AQA

GCSE

Combined: Trilogy Physics

8464

Student Guide 1.2

Oct 2019

This is my interpretation of the AQA Specification Version 1.1 available at www.aqa.org.uk

Please check their website for the most up-to-date specification as you prepare for your exams

Exams

There are six exams at the end of Year 11 for AQA GCSE Combined: Trilogy 8464, two of these are for the Physics content.

Physics Paper 1	▪ Energy ▪ Electricity ▪ Particle Model ▪ Atomic Structure	Multiple choice, short answer and extended response	1 hour 15 minutes	70 marks
Physics Paper 2	▪ Forces ▪ Waves ▪ Magnetism and Electromagnetism	Multiple choice, short answer and extended response	1 hour 15 minutes	70 marks

Each paper will have questions that allow you to **demonstrate** knowledge (~40%), **apply** knowledge (~40%) and **analyse** information and ideas (~20%).

There are both Foundation and Higher tiers available with grades from 1 (lowest) to 9 (highest) as well as a U for really low marks (unclassified).

Foundation	U	1-1	2-1	2-2	3-2	3-3	4-3	4-4	5-4	5-5			
Higher	U	-	4-4	5-4	5-5	6-5	6-6	7-6	7-7	8-7	8-8	9-8	9-9

Your grade will be calculated from the total marks you score out of 420 from all six papers.

This guide will help you prepare for your exams. It contains the knowledge and skills you need to learn during the course and can be used as a checklist when you start your revision.

There are also hundreds of video tutorials you can watch on the website to help you understand the physics in greater detail.

Physics Topics

You need to make sure that you have covered all the material in the following pages as you complete your GCSE Physics.

- Energy
- Electricity
- Particle Model
- Atomic Structure
- Forces
- Waves
- Magnetism and Electromagnetism

H = Higher tier in bold

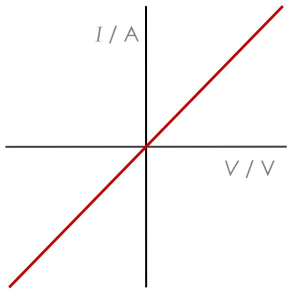
Energy

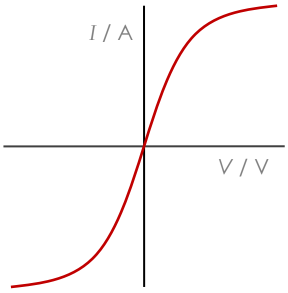
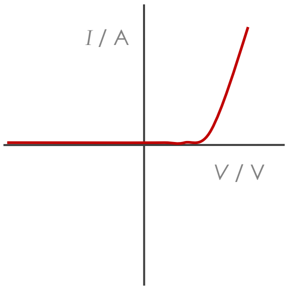
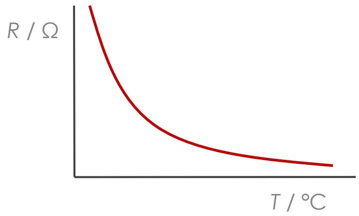
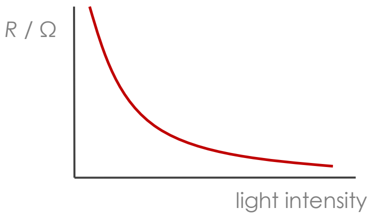
	Energy changes and stores	R	A	G
	Describe all the changes involved in the way energy is stored for: ▪ an object projected upwards ▪ a moving object hitting an obstacle ▪ an object accelerated by a constant force ▪ a vehicle slowing down ▪ a kettle heating up water			
	Calculate the changes in energy stored by a system when: ▪ it is heated ▪ work is done by forces ▪ work is done when a current flows			
	Use calculations to show how the overall energy in a system (an object or group of objects) is redistributed when the system changes.			
	Calculate the amount of energy associated with a moving object: kinetic energy = ½ x mass x speed^2 $E_k = \frac{1}{2} m v^2$			
	Calculate the amount of energy associated with stretching (or compressing) a spring: elastic potential energy = ½ x spring constant x extension^2 $E_e = \frac{1}{2} k e^2$			
	Calculate the amount of energy associated with an object raised above ground level: gravitational potential energy = mass x gravitational field strength x height $E_p = m g h$			

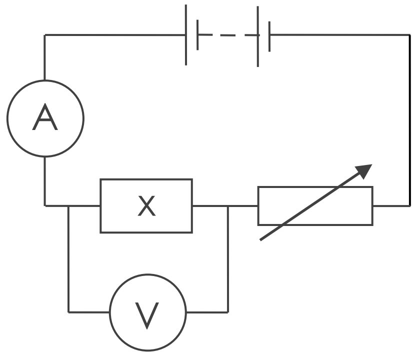
	Calculate the amount of energy stored or released from a system as its temperature changes: change in thermal energy = mass x specific heat capacity x change in temperature $\Delta E = m\ c\ \Delta\theta$			
	Recall that the specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius.			
	Recall that power is defined as the rate at which energy is transferred, or at which work is done, and that an energy transfer of one joule per second is equal to one watt of power.			
	Use the equations: power = energy transferred / time $P = E / t$ power = work done / time $P = W / t$			
	Give examples that illustrate the definition of power. For example, comparing two electric motors that lift a weight through the same height but in a different time.			
	Conservation and dissipation of energy	R	A	G
	Describe, with examples, that where there are energy transfers in a closed system there is no net change to the total energy of that system (energy cannot be created or destroyed).			
	Describe, with examples, how in all system changes energy is dissipated so it is stored in less useful ways (the energy is 'wasted').			
	Explain ways of reducing unwanted energy transfers. For example, through lubrication or thermal insulation.			
	Realise the higher the thermal conductivity of a material the higher the rate of energy transfer by conduction across the material. [You do not need to know the definition of thermal conductivity]			
	Describe how the rate of cooling of a building is affected by the thickness and thermal conductivity of its walls.			
	Calculate the energy efficiency for an energy transfer using: efficiency = useful output energy transfer / total input energy transfer efficiency = useful power output / total power input			
H	**Describe ways to increase the efficiency of an intended energy transfer.**			

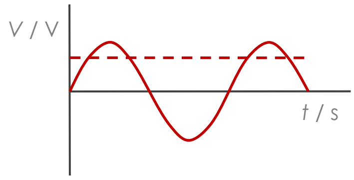
National and global energy resources		R	A	G
	Describe the main energy resources available for use on Earth including fossil fuels (coal, oil, gas), nuclear fuels and renewable energy resources (biofuel, wind, hydro-electric, geothermal, tides, waves and the Sun). [Descriptions of how these resources are used to generate electricity are not required]			
	Distinguish between energy resources that are renewable (one that is, or can be, replenished as it is used) and non-renewable.			
	Compare ways that energy resources are used in transport, electricity generation and heating.			
	Understand why some energy resources are more reliable than others.			
	Describe and consider the environmental impact arising from using these energy resources.			
	Explain patterns and trends in the use of energy resources.			
	Show that science has the ability to identify environmental issues arising from the use of energy resources but not always the power to deal with the issues because of political, social or economic considerations.			

Electricity

	Current, potential difference and resistance	R	A	G
	Draw and use standard circuit symbols. [Please see the Common Circuit Symbols table at the end of this document]			
	Realise that for charge to flow through a closed circuit there must be a source of potential difference (also known as voltage) and that the size of the electric current is the rate of flow of electric charge.			
	Use the equation: charge = current x time $Q = I\,t$			
	Recognise that the current has the same value at any point in a single closed loop of a circuit.			
	The current through a component depends on both the resistance of the component and the potential difference across it. The greater the resistance, the smaller the current for a given potential difference.			
	Use the equation: potential difference = current x resistance $V = I\,R$			
	Explain that for some resistors the resistance remains constant but in others it can change depending on the current through it. The current through an ohmic conductor at constant temperature is directly proportional to the potential difference across it, so its resistance remains constant. 			
	Devices such as filament lamps, diodes, thermistors and light dependent resistors change their resistance.			

	The resistance of a filament lamp increases as the current through it increases. 			
	Current only flows through a diode in one direction because it has a very high resistance in the other direction. 			
	The resistance of a thermistor decreases as the temperature increases.  You should recognise the applications of thermistors in circuits including thermostats.			
	The resistance of an LDR decreases as light intensity increases. 			
	Recall applications of LDRs in circuits including how lights are switched on when it gets dark.			

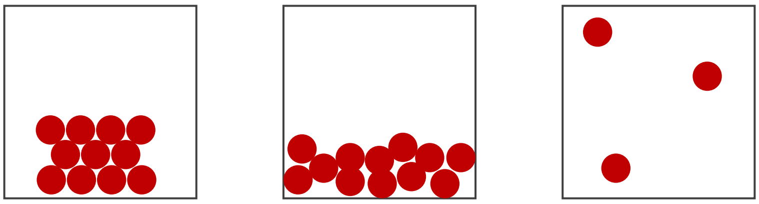
		R	A	G
	Explain how to design and build a circuit used to measure the resistance of a component by measuring the current through it and potential difference across it, and draw an appropriate circuit diagram.  			
Series and parallel circuits		**R**	**A**	**G**
	Describe the difference between series and parallel circuits.			
	Understand that for components joined in series: ▪ there is the same current through each component ▪ the total potential difference of the power supply is shared between the components ▪ the total resistance of two components is the sum of resistances of each component total resistance = sum of individual resistances $R_{Total} = R_1 + R_2$			
	Understand that for components connected in parallel: ▪ the potential difference across each component is the same ▪ the total current through the whole circuit is the sum of the currents through the separate components ▪ the total resistance of two resistors is less than the resistance of the smallest individual resistor [you do not need to be able to calculate this]			
	Use circuit diagrams to construct and check series and parallel circuits containing a variety of common components.			
	Explain why adding resistors in series increases the resistance of the circuit while adding them in parallel decreases the total resistance of the circuit.			
	Explain the design and use of dc series circuits for measurement and testing purposes.			
	Calculate the potential differences, currents and resistances in series circuit problems.			
	Solve problems in circuits which include resistors in series using the concept of equivalent resistance ($R_{Total} = R_1 + R_2$).			

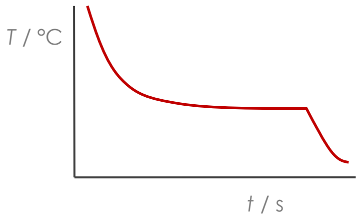
Domestic uses and safety		R	A	G
	Know that domestic electricity in the United Kingdom is an ac (alternating current) supply with a frequency of 50 Hz and is about 230 V.			
	Explain the difference between direct and alternating potential difference. 			
	Recall that most electrical appliances are connected to the mains using three-core cable: ▪ the live wire (brown) provides the alternating potential difference from the supply ▪ the neutral (blue) completes the circuit ▪ the earth wire (green and yellow stripes) is a safety wire to stop the appliance becoming live			
	Recall that: ▪ the potential difference between the live wire and earth (0 V) is about 230 V ▪ the neutral wire is at, or close to, earth potential (0 V) ▪ the earth wire is at 0 V and only carries a current if there is a fault			
	Explain that a live wire may be dangerous even when a switch in the mains circuit is open.			
	Explain the dangers of providing any connection between the live wire and earth.			

Energy transfers		R	A	G
	Explain how the power of a circuit device (the energy transferred over a period of time) is related to the potential difference across it and the current through it.			
	Calculate the electrical power transferred using: power = potential difference x current $P = V I$ power = current^2 x resistance $P = I^2 R$			
	Describe how domestic appliances transfer energy from batteries or ac mains to the kinetic energy of motors, the thermal energy of heating devices or lighting devices.			

	Recall that work is done when charge flows in a circuit. The amount of energy transferred by electrical work can be calculated using: energy transferred = power x time $E = P\,t$ energy transferred = charge x potential difference $E = Q\,V$			
	Describe, with examples, the relationship between the power ratings of domestic appliances and the changes in stored energy when they are used.			
	Recall that the National Grid is a system of cables and transformers linking power stations to consumers.			
	Recall that step-up transformers increase the potential difference from the power station to the transmission cables. The potential difference is then decreased in a step-down transformer for domestic use.			
	Explain why the National Grid is an efficient way to transfer energy.			
H	**Use the equation:** **potential difference across primary coil x current in primary coil = potential difference across secondary coil x current in secondary coil** $V_p\,I_p = V_s\,I_s$ [Detailed knowledge of the structure of a transformer is not required]			

Particle Model of Matter

	Changes of state and the particle model	R	A	G
	Calculate the density of materials using the equation: density = mass / volume $\rho = m / V$			
	Realise that the particle model can be used to explain the different states of matter and differences in density due to the arrangement of atoms or molecules.			
	Draw and recognise simple diagrams to model solids, liquids and gases. 			
	Describe how when materials change state their mass is conserved (including melting, evaporating, boiling, condensing, freezing and subliming).			
	Realise that changes of state are physical changes not chemical changes, as the material will recover its original properties if the change is reversed.			
	Internal energy and energy transfers	**R**	**A**	**G**
	Recall that the energy stored inside a system by the particles is called the internal energy and can be defined as the total kinetic and potential energy of all the particles that make up a system.			
	Recall that heating a system changes the energy stored and this either raises the temperature or changes the state.			
	The amount the temperature of a system increases is related to the type of material, its mass and the energy input. This can be calculated by the following equation: change in thermal energy = mass x specific heat capacity x change in temperature $\Delta E = m\ c\ \Delta\theta$			
	Define the specific heat capacity of a substance as the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius.			
	Recall that when a change of state occurs the energy inputted changes the internal energy but not the temperature of the substance.			

	Define the specific latent heat of a substance as the amount of energy required to change the state of one kilogram of the substance with no change in temperature.			
	Use the equation for a change of state: energy for a change of state = mass x specific latent heat $E = m\,L$			
	Interpret heating and cooling curves that include changes of state.  			
Particle model and pressure		R	A	G
	Explain how the motion of molecules in a gas is related to both its temperature and pressure (this is related to the average kinetic energy of the molecules that are in constant random motion).			
	Explain qualitatively that there is a proportional relationship between pressure and temperature of a gas at constant volume.			

Atomic Structure

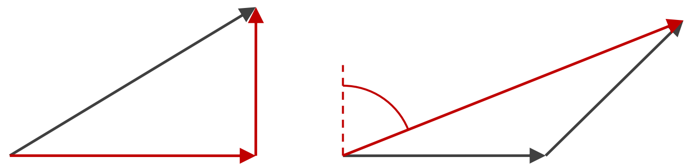
	Atoms and isotopes	R	A	G
	Recall that the radius of an atom is about 1×10^{-10} m and the radius of the nucleus is about 10 000 times smaller. Most of the mass of an atom is concentrated in the nucleus which is made up of protons and neutrons, surrounded by negatively charged electrons.			
	Recall that the electrons are arranged in different energy levels at different distances from the nucleus. Electrons can absorb electromagnetic radiation and move further away from the nucleus or drop to a lower energy level by the emission of electromagnetic radiation.			
	Recall that atoms have no overall charge and contain the same number of protons and electrons, with the number of protons called the atomic number. The total number of protons and neutrons is called the mass number. If an atom loses one or more electrons it then becomes a positive ion.			
	Represent atoms in the following way: mass number $^{12}_{6}C$ atomic number			
	Define isotopes as atoms of the same element with a different number of neutrons.			
	Describe how new experimental evidence may lead to a scientific model being changed or updated, in this example: ▪ atoms were first thought of as tiny spheres that could not be broken up ▪ after the electron was discovered the model that was used was called the plum pudding model. This is a ball of positive charge with negative charges embedded throughout the atom ▪ the alpha scattering experiments then showed that the mass of an atom was concentrated in a central charged nucleus ▪ Niels Bohr then adapted this nuclear model by suggesting that the electrons orbit the nucleus at specific distances. His theoretical calculations agreed with experimental evidence ▪ later experiments found that the positive nucleus could be subdivided into smaller positive particles called protons ▪ James Chadwick then discovered neutrons about twenty years after the discovery of the nucleus			
	Explain how evidence from the scattering experiments led to a change in the atomic model, and differences in the plum pudding and nuclear model.			
	Atoms and nuclear radiation	**R**	**A**	**G**
	Recall that some unstable atomic nuclei may give out radiation as they change to become more stable. This is called radioactive decay.			

	Define activity as the rate at which a source of unstable nuclei decays.			
	Define count-rate as the number of decays recorded each second by a detector (for example, a Geiger-Muller tube).			
	Recall the properties of alpha, beta and gamma radiation including their penetration through materials, their range in air and their ionising powers: ▪ alpha (α) consists of two neutrons and two protons ▪ beta (β) is a high speed electron emitted from the nucleus when a neutron decays to a proton ▪ gamma (γ) is a wave of electromagnetic radiation emitted from the nucleus ▪ neutrons (n) can also be emitted			
	Apply your knowledge to the uses of radiation and evaluate the best source or radiation for a given situation.			
	Use the names and symbols of common nuclei and particles to write balanced nuclear equations for alpha and beta decays. Alpha decay $^{200}_{80}X \longrightarrow ^{196}_{78}Y + ^{4}_{2}He$ Beta decay $^{20}_{8}W \longrightarrow ^{20}_{9}Z + ^{0}_{-1}e$ Gamma decay The mass or charge of the nucleus does not change [The identification of daughter nuclei from such equations is not required]			
	Use the names and symbols of common nuclei and particles to write balanced equations for alpha and beta decays. [The identification of daughter nuclei from such equations is not required]			
	Explain the concept of half-life and how this is related to the random nature of radioactive decay.			
	Define the half-life of a radioactive isotope as: ▪ the time it takes for the number of nuclei of the isotope in a sample to halve or ▪ the time it takes for the count-rate, or activity, from a sample containing the radioactive isotope to fall to half its initial level			
	Determine the half-life of a radioactive isotope from information given in a question.			

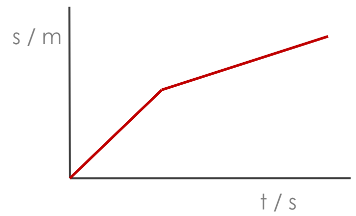
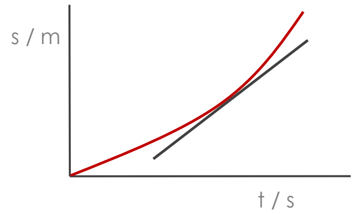
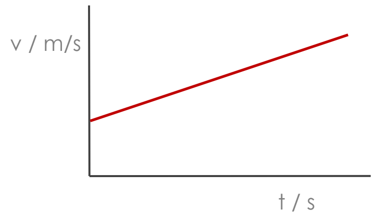
H	**Calculate the net decline, as a ratio, after a given number of half-lives.**			
	Define contamination as the unwanted presence of material containing radioactive atoms on other material while irradiation is the process of exposing an object to nuclear radiation.			
	Compare the hazards associated with contamination versus irradiation, and that suitable precautions must be taken to protect against any hazards from the radioactive sources used in irradiation.			
	Understand that it is important for the findings of research into the effects of radiation on humans to be published, shared with scientists and peer reviewed.			

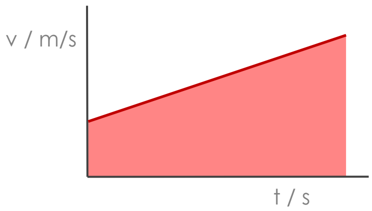
Forces

	Forces and their interactions	R	A	G
	Recall that scalars have only magnitude (size) while vectors have magnitude and direction and can be represented by arrows.			
	Recall that a force is a push or a pull that acts on an object due to its interacting with another object. For contact forces the objects are physically touching and include: ▪ friction ▪ air resistance ▪ tension ▪ normal contact force For non-contact forces the objects are physically separated and include: ▪ gravitational ▪ electrostatic ▪ magnetic			
	Recall that weight is the force acting on an object due to gravity. On Earth it is due to the gravitational field around the Earth.			
	Realise that the weight of an object also depends on the size of the gravitational field strength where that object is.			
	Calculate the weight of an object using the equation: weight = mass x gravitational field strength $W = m\ g$ The value of g will always be given in any questions, and it can be seen that weight and mass are directly proportional ($W \propto m$).			
	Recall that the weight of an object acts at a single point called the centre of mass.			
	Recall that weight can be measured with a calibrated spring-balance, also known as a newtonmeter.			
	If a number of forces act on an object, they may be replaced by a single force that has the same effect. This is called the resultant force. You should be able to calculate the resultant force of two forces that act in a straight line.			
H	**Describe examples of the forces acting on an isolated object or system.**			
H	**Use free body diagrams to show examples where several forces act on an object leading to a resultant force, or when they are balanced and the resultant force is zero.**			

H	**Resolve a single force into two components that act at right angles to each other.**			
H	**Use vector diagrams to resolve forces, show equilibrium and determine the resultant of two forces showing both magnitude and direction.** 			
Work done and energy transfer		R	A	G
	Recall that when a force causes an object to move through a distance, work is done on the object, i.e. the force does work on the object when the force causes a displacement of the object.			
	Calculate the work done by a force using: work done = force x distance (moved along the line of action of the force) $W = F\,s$			
	Define one joule as the work done when a force of one newton causes a displacement of one metre.			
	Describe the energy transfers involved when work is done.			
	Convert between newton metres and joules.			
	Realise that work done against frictional forces acting on an object causes the object's temperature to rise.			
Forces and elasticity		R	A	G
	Give examples of the forces involved in stretching, bending or compressing an object.			
	Explain why, for a stationary object, to change its shape by bending, stretching or compression, more than one force must be applied.			
	Describe the difference between elastic and inelastic deformation of stretched objects.			
	Recall that the extension of an elastic object, like a spring, is directly proportional to the force applied, provided the limit of proportionality is not exceeded.			
	Recall and use the equation: force = spring constant x extension $F = k\,e$ Including for the compression of an object.			

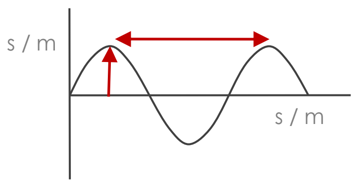
	Recall that the force that stretches or compresses an object does work and this potential energy is stored in the spring. Provided the spring is not elastically deformed the work done is equal to the elastic potential energy stored.			
	Describe the difference between a linear and non-linear relationship between force and extension.			
	Calculate a spring constant and interpret data from an investigation between force and extension.			
	Calculate the amount of energy associated with stretching (or compressing) a spring: elastic potential energy = ½ x spring constant x extension^2 $E_e = \frac{1}{2} k e^2$			
Forces and motion		**R**	**A**	**G**
	Recall that distance is a scalar quantity and it is how far an object moves. Displacement includes both the distance an object moves and the direction it moves from its start point, so is a vector.			
	Express displacements with both magnitude and direction.			
	Recall that speed is a scalar quantity.			
	Recall that the speed of a person depends on age, fitness and terrain. Typical values are in the region of: ▪ walking 1.5 m/s ▪ running 3 m/s ▪ cycling 6 m/s			
	Recall that the speed of sound in air is about 330 m/s.			
	Take measurements of distance and time to calculate speeds.			
	For an object travelling at a constant speed use the equation: distance travelled = speed x time $s = v t$			
	Calculate the average speed for non-uniform motion.			
	Define the velocity of an object as its speed in a given direction. Velocity is a vector quantity.			
H	**Explain qualitatively that motion in a circle involves constant speed but changing velocity.**			

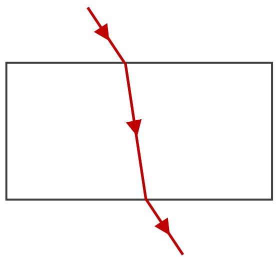
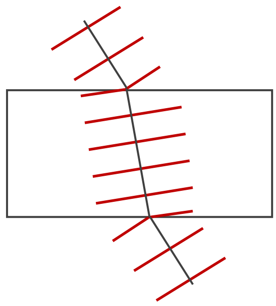
	Realise that if an object moves along a straight path, the distance travelled can be represented on a distance-time graph and its speed can be determined from the gradient of the line. 			
H	**Determine the speed of an accelerating object by drawing a tangent to the line on a distance-time graph and measuring the gradient of this line.** 			
	Draw distance-time graphs from measurements and interpret data from them.			
	Calculate the acceleration of an object by using: acceleration = change in velocity / time taken $a = \Delta v / t$			
	Realise that an object slowing down is decelerating.			
	Estimate the magnitude of everyday accelerations.			
	Draw velocity-time graphs from measurements and interpret data from them.			
	Calculate the acceleration of an object from the gradient of a velocity-time graph. 			

H	**Calculate the distance travelled (displacement) by an object from the area under a velocity-time graph (including by counting squares if appropriate).**  			
	For uniform motion apply the following equation: final velocity^2 – initial velocity^2 = 2 x acceleration x distance $v^2 - u^2 = 2\ a\ s$			
	Recall that near the Earth's surface, any object falling freely under gravity has an acceleration of about 9.8 m/s^2.			
	Recall that an object falling through a fluid initially accelerates due to the force of gravity. Eventually the resultant force on the object will be zero because of air resistance and it will move at its terminal velocity.			
	Define Newton's First Law: If the resultant force acting on an object is zero and the object is: ▪ stationary, the object remains stationary ▪ moving, the object continues to move at the same velocity E.g. if a vehicle moves at a steady speed it is because the driving force is balanced by the resistive forces, and the velocity of an object will only change if a resultant force acts on the object.			
	Apply Newton's First Law to explain the motion of objects with a uniform velocity and objects where the speed or direction changes.			
H	**Recall that the tendency of objects to continue in their state of rest, or uniform motion, is called inertia.**			
	Define Newton's Second Law: The acceleration of an object is proportional to the resultant force acting on the object and inversely proportional to the mass of the object. resultant force = mass x acceleration $F = m\ a$			
H	**Explain that inertial mass is a measure of how difficult it is to change the velocity of an object and is defined as the ratio of force over acceleration.**			
	Estimate the speed, acceleration and forces involved in large accelerations for everyday road transport, using the **~** symbol to represent an approximate value.			

	Define Newton's Third Law: Whenever two objects interact, the forces they exert on each other are equal and opposite.			
	Apply Newton's Third Law to examples of equilibrium situations.			
	Define the stopping distance of a vehicle as the sum of the distances the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels under the braking force (braking distance).			
	Recall that reaction times for people range from 0.2 s to 0.9 s and may be affected by tiredness, alcohol, drugs and distractions.			
	Explain methods used to measure human reaction times.			
	Evaluate and interpret measurements from simple methods to measure reaction times of different students.			
	Evaluate the effect of various factors on reaction times from given data.			
	Recall that the braking distance of a vehicle can be affected by adverse road and weather conditions (wet and icy) and the poor condition of the vehicle (limited to brakes and tyres).			
	Explain the factors that affect the distance required for vehicles to come to rest in an emergency and the implications for safety.			
	Estimate how the distance required for road vehicles to stop in an emergency varies over a range of typical speeds.			
	Recall that when a force is applied to the brakes of a vehicle, work done by the friction force between the brake pads and the brake disc reduces the kinetic energy of the vehicle and increases the temperature of the brakes.			
	Realise that the greater the speed of a vehicle the greater the braking force needed to stop the vehicle in a certain distance. The greater the braking force the greater the deceleration, which may lead to brakes overheating or loss of control.			
H	**Estimate the forces involved in the deceleration of road vehicles in typical situations on public roads.**			
Momentum		R	A	G
H	**Define momentum as:** **momentum = mass x velocity** $p = m\,v$			
H	**Define the conservation of momentum as in a closed system the total momentum before an event is equal to the total momentum after the event.**			
H	**Describe and explain examples of momentum in an event (such as a collision).**			

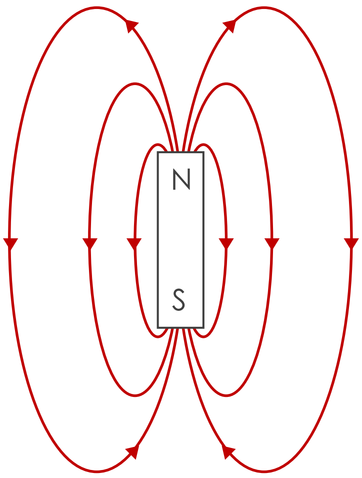
Waves

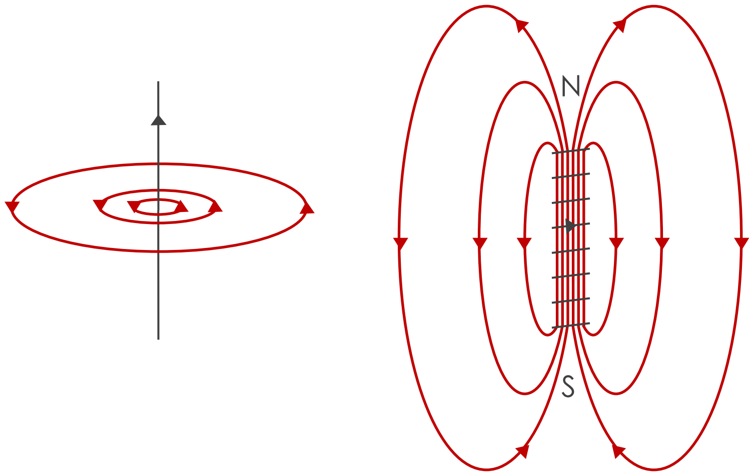
	Waves in air, fluids and solids	R	A	G
	Describe the differences between longitudinal and transverse waves. Ripples on the surface of water are an example of transverse waves, while sound waves travelling through air show areas of compression and rarefaction so are longitudinal.			
	Describe evidence for both water and sound waves that it is the wave and not the water or air that is travelling.			
	Describe the motion of a wave in terms of amplitude, wavelength, frequency and period. ▪ the amplitude of a wave is defined as the maximum displacement of a point on a wave away from its undisturbed position ▪ the wavelength of a wave is the distance from a point on one wave to the equivalent position on the adjacent wave ▪ the frequency of a wave is the number of waves passing a point each second			
	Use the equation: period = 1 / frequency $T = 1 / f$			
	Use the equation for all waves: wave speed = frequency x wavelength $v = f \lambda$			
	Identify wavelength and amplitude from diagrams. 			
	Describe a method to measure the speed of sound waves in air.			
	Describe a method to measure the speed of ripples on a water surface.			
	Electromagnetic waves	**R**	**A**	**G**
	Recall that electromagnetic waves are transverse and form a continuous spectrum. They all travel at the same speed through a vacuum.			

	Recall the order of the EM spectrum: Long wavelength Radio Low frequency Microwaves Infrared Visible Ultraviolet X-rays Short wavelength Gamma High frequency			
	Realise that our eyes only detect visible light which is a limited range of electromagnetic waves			
	Give examples that illustrate the transfer or energy by EM waves.			
H	**Realise that different substances absorb, transmit, reflect or refract EM waves in ways that vary with their wavelength.** **Some effects are due to the different velocities of the waves in different substances.**			
	Construct ray diagrams to illustrate refraction of waves at the boundary between two media. 			
H	**Explain refraction using wave front diagrams and the change of speed that occurs when a wave travels from one medium to another.** 			
H	**Describe how radio waves can be produced by oscillations in electrical circuits. These radio waves can then be absorbed by another circuit where they cause an alternating current with the same frequency.**			
	Recall that changes in atoms and their nuclei can result in the EM waves being generated or absorbed over a wide frequency range. For example, gamma rays originate from the changes in the nucleus of an atom.			

	Recall that ultraviolet, X-rays and gamma rays can be hazardous for humans due to their effect on body tissue, the effect depending on the type of radiation and the size of the dose. UV can cause the skin to age prematurely and increases the risk of skin cancer. X-rays and gamma are ionising radiation that can cause mutations of genes leading to cancer. The radiation dose (measured in sieverts) is a measure of the harm resulting from exposure to radiation. [You do not need to be able to recall the unit of radiation dose]			
	Draw conclusions from given data about the risks and consequences of exposure to radiation.			
	Recall the practical application of EM waves including: Radio — Television and radio Microwaves — Satellite communications and cooking food Infrared — Electrical heaters, cooking food and infrared cameras Visible — Fibre optic communications Ultra Violet — Energy efficiency lamps and sun tanning X-rays and Gamma — Medical imaging and treatments			
H	**Give brief explanations as to why each type of radiation is suitable for its practical applications.**			

Magnetism and Electromagnetism

	Permanent and induced magnetism, magnetic force and fields	R	A	G
	Describe the attraction and repulsion between unlike and like poles of permanent magnets respectively. The magnetic force (a non-contact force) is strongest at the poles.			
	Describe the difference between permanent and induced magnets. ▪ a permanent magnet produces its own magnetic field ▪ an induced magnet is a material that becomes a magnet when it is placed in a magnetic field. This induced magnetism always causes a force of attraction. The induced magnet loses its magnetism once it is removed from the magnetic field causing it.			
	Recall that a magnetic field is the region around a magnet where a force acts on another magnet or magnetic material (including iron, steel, cobalt and nickel). This magnetic force is always attractive.			
	Recall that the strength of the magnetic field depends on the distance from the magnet (it is strongest at the poles) and its direction is given by the force experienced by a north pole placed at that point. A magnetic field line is directed from the north pole to the south pole of a magnet.			
	Describe how to plot the magnetic field pattern using a compass.			
	Draw the magnetic field pattern around a bar magnet, showing how the strength and direction change.  			
	Explain how the behaviour of a magnetic compass (containing a small bar magnet) is related to evidence that the Earth's core must be magnetic since the compass aligns itself to the Earth's magnetic field.			

The motor effect		R	A	G
	Recall that when a current flows through a conducting wire, a magnetic field is produced. The strength depends on the size of the current and distance from the wire. Shaping the wire to form a solenoid (coil) increases the strength of the magnetic field. This field is strong and uniform inside the solenoid while similar in shape to the field around a bar magnet on the outside. Adding an iron core increases the strength of the field still further and this (a solenoid with an iron core) is called an electromagnet.			
	Describe how the magnetic field around wire carrying a current can be demonstrated.			
	Draw the magnetic field around a straight current carrying wire and for a solenoid.  			
	Explain how a solenoid increases the magnetic effect of the current.			
H	**Recall that when a conductor carrying a current is placed in a magnetic field, the magnet producing a field and the conductor exert a force on each other causing relative motion. This is known as the motor effect.**			
H	**Show that Fleming's left-hand rule represents the relative orientation of the force, the conventional current in the conductor and the direction of the magnetic field.**			
H	**Recall the factors that affect the size of the force on the conductor.**			
H	**For a conductor at right angles to a magnetic field carrying a current, use the equation:** **force = magnetic flux density x current x length** $F = B\,I\,l$			
H	**Explain how the force on a conductor in a magnetic field causes the rotation of a coil in an electric motor.**			
H	**Explain how moving-coil loudspeakers and headphones work using the motor effect to convert variations in electrical current into pressure variations in sound waves.**			

Working Scientifically

Alongside the Physics content that you learn during your GCSE course, there are also scientific skills that you must be able to apply to your own practical work, when analysing other people's results and to questions you may be asked.

Area	Development of scientific thinking
Scientific theories	You could be asked to give examples that show how scientific models and theories have changed over time, explain why new data led to changes in these theories and decide whether or not data supports a certain theory.
Using models	You could be asked to give ways in which a model that explains something could be tested by observation or experiment.
Power and limitations of science	You could be asked to explain why data is needed to answer scientific questions and why this data may be uncertain or incomplete. You should also be able to outline a simple ethical argument about new technology.
Scientific applications	You could be asked to describe and explain examples of the technological applications of science, and evaluate methods used to tackle problems created by the human impact on the environment.
Risks	You could be asked to give examples of hazards associated with science based technologies, and suggest reasons why the perceived risk is often different to the measured risk.
Peer review	You could be asked to explain that the process of peer review helps to detect false claims, while media reports of scientific developments which are not peer reviewed are often oversimplified, inaccurate or biased.
Area	**Experimental skills**
Hypotheses	You could be asked to suggest a hypothesis to explain data or observations.
Experiments	You could be asked to describe practical procedures, identify independent, dependent and control variables and explain why the procedure is well designed for that purpose.
Selection	You could be asked to suggest and explain why a particular instrument or technique is suitable for a particular purpose.
Health and safety	You could be asked to identify the main hazards in an experiment and suggest ways of reducing risk.
Sampling	You could be asked to suggest and describe a suitable sampling technique in a given context.
Measurements	You could be asked to read measurements and record data appropriately.

Evaluation	You could be asked to evaluate methods used and assess whether sufficient precise measurements have been taken.
Area	**Analysis and evaluation**
Presenting observations	You could be asked to construct diagrams, tables and histograms and plot two variables from experimental data.
Translating data	You could be asked to translate between graphical and numerical data.
Mathematical analysis	You could be asked to use an appropriate number of significant figures, find the mean, change the subject of a calculation and solve it, determine slopes and intercepts of graphs and draw a tangent to a curve.
Uncertainty	You could be asked to use the range of a set of readings about the mean as a measure of uncertainty.
Interpreting data	You could be asked to use data to make predictions, describe patterns in results and draw conclusions from observations.
Explanations	You could be asked to comment on the extent to which data is consistent with the hypotheses and identify which hypothesis gives a better explanation.
Evaluating data	You could be asked to evaluate data using the following terms appropriately: ▪ **accurate** measurements are close to the true value ▪ **precise** measurements cluster together ▪ **repeatable** measurements are ones that give similar results when repeated by the same people under similar conditions ▪ **reproducible** measurements give similar results by different people with different equipment ▪ **random** error is due to results varying in unpredictable ways ▪ **systematic** errors are due to results differing from the true value by a consistent amount each time ▪ **anomalous** values could be the product of a poor measurement and should be ignored
Communication	You could be asked to present coherent and logical responses to questions on the required practicals and other practical investigations.
Area	**Scientific vocabulary**
Vocabulary	You could be asked to use appropriate scientific terminology and definitions across all topics.
Quantities and units	You could be asked to use SI units, prefixes and convert units as appropriate.

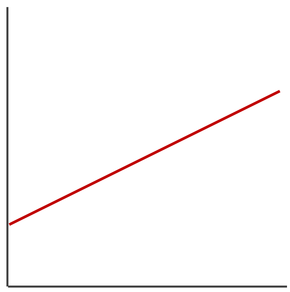
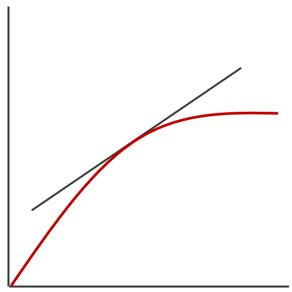
Required Practicals

There are a number of practical experiments you should complete in school for your GCSE Physics. You must understand how to set up and use the equipment, identify variables and analyse any results you take. You will be assessed on this in your final written exams.

No.	Required Practical Activity
1	Determine the specific heat capacity of one or more materials
2	Set up circuits to investigate: ▪ The resistance of a length of wire at constant temperature ▪ Resistors in series and parallel
3	Set up circuits to investigate the I-V characteristics of: ▪ A resistor ▪ A filament lamp ▪ A diode
4	Make and record measurements to determine the density of: ▪ Regular objects ▪ Irregular objects ▪ Liquids
5	Investigate the relationship between force and extension for a spring
6	Investigate the effect on acceleration of: ▪ Varying the force for a constant mass ▪ Varying the mass for a constant force
7	Make observations to identify the suitability of apparatus for measuring the frequency, wavelength and speed of: ▪ Waves in a ripple tank ▪ Waves in a solid
8	Investigate how the amount of infrared radiation absorbed or radiated by a substance depends on the surface

Maths for GCSE Physics

Alongside the work you are already completing for your GCSE Maths, there are a number of skills that are used throughout GCSE Physics that you must be familiar with.

Topic	You must be able to:
Numbers	▪ Use numbers in decimal and standard form ($x10^n$)
Data	▪ Use an appropriate number of significant figures ▪ Understand mean, mode and median ▪ Find the mean of a series of numbers
Equations	▪ Use the symbols: $=$ Equals $\sim$ Approximately equal to $\propto$ Proportional $<$ Less than $<<$ Much less than $>$ Greater than $>>$ Much greater than ▪ Rearrange equations and use them to solve numerical problems
Graphs	  ▪ Understand that $y = mx + c$ represents a linear relationship ▪ Work out the slope (gradient) and intercept from a graph ▪ Use a tangent to a curve to work out the gradient ▪ Calculate the area below a line and realise what this represents
Shapes	▪ Calculate areas of rectangles and triangles ▪ Calculate the volume and surface area of a cube

Quantities and Units

You should be able to recognise and recall all of these quantities, units and their symbols.

Quantity	Symbol	Unit	Symbol
Acceleration	a	metres per second squared	m/s^2
Activity	A	becquerel	Bq
Area	A	metres squared	m^2
Change in	Δ (delta)	-	-
Charge	Q	coulombs	C
Current	I	amps	A
Density	ρ (rho)	kilograms per cubic metre	kg/m^3
Distance or displacement	s	metres	m
Efficiency	-	percentage	%
Elastic potential energy	E_e	joules	J
Energy	E	joules	J
Extension	e	metres	m
Final velocity	v	metres per second	m/s
Force (resultant force)	F	newtons	N
Frequency	f	hertz	Hz
Gravitational field strength	g	newtons per kilogram	N/kg
Gravitational potential energy	E_p	joules	J
Height	h	metres	m
Initial velocity	u	metres per second	m/s
Kinetic energy	E_k	joules	J
Magnetic flux density	B	tesla	T
Magnification	M	-	-
Mass	m	kilograms	kg
Momentum	p	kilogram metres per second squared	$kg\ m/s^2$
Potential difference	V	volts	V
Power	P	watts	W

Radiation dose	-	sieverts	Sv
Resistance	*R*	ohms	Ω *(omega)*
Specific heat capacity	*c*	joules per kilogram per degree Celcius	J/kg °C
Specific latent heat	*L*	joules per kilogram	J/kg
Speed	*v*	metres per second	m/s
Spring constant	*k*	newtons per metre	N/m
Temperature	*θ* *(theta)*	degrees Celsius	°C
Thermal energy	*E*	joules	J
Time	*t*	seconds	s
Velocity	*v*	metres per second	m/s
Volume	*V*	metres cubed	m^3
Wave speed	*v*	metres per second	m/s
Wavelength	*λ* *(lambda)*	metres	m
Weight	*W*	kilograms	kg
Work done	*W*	joules	J

Equations

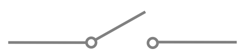
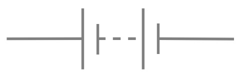
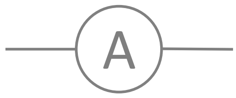
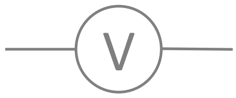
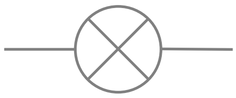
Only a few equations will be given to you in the exam on the Physics Equation Sheet. You must be able to remember the rest of these equations.

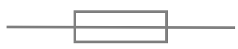
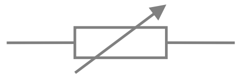
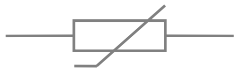
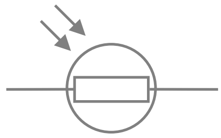
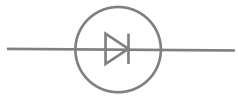
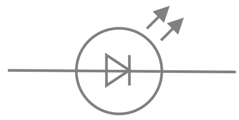
	Equation	Symbol
	kinetic energy = ½ x mass x speed^2	$E_k = ½\ m\ v^2$
Equation Sheet	elastic potential energy = ½ x spring constant x extension^2	$E_e = ½\ k\ e^2$
	gravitational potential energy = mass x gravitational field strength x height	$E_p = m\ g\ h$
Equation Sheet	change in thermal energy = mass x specific heat capacity x change in temperature	$\Delta E = m\ c\ \Delta\theta$
	power = energy transferred / time	$P = E\ /\ t$
	power = work done / time	$P = W\ /\ t$
	efficiency = $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$	-
	efficiency = $\frac{\text{useful power output}}{\text{total power input}}$	-
	charge = current x time	$Q = I\ t$
	potential difference = current x resistance	$V = I\ R$
	resistors in series: total resistance = sum of individual resistances	$R_{Total} = R_1 + R_2$
	power = potential difference x current	$P = V\ I$
	power = current^2 x resistance	$P = I^2\ R$
	energy transferred = power x time	$E = P\ t$
	energy transferred = charge x potential difference	$E = Q\ V$
	density = mass / volume	$\rho = m\ /\ V$
Equation Sheet	energy for a change of state = mass x specific latent heat	$E = m\ L$
	weight = mass x gravitational field strength	$W = m\ g$

	work done = force x distance (moved along the line of action of the force)	$W = F s$
	force = spring constant x extension	$F = k e$
	distance travelled = speed x time	$s = v t$
	acceleration = change in velocity / time taken	$a = \Delta v / t$
Equation Sheet	final velocity^2 – initial velocity^2 = 2 x acceleration x distance	$v^2 - u^2 = 2 a s$
	resultant force = mass x acceleration	$F = m a$
Higher	**momentum = mass x velocity**	$p = m v$
Equation Sheet	period = 1 / frequency	$T = 1 / f$
	wave speed = frequency x wavelength	$v = f \lambda$
Higher **Equation Sheet**	**For a conductor at right angles to a magnetic field carrying a current:** **force = magnetic flux density x current x length**	$F = B I l$
Higher **Equation Sheet**	**potential difference across primary coil x current in primary coil = potential difference across secondary coil x current in secondary coil**	$V_p I_p = V_s I_s$

Common Circuit Symbols

You must remember these circuit symbols and be able to draw them correctly in circuits.

Component	Symbol
Open Switch	
Closed Switch	
Cell	
Battery	
Ammeter	
Voltmeter	
Filament lamp	

Component	Symbol
Resistor	
Fuse	
Variable resistor	
Thermistor	
Light dependent resistor (LDR)	
Diode	
Light emitting diode (LED)	

Definitions

These are the key words that you must know the meaning of.

Term	Definition
Power	Power is defined as the rate at which energy is transferred or at which work is done
Current	Electric current is the rate of flow of electric charge
Ohmic conductor	The current through an ohmic conductor at constant temperature is directly proportional to the potential difference across it
National Grid	The National Grid is a system of cables and transformers linking power stations to consumers
Internal energy	Internal energy is the total kinetic and potential energy of all the particles that make up a system
Specific heat capacity	The specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius
Specific latent heat	The specific latent heat of a substance is the amount of energy required to change the state of one kilogram of the substance with no change in temperature
Activity	Activity is the rate at which a source of unstable nuclei decays
Count-rate	Count-rate is the number of decays recorded each second by a detector
Half-life	The half-life of a radioactive isotope is the time it takes for the number of nuclei of the isotope in a sample to halve or The time it takes for the count-rate, or activity, from a sample containing the radioactive isotope to fall to half its initial level
Contamination	Contamination is the unwanted presence of material containing radioactive atoms on other material
Irradiation	Irradiation is the process of exposing an object to nuclear radiation
Joule	One joule of work is done when a force of one newton causes a displacement of one metre
Displacement	Displacement includes both the distance an object moves and the direction it moves from its start point
Velocity	The velocity of an object is its speed in a given direction
Newton's First Law	If the resultant force acting on an object is zero and the object is: ▪ stationary, the object remains stationary ▪ moving, the object continues to move at the same velocity

Term	Definition
Newton's Second Law	The acceleration of an object is proportional to the resultant force acting on the object and inversely proportional to the mass of the object
Newton's Third Law	Whenever two objects interact, the forces they exert on each other are equal and opposite
Stopping distance	The stopping distance of a vehicle is the sum of the distances the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels under the braking force (braking distance)
Momentum	Momentum is defined as mass times velocity
Conservation of momentum	In a closed system, the total momentum before an event is equal to the total momentum after the event
Amplitude	The amplitude of a wave is defined as the maximum displacement of a point on a wave away from its undisturbed position
Wavelength	The wavelength of a wave is the distance from a point on one wave to the equivalent position on the adjacent wave
Frequency	The frequency of a wave is the number of waves passing a point each second