $x = 2$) on the line where you want to find the gradient
- Draw a right-angled triangle from these 2 points
- Determine the values of Δy and Δx
- Gradient = Δy / Δx = (50 – 28) / (3.6 – 1)
- = 22 / 2.6
- = 8.5 (1 dp)

Rearranging equations

The **subject** of an equation is the quantity that is on its own. The **equations** that you need to recall, or choose from a sheet, often need to be **rearranged** to make a different quantity the **subject**.

- Whatever is done to one side of the equation needs to be done to the other
- **Inverse operations** are used, usually **×** and **÷ which are the opposite of each other**.

Examples

$V = I \times R$

V is the subject. Rearrange the equation to make I the subject. You need to get I on its own.

I is multiplied by R, so to remove R from the right-hand side, both sides of the equation need to be divided by R

$\frac{V}{R} = \frac{I \times R}{R}$, so $I = \frac{V}{R}$

$P = \frac{E}{t}$

P is the subject. Rearrange the equation to make t the subject. You need to get t on its own.

E is divided by t, so first make E the subject by multiplying both sides of the equation by t

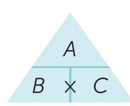
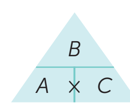
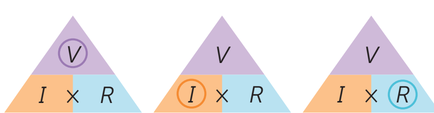
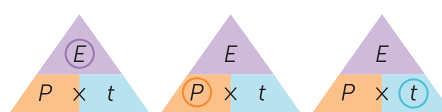
$P \times t = \frac{E \times t}{t}$ so $E = P \times t$

Now get t on its own by dividing both sides by P

$\frac{P \times t}{t} = \frac{E}{P}$, so $t = \frac{E}{P}$

Sometimes knowing the units can help you remember an equation, or you can work out a unit from an equation.

It is much better to understand and learn how to rearrange an equation properly. However, using a **formula triangle** can help as long as you use the correct triangle. Cover the quantity you want to find and then see if you need to multiply or divide the other quantities.

General equation type	$A = B \times C$ 	$A = B / C$ 
Example	potential difference = current × resistance $V = I \times R$	power = $\frac{\text{energy transferred}}{\text{time}}$ $P = E / t$
Formula triangle	 $V = I \times R$ $I = \frac{V}{R}$ $R = \frac{V}{I}$	 $P = \frac{E}{t}$ $E = P \times t$ $t = \frac{E}{P}$

KEY TERMS IN PRACTICAL WORK

Experimental design

Key term	Meaning
Evidence	Measurements or observations collected using a valid method
Fair test	When the dependent variable is only affected by the independent variable
Hypothesis	A suggested explanation for observations or facts
Prediction	A reasoned statement that suggests what will happen in the future
Valid	A valid method involves fair testing and is suitable for an investigation
Valid conclusion	A discussion of a valid experiment and what it shows

Variables

A variable is a characteristic that can be measured or observed.

Type of variable	Meaning
Categoric	It has names or labels rather than values
Continuous	It has values rather than names or labels
Control	It affects the dependent variable, so it must be kept the same or monitored
Dependent	It is measured or observed each time the independent variable is changed
Independent	It is deliberately changed by the investigator

Measurements and measuring

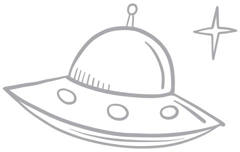
Key term	Meaning
Accurate	Close to the true value
Calibrated	A device is calibrated when its scale is checked against a known value
Data	Measurements or observations that have been gathered
Interval	The measured gap between readings
Precise	Very little spread about the mean value
Range	The values between the measured maximum and minimum values
Repeatable	When the same results are obtained using the same method and apparatus
Reproducible	Someone else gets the same results, or when different apparatus and methods are used
Resolution	The smallest change a measuring device can show
True value	The value you would get in an ideal measurement
Uncertainty	An interval in which the true value will be found

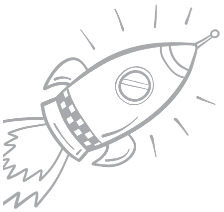
Errors

Type of error	Meaning
Anomalous value	Anomalous results lie outside the range explained by random errors
Random	Unpredictably different readings – their effects are reduced by repeats
Systematic	Readings that differ from true values by the same amount each time
Zero	A type of systematic error where a device does not read 0 when it should

NOTES, DOODLES AND EXAM DATES

Doodles





Exam dates

Paper 1:

Paper 2:

INDEX

EXAMINATION TIPS

When you practise examination questions, work out your approximate grade using the following table. This table has been produced using a rounded average of past examination series for this GCSE. Be aware that actual boundaries will vary by a few percentage points either side of those shown.

GCSE Physics

Grade	9	8	7	6	5	4	3	2	1	U
F Tier (%)					63	55	40	26	12	0
H Tier (%)	70	61	53	44	35	26	19			

Combined Science: Trilogy

Grade	5–5	5–4	4–4	4–3	3–3	3–2	2–2	2–1	1–1	U
F Tier (%)	59	54	50	44	37	31	25	19	13	0

Grade	9–9	9–8	8–8	8–7	7–7	7–6	6–6	6–5	5–5	5–4	4–4	4–3	3–3
H Tier (%)	66	62	58	53	49	44	40	35	31	26	22	19	14

1. Read questions carefully. This includes any information such as tables, diagrams and graphs.
2. Remember to cross out any work that you do not want to be marked.
3. Answer the question that is there, rather than the one you think should be there. In particular, make sure that your answer matches the command word in the question. For example, you need to recall something accurately in a describe question but not say why it happens. However, you do need to say why something happens in an explain question and should include a connecting word such as 'so', 'but', therefore', or 'because'.
4. All the examination papers will include multiple-choice questions (MCQs). Make sure you tick the correct number of boxes. When you are asked to link boxes draw straight lines. When you are asked to complete sentences using words from a word list, make sure you use words from that list.
5. Physics involves a lot of equations. Some are on the equations sheet but most need to be recalled and then used. Forgetting or failing to learn these will cost you a lot of marks. Learn the formulae well and be able to use them confidently. Also, make sure you learn a method for rearranging equations and know the correct SI units.
6. Show all the relevant working out in calculations. If you go wrong somewhere, you may still be awarded some marks if the working out is there. It is also much easier to check your answers if you can see your working out. Remember to give units when asked to do so and follow instructions about standard form or significant figures.
7. Plot the points on graphs to within half a small square. Lines of best fit can be curved or straight,but must ignore anomalous points. If the command word is sketch rather than plot, you only need to draw an approximate graph, not an accurate one.
8. Follow instructions carefully when writing or balancing nuclear equations. Check that all the numbers of particles and charges balance.
9. Remember that you may be asked to label a diagram or to complete a diagram. You may or may not be given the words to use.
10. Make sure you can recall experiments you have done or observed. About 15% of the exam is based on the required practicals.

Good luck!

AQA GCSE **Physics** 8463 / 8464

ClearRevise™

Illustrated revision and practice:

- Physics and Trilogy at Foundation and Higher levels
- Over 1000 marks of examination style questions
- Answers provided for all questions within the book
- Illustrated topics to improve memory and recall
- Specification references for each topic
- Examination tips and techniques

Experience + science + beautiful design = better results

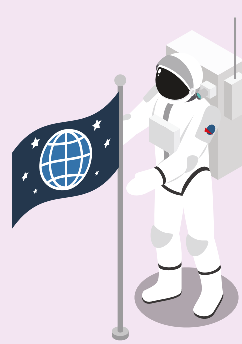
Absolute clarity is the aim with a new generation of revision guide. This guide has been expertly compiled and edited by outstanding teachers of Physics, highly experienced examiners and a good measure of scientific research into what makes revision most effective.

PG Online have a record of significantly raising and sustaining GCSE examination results in schools using their award-winning teaching resources.

Past examination questions are essential to good preparation, improving understanding and confidence. This guide has combined revision with tips and more practice questions than you could shake a stick at. All the essential ingredients for getting a grade you can be really proud of.

Each specification topic has been referenced and distilled into the key points and connective strands to write in an examination for top marks. Questions on all topics assessing knowledge, application and analysis are all specifically and carefully devised throughout this book.

www.clearrevise.com



ISBN 9781910523339

9 781910 523339

PG ONLINE