

AQA : GCSE specification 3453

Physics Specification A (Modular)

Please ensure that you have selected the correct specification.

Summary of Subject Content

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15.5	How do we know that the Earth's crust is moving?	

On the following pages, the left-hand column shows:

- KS3** Content which is particularly relevant from key stage 3.
- FT and HT** Content included in **both** Foundation **and** Higher tiers.
- HT** Content included **only** in Higher tier.

page numbers in **Physics for You**

10	Module 09 – Energy	Physics for You
	<p><i>This module includes the following:</i></p> <p><i>Investigations of thermal energy transfer by means of radiation – and of how all types of thermal energy transfer can be reduced when necessary.</i></p> <p><i>For the higher tier only, explaining how thermal energy transfers by means of conduction and convection occur.</i></p> <p><i>Calculating:</i></p> <ul style="list-style-type: none"> • <i>The energy transferred by appliances from their power and the length of time they are used;</i> • <i>The cost of using electrical appliances;</i> <p><i>And the higher level only;</i></p> <ul style="list-style-type: none"> • <i>The energy transferred to bodies by lifting them i.e. gravitational potential energy.</i> <p><i>An examination of the idea of efficiency in relation to energy transfer.</i></p> <p><i>A detailed study of the advantages and disadvantages, from various points of view, of a range of renewable and non-renewable energy resources.</i></p>	Chapters 8, 16, 32
10.1	<p>How is heat (thermal energy) transferred and how can we reduce heat transfer?</p> <p><i>Sometimes we want to transfer heat effectively from one place to another. At other times we want to reduce heat losses as much as we can. To be able to do either of these things we need to know how heat is transferred and which methods of heat transfer are most important in particular cases.</i></p>	
KS3	<p>When different parts of a substance are at different temperatures, energy is transferred by the substance from places where the temperature is higher to places where the temperature is lower.</p>	pages 42-43
	<p>Transfer of energy by a substance, without the substance itself moving, is called conduction. Metals are very good conductors. Non-metals are usually poor conductors (insulators). Gases are very poor conductors.</p>	p. 43-44
	<p>Liquids and gases can flow and so can energy from places where the temperature is higher to places where the temperature is lower.</p> <p>Transfer of energy by liquids or gases moving in this way is called convection.</p>	p. 46-47
	<p>Energy is continually being transferred to and from all objects by radiation, even through empty space (a vacuum).</p>	p. 48-50

FT & HT	<p>Hot bodies mainly emit mainly infra red radiation.</p> <p>The hotter an object is, the more energy it radiates. Dark, matt surfaces emit more radiation than light, shiny surfaces at the same temperature. Particles of matter are not involved.</p> <p>Dark, matt surfaces are good absorbers (poor reflectors) of radiation.</p> <p>Light shiny surfaces are good reflectors (poor absorbers) of radiation.</p>	p. 48-9, 219, 221
	<p>Candidates should be able:</p> <ul style="list-style-type: none"> • To describe various ways in which heat energy is transferred from buildings; • To describe and explain ways in which the rates of these energy transfers can be reduced. <p>Candidates should be able, when given appropriate information, to evaluate the effectiveness and cost-effectiveness of methods used to reduce energy consumption in buildings.</p>	p. 45, 50
HT	<p>Conduction occurs in metals because the hotter the metal is the more kinetic energy the ions in the metal structure have. This energy is transferred to cooler parts of a piece of metal by free electrons as they diffuse through the metal and collide with ions and with other electrons.</p>	p. 43
	<p>Convection currents occur in liquids and gases because their particles move faster when they are hot causing the liquid or gas to expand. Warm regions are then less dense than cold regions. The warm regions rise up through the colder regions and colder regions replace the warmer regions.</p> <p>Thermal radiation transfer is the transfer of energy by waves.</p>	p. 46, 48, 219
10.2	<p>Why are electrical appliances so useful, what does it cost to use them?</p> <p><i>We often use electrical appliances because they transfer electrical energy as whatever form of energy we need at the flick of a switch. What we pay for when we use an electrical appliance is the energy it transfers. Some appliances transfer energy faster than others and so cost more to use.</i></p>	
FT & HT	<p>Much of the energy transferred in homes and industry is electrical energy. This is because electrical energy is readily transferred as:</p> <ul style="list-style-type: none"> • Heat (thermal energy); • Light; • Sound; • Movement (kinetic energy). 	p. 9-10, 112, 270
	<p>Candidates should be able:</p> <ul style="list-style-type: none"> • To specify the energy transfers everyday electrical devices are designed to bring about; • To give examples of everyday electrical devices designed to bring about particular energy transfers. 	p. 9-10

FT & HT	<p>How much electrical energy an appliance transfers depends on:</p> <ul style="list-style-type: none"> • how long the appliance is switched on; • how fast the appliance transfers energy (its power). <p>The power of an appliance is measured in watts (W) or kilowatts (1kW = 1000W).</p>	<p>p. 272</p>
	<p>The amount of energy transferred from the mains is measured in kilowatt-hours, called Units:</p> $\text{energy transferred} = \text{power} \times \text{time}$ <p>(kilowatt hour, kWh) (kilowatt, kW) (hour, h)</p> <p>Candidates should be able, when provided with suitable diagrams of a digital domestic electricity meter, to calculate the number of Units used.</p> <p>The cost of this energy can be calculated using:</p> $\text{total cost} = \text{number of Units} \times \text{cost per Unit}$	<p>p. 273</p>
	<p>Energy is normally measured in joules (J).</p>	<p>p. 37, 107</p>
	<p>Power is a measure of how fast energy is transferred. The greater the power, the more energy is transferred in a given time.</p> $\text{power (watt, W)} = \frac{\text{energy transferred (joule, J)}}{\text{time taken (second, s)}}$ <p>1 watt is the transfer of 1J of energy in 1s.</p>	<p>p. 118-9</p>
	<p>The total amount of energy, in joules, transferred by an electrical device can be calculated as follows:</p> $\text{Energy transferred} = \text{power} \times \text{time}$ <p>(joule, J) (watt, W) (second, s)</p>	<p>p. 119, 273</p>
HT	<p>Electrical energy may also be transferred as gravitational potential energy.</p> <p>Gravitational potential energy is the energy stored in an object because of the height to which the object has been lifted against the force of gravity.</p> $\text{change in gravitational potential energy} = \text{weight} \times \text{change in vertical height}$ <p>(joule, J) (newton, N) (metre, m)</p>	<p>p. 116</p>

continued . . .

<p>10.3</p>	<p>How efficient are the appliances we use?</p> <p><i>The electrical appliances and all the other energy transferring devices we use are never perfect; they never transfer all the energy we supply as the energy form we want to the place where we want it. We need to know how efficient different energy-transferring devices are, so that we can choose between them and try to improve them.</i></p>	
<p>FT & HT</p>	<p>Whenever energy is transferred, only part of it is transferred to where it is wanted and in the form it is wanted (usefully transferred). The rest of the energy is transferred in some non-useful way and so wasted.</p> <p>Candidates should be able to describe the intended energy transfers and the main energy wastages which occur when using a range of everyday devices.</p> <p>The energy which is ‘wasted’ during energy transfers and the energy which is usefully transferred both end up being transferred to the surroundings which become warmer.</p> <p>The energy becomes increasingly spread out and becomes increasingly more difficult to use for further useful energy transfers.</p> <p>The more of the energy supplied to a device that is usefully transferred, the more efficient we say the device is.</p> <p>Candidates should be able, when provided with appropriate information, to evaluate methods of reducing wasteful transfers of energy.</p> <p>The efficiency of a device can be calculated using:</p> $\text{efficiency} = \frac{\text{useful energy transferred by device}}{\text{total energy supplied to device}}$	<p>p. 112-3, 122, 9-10, and worksheet in the Teacher Support Pack</p>
<p>10.4</p>	<p>How should we generate the electricity we need?</p> <p><i>Electricity is what is called a secondary energy source; some other energy resource is needed to generate it. Various energy sources can be used to generate the electricity we need. We must carefully consider the advantages and disadvantages of using each energy source before deciding which source(s) it would be best to use in any particular situation.</i></p>	
<p>KS3</p>	<p>Coal, oil, gas and wood are all fuels. They release energy when they are burned.</p> <p>The Earth’s supply of the fossil fuels (coal, oil and gas) and of nuclear fuels is limited. They are often called non-renewable energy resources. It will take millions of years to replace the fossil fuels we have used. Most of the energy used by humans comes from non-renewable fuels, mainly from fossil fuels. The more economical people are with these fuels, the longer they will last.</p> <p>More trees can be grown to replace trees that are cut down to provide wood for fuel. Wood is a renewable energy resource.</p> <p>Renewable energy resources include sunlight, the wind, the waves, running water and the tides. These energy resources will not run out.</p> <p>Electricity is a very convenient and widely used energy source. It is generated in power stations using some other energy resource.</p>	<p>p. 11-13</p>

FT & HT	<p>In most power stations, energy from fuel is used to heat water. In Britain, many power stations burn fossil fuels. Other power stations use nuclear fuel, mainly uranium and plutonium. The steam which is produced is used to drive turbines. The turbines then drive generators which produce electricity.</p>	<p>p. 113</p>
	<p>Electricity can also be generated from renewable energy resources. Energy from renewable resources can be used to drive turbines directly. The resources used in this way include:</p> <ul style="list-style-type: none"> • The wind; • The rise and fall of water due to waves; • The flow of water from a higher level to a lower level from behind tidal barrages or the dams of hydroelectric schemes. 	<p>p. 113, 12-13, 111, worksheet</p>
	<p>In some volcanic area, hot water and steam rise to the surface. The steam can be tapped and used to drive turbines producing geothermal energy supplies. The energy released in volcanic areas originally came from the decay of radioactive elements, including uranium, within the Earth.</p>	<p>p. 13</p>
	<p>Electricity can be produced directly from the Sun's radiation using solar cells.</p>	<p>p. 12, 114</p>
	<p>Using different energy sources has different effects on the environment.</p> <ul style="list-style-type: none"> • Burning fossil fuels releases carbon dioxide, a gas which increases the greenhouse effect and causes increased global warming. For the same amount of energy released, coal produces more carbon dioxide than oil and oil produces more carbon dioxide than natural gas. There is no feasible way of preventing the very large amounts of carbon dioxide involved from entering the atmosphere. Burning most types of coal and oil also releases sulphur dioxide, a gas that helps to produce acid rain. The sulphur can be removed from these fuels before they are burnt or the sulphur dioxide removed from the waste gases before they enter the atmosphere, though this increases the cost of the electricity that is generated. • Nuclear fuels do not produce gases which increase the greenhouse effect or which help to produce acid rain. When they are running normally, very little radiation or radioactive material escapes into the surroundings. If there is an accident, however, large amounts of very dangerous radioactive material may be released over a wide area. Nuclear power stations also produce waste, some of which stays dangerously radioactive for thousands of years and which has to be stored safely. • Groups of large wind generators (wind farms) are usually sited on hills and/or coasts and are considered unsightly by some people. They can also be noisy for people living nearby. Wind farms cause visual pollution and noise pollution. • Using energy from tides involves building barrages across river estuaries. This destroys the habitat of many organisms, e.g. wading birds and the mud-living organisms on which they feed. • Hydroelectricity schemes involve damming upland river valleys. This means flooding land that may have previously been used for farming or forestry. 	<p>p. 115, 359, 12-13</p>

FT & HT	<p>Energy sources also differ in when they are available for generating electricity.</p> <ul style="list-style-type: none"> Power stations which use fuels can produce electricity at any time (of the day or of the year); they are reliable energy sources. The time it takes to start them up varies considerably: <ul style="list-style-type: none"> Nuclear longest time Coal Oil natural gas shortest time The amount of electricity produced by wind generators depends on the strength of the wind which varies considerably. The amount of electricity produced by tidal barrages depends on the state of the tide, which varies during each day, and the height of the tide, which varies both on a monthly and yearly cycle. The amount of electricity produced by solar cells depends on the intensity of light that falls on them. <p>Each of these energy sources can generate electricity only at certain times; they are all to some extent unreliable.</p> <ul style="list-style-type: none"> Hydroelectric schemes are generally very reliable. They can also be started up very quickly to meet sudden increases in the demand for electricity. They can also be operated in reverse using surplus electricity from other power stations to pump water from a lower reservoir to a higher one. This means that most of the energy from the surplus electricity is stored rather than being wasted. 	<p>p. 114-5, 13</p>
	<p>Solar cells have a very high cost per Unit of electricity produced over their lifetime compared to all other sources of electricity except non-rechargeable batteries. Despite their cost, they are often the best energy source for producing electricity in remote locations (e.g. on satellites) or where only small amounts of electricity are needed (e.g. for watches or calculators).</p>	<p>p. 113, 114</p>
	<p>Candidates should be able to compare and contrast the particular advantages and disadvantages of using different energy sources to generate electricity.</p>	<p>p. 115, 359</p>
HT	<p>Candidates should be able to identify and evaluate the financial and environmental costs of using various energy resources to generate electricity and to evaluate these costs against the benefits to society, taking into consideration:</p> <ul style="list-style-type: none"> the factors listed above; that though there are no fuel costs with renewables, the energy is dilute so that the capital cost of the generating equipment is high; that though the fuel costs for nuclear power stations are low, the cost of building the power stations, and of de-commissioning them at the end of their useful life, is high; the need to match supply and demand; any additional information, including quantitative information, with which they are provided. 	<p>p. 113-115</p>

page numbers in **Physics for You**

11	Module 10 – Electricity	Physics for You
	<p><i>This module includes the following:</i></p> <p><i>Exploring the relationship between the three key variables, potential difference, resistance and current and applying it to a range of devices.</i></p> <p><i>Examining uses of the magnetic effects of electrical currents including the transfer of electrical energy as movement in electric motors and circuit breakers.</i></p> <p><i>Using the concept of electrical charge:</i></p> <ul style="list-style-type: none"> • <i>in the context of static electricity, its uses and the problems it causes;</i> • <i>to explain electric currents and electrolysis.</i> <p><i>Considering the nature of mains electricity and its safe use.</i></p> <p><i>Calculating:</i></p> <ul style="list-style-type: none"> • <i>power, in terms of p.d. and current (and hence of appropriate fuses for appliances of given power);</i> <p><i>And, at the higher tier:</i></p> <ul style="list-style-type: none"> • <i>energy transfer in terms of p.d. and charge;</i> • <i>charge in terms of current and time.</i> <p><i>Investigating electromagnetic induction and its use in generators and transformers.</i></p>	<p>Chapters 30, 31, 32, 36</p>
11.1	<p>What does the current through an electrical circuit depend on?</p> <p><i>How large a current flows depends on how hard the supply is trying to push a current through a circuit and how hard the circuit resists having a current pushed through it.</i></p>	
KS3	<p>A current will flow through an electrical component (or device) only if there is a voltage or potential difference (p.d.) across its ends. The bigger the potential difference across a component, the bigger the current that flows through it.</p> <p>Components resist a current flowing through them. The bigger their resistance, the smaller the current produced by a particular voltage, or the bigger the voltage needed to produce a particular current.</p>	<p>pages 254-261</p>
	<p>The p.d. across a component in a circuit is measured in volts (V) using a voltmeter connected across (in parallel with) the component.</p>	<p>p. 258</p>
	<p>The current flowing through a component in a circuit is measured in amperes (A) using an ammeter connected in series with the component.</p>	<p>p. 256</p>
FT & HT	<p>Current-voltage graphs are used to show how the current through a component varies with the voltage across it.</p> <p style="text-align: center;"><i>[insert Current-Voltage diagrams]</i></p>	<p>p. 265, and worksheets in the Teacher Support Pack</p>

FT & HT	When components are connected in series: <ul style="list-style-type: none"> • their total resistance is the sum of their separate resistances; • the same current flows through each component; • the total potential difference of the supply is shared between them. 	p. 262, 267
	When components are connected in parallel: <ul style="list-style-type: none"> • there is the same potential difference across each component; • the current through each component depends on its resistance; the greater the resistance; the smaller the current; • the total current through the whole circuit is the sum of the currents through the separate components. 	p. 263, 267
	The potential difference provided by cells connected in series is the sum of the potential difference of each cell separately (bearing in mind the direction in which they are connected).	p. 266
	Candidates should be able to interpret and/or draw circuit diagrams using standard symbols. The following standard symbols should be known. <i>[switch, lamp, fuse, cell, battery, voltmeter, ammeter, diode, resistor, variable resistor, thermistor, LDR]</i>	p. 254
	Potential difference, current and resistance are related as shown: <div style="display: flex; justify-content: center; align-items: center; gap: 20px;"> <div style="text-align: center;">Potential difference (volt, V)</div> <div>=</div> <div style="text-align: center;">current (ampere, A)</div> <div>×</div> <div style="text-align: center;">resistance (ohm, Ω)</div> </div>	p. 259
	The current through a resistor (at a constant temperature) is proportional to the voltage across the resistor.	p. 265
	The resistance of a filament lamp increases as the temperature of the filament increases.	p. 265
	The current through a diode flows in one direction only. The diode has a very high resistance in the reverse direction.	p. 265, 322
	The resistance of a light dependent resistor decreases as the light intensity increases.	p. 325
	The resistance of a thermistor decreases as the temperature increases <i>[i.e. knowledge of negative temperature coefficient thermistor only is required].</i>	p. 265, 325
11.2	How can electricity be used to make things move? <i>Electric currents produce magnetic fields. These can be used to make things move, for example, electric motors and circuit breakers.</i>	
KS3	A magnet exerts a force on any piece of magnetic material including iron and steel, or another magnet which is placed near it. (There is a magnetic field around the magnet).	p. 284, 287
	A coil of wire acts like a bar magnet when an electric current flows through it. One end becomes a north-seeking pole and the other end a south-seeking pole. This is called an electromagnet. Reversing the current in an electromagnet reverses the poles of the electromagnet.	p. 293

FT & HT	<p>When a wire carrying an electric current is placed in a magnetic field, it may experience a force. The size of the force can be increased by:</p> <ul style="list-style-type: none"> • increasing the strength of the magnetic field; • increasing the size of the current. <p>The direction of the force is reversed if either the direction of the current or the direction of the magnetic field is reversed.</p>	p. 296
	<p>Candidates should be able – when provided with diagrams and/or other appropriate information – to explain how electromagnet effects are used in simple d.c. motors and circuit breakers.</p> <p><i>[Details of the split ring for reversing the current of a d.c. motor each half turn will not be required].</i></p>	p. 297-9
11.3	<p>What is static electricity, how can it be used, and what is the connection between static electricity and electric currents?</p> <p><i>Static electricity – the things it does and the problems it causes – can be explained in terms of electrical charges. When electrical charges move we get an electric current.</i></p>	
FT & HT	<p>When certain different insulating materials are rubbed against each other they become electrically charged. Electrically charged objects attract small objects placed near them.</p>	p. 247
	<p>When two electrically charged objects are brought close together, they exert a force on each other. Two charged objects may either pull towards each other (attract) or push each other away (repel).</p>	p. 247
	<p>These observations can be explained in terms of two types of charge called positive (+) and negative (-). Two objects which have the same type of charge repel. Two objects which have different types of charge attract.</p>	p. 248
	<p>When two different materials are rubbed against each other, electrons, which have a negative charge, are rubbed off one material on to the other. The material which gains electrons becomes negatively charged; the material which loses electrons is left with an equal positive charge.</p>	p. 248
	<p>Electrostatic charges can be useful in everyday life.</p>	p. 252
	<p>For example in photocopiers:</p> <ul style="list-style-type: none"> • a copying plate is electronically charged; • an image of the page you want to copy is projected on to the plate; • where light falls on the plate, the electrical charges leak away; • the parts of the plate that are still charged attract bits of black powder; • the black powder is transferred from the plate to a sheet of paper; • the paper is heated to make the black powder stick; • there is now a copy of the original page. 	p. 321, and worksheet in the Teacher Support Pack

FT & HT	<p>When printing with an inkjet printer:</p> <ul style="list-style-type: none"> • Tiny droplets of ink are electrically charged as they are forced out of a very fine nozzle; • The droplets pass between metal plates across which a voltage can be applied so that one plate is negative and the other plate is positive; • The charged droplets of ink are attracted towards the plate with the opposite charge and away from the plate with the same charge. This means that they are deflected as they pass between the plates; • The size and direction of the voltage applied across the plates is controlled so that each droplet in turn is deflected to a particular place on the paper; • Each droplet of ink produces a tiny dot on the paper and many such dots, each in exactly the right place, produce the printed characters. 	p. 321, worksheet
	A charged conductor can be discharged by connecting it to earth with a conductor.	p. 249, 251
	Candidates should be able , when provided with the appropriate information about a situation in which static electricity is dangerous, to explain why it is dangerous and how precautions can be taken to ensure that the electrostatic charge is discharged safely.	p. 250-252
	In solid conductors, an electric current is a flow of electrons.	p. 255
	When some chemical compounds are melted or dissolved in water they conduct electricity. These compounds are made up of electrically charged particles called ions. The current is due to negatively charged ions moving to the positive terminal (electrode) and the positively charged ions moving to the negative electrode. Simpler substances are released at the terminals (electrodes). This process is called electrolysis.	p. 277
HT	The greater the charge on an isolated object, the greater the voltage (potential difference) between object and earth. If the voltage becomes high enough, a spark may jump across the gap between the object and any earthed conductor which is brought near it.	p. 251
	Metals are good conductors of electricity because some of the electrons from their atoms can move freely throughout the metal structure.	p. 255
	<p>During electrolysis the mass and/or volume of the substance deposited or released at the electrode increases in proportion to:</p> <ul style="list-style-type: none"> • the current; • the time for which the current flows. 	p. 278
11.4	<p>What is mains electricity and how can it be used safely?</p> <p><i>Mains electricity is very useful but is also very dangerous. It is important for everyone to know how to use it safely.</i></p>	

FT & HT	The UK mains supply is about 230 volts. Mains electricity can kill if it is not used safely.	p. 274
	<p>Most electrical appliances are connected to the mains using cable and a 3-pin plug. To make them safe to use:</p> <p>cable comprises:</p> <ul style="list-style-type: none"> • two or three inner cores of copper, because copper is a good conductor; • outer layers of flexible plastic, because plastic is a good insulator. <p>a plug has:</p> <ul style="list-style-type: none"> • a plastic or rubber case, because plastic and rubber are good insulators; • pins made from brass, because brass is a good conductor; • a fuse; • an earth pin; • a cable grip. 	p. 275
	The fuse in a plug should always be the same as the one recommended by the manufacturer of the appliance. Appliances with metal cases are usually earthed.	p. 275
	<p>When connecting an appliance to a 3-pin plug:</p> <ul style="list-style-type: none"> • the blue wire is connected to the neutral terminal; • the brown wire is connected via a fuse to the live terminal; • the green/yellow wire (when fitted) is connected to the earth terminal; • the cable should be secured in the plug by the cable grip; • a fuse of the correct value (rating) should be in place. 	p. 275
	<p>Candidates should be able, when provided with appropriate diagrams:</p> <ul style="list-style-type: none"> • to recognise errors in the wiring of a mains (3-pin) plug; • to recognise dangerous practice in the use of mains electricity. 	p. 275
	An alternating current (a.c) is one which is constantly changing direction. Mains electricity is an a.c. supply. In the UK it has a frequency of 50 cycles per second or 50 hertz (Hz) which means that it changes direction and back again 50 times each second.	p. 274, 305
	Cells and batteries supply a current which always flows in the same direction. This is called a direct current (d.c.).	p. 254
	Candidates should be able to compare the voltages of d.c. supplies and the frequencies and peak voltages of a.c. supplies from diagrams of oscilloscope traces.	p. 305, 317 worksheet
	<p>If a fault in an electrical circuit or an appliance causes too great a current to flow, the circuit is switched off by a fuse or a circuit breaker.</p> <p>The fuse should have a value higher than, but as close as possible to, the current through the appliance when it is working normally.</p> <p>When the current through a fuse wire exceeds the current rating of the fuse the wire becomes hot and will (eventually) melt breaking the circuit and switching off the current.</p>	p. 275
	Candidates should be able , when provided with appropriate information, to explain how a circuit breaker works.	p. 270, 312, 345 worksheet

FT & HT	Appliances with metal cases need to be earthed. The earth pin is connected to the case via the yellow/green wire. If a fault in the appliance connects the case to the live wire, and the supply is switched on, a very large current flows to earth and overloads the fuse.	p. 275
HT	The live terminal of the mains supply alternates between a positive and negative voltage with respect to the neutral terminal. The neutral terminal stays at a voltage close to zero with respect to earth.	p. 274
11.5	Why do we need to know the power of electrical appliances? <i>Electrical appliances transfer energy. The power of an electrical appliance is the rate at which it transfers energy. Most appliances have their power (in watts) and the voltage of the supply they need printed on them. From this we can calculate their current and so the fuse they need. [In fact, potential difference is defined in terms of the energy released per unit of charge transferred.]</i>	
KS3	As an electric current flow through a circuit, energy is transferred from the battery or power supply to the components in the electrical circuit.	p. 112
FT & HT	An electric current is a flow of charge.	p. 255, 267
	When electrical charge flows through a resistor, electrical energy is transferred as heat.	p. 270
	The rate of energy transfer (power) is given by: Power = potential difference × current (watt, W) (volt, V) (ampere, A)	p. 272
	1 watt is the transfer of 1J of energy in 1s.	p. 118, 272
HT	The higher the voltage of a supply, the greater the amount of energy transferred for a give amount of charge which flows. Energy transferred = potential difference × charge (joule, J) (volt, V) (coulomb, C)	p. 267
	The amount of electrical charge which flows is related to current and time as follows: Charge = current × time (coulomb, C) (ampere, A) (second, s)	p. 266
11.6	How do generators and transformers work? <i>Just as electric currents can be used to produce magnetic fields, so magnetic fields can be used to produce electric currents. This idea is used in generators to produce electricity and in transformers to increase or decrease voltage.</i>	
FT & HT	If a magnet is moved into a coil of wire which is part of a complete circuit a current is produced (induced) in the wire. If the magnet is moved out of the coil, or the other pole of the magnet is moved into the coil, the direction of the induced current is reversed.	p. 303
	Transformers are used to change the voltage of an a.c. supply. At power stations, transformers are used to produce very high voltages before the electricity is transmitted to where it is needed through power lines (National Grid). Local transformers reduce the voltage to safer levels before the electricity is supplied to consumers.	p. 308-9

FT & HT	Electricity can be generated by rotating a coil of wire in a magnetic field or by rotating a magnet inside a coil of wire. This is how a generator works.	p. 304
	<p>If a wire, or coil of wire ‘cuts through’ a magnetic field, or vice-versa, a voltage (potential difference) is produced between the ends of the wire. This induced voltage causes a current to flow if the wire is part of a complete circuit.</p> <p>The size of the induced voltage increases when:</p> <ul style="list-style-type: none"> • the speed of the movement increases; • the strength of the magnetic field is increased; • the number of turns on the coil is increased; • the area of the coil is greater. 	p. 306
HT	Candidates should be able , when provided with a diagram, to explain how an a.c. generator works, including the purposes of the slip rings and brushes.	p. 304
	<p>A changing magnetic field will also produce an induced voltage in a coil. This is how a transformer works.</p> <p>The higher the voltage, the smaller the current needed to transmit energy at the same time. Less energy is wasted by heating up the power lines.</p> <p>A transformer consists of two separate coils wound around an iron core. When an alternating voltage is applied across one coil (the primary) an alternating voltage is produced across the other coil (secondary).</p> <p>The voltages across the primary and secondary coils of a transformer are related as shown:</p> $\frac{\text{Voltage across primary (volt, V)}}{\text{Voltage across secondary (volt, V)}} = \frac{\text{number of turns on primary}}{\text{number of turns on secondary}}$	p. 307-9

page numbers in **Physics for You**

12	Module 11 – Forces	Physics for You
	<p><i>This module includes the following:</i></p> <p><i>Interpreting graphical representations of speed and acceleration.</i></p> <p><i>Examining the effects of forces on motion i.e..</i></p> <ul style="list-style-type: none"> • <i>unbalanced forces which produce accelerations as expressed in their relationship $F = m a$;</i> • <i>frictional forces which oppose motion and which are not only important for slowing down and stopping vehicles but are also responsible for steady driving forces eventually resulting in steady speeds.</i> <p><i>Calculating:</i></p> <ul style="list-style-type: none"> • <i>the work done by forces which act on bodies to affect their movement;</i> • <i>the kinetic energy of a moving body.</i> <p><i>Exploring the role of gravitational forces:</i></p> <ul style="list-style-type: none"> • <i>in keeping satellites in orbit;</i> • <i>in maintaining the stability of the solar system;</i> • <i>in the life histories of stars.</i> <p><i>Considering, at the higher tier only, the implications of the estimated speeds of distant galaxies for the origins of the Universe.</i></p>	Chapters 18, 20
12.1	<p>How can we describe the way things move?</p> <p><i>Even when things are moving in a straight line, describing their movement is not easy. They can move with different speeds and can also change their speed (accelerate).</i></p> <p><i>Graphs showing how either the distance of a body from its starting point or its speed change over a period of time can help us to describe the movement of the body.</i></p>	
KS3	<p>For an object moving at a steady speed in a straight line, the distance it travels and the time it takes are related as shown:</p> $\text{Speed (metre/second, m/s)} = \frac{\text{distance travelled (metre, m)}}{\text{time taken (second, s)}}$	page 130
FT & HT	<p>If an object moves in a straight line, how far it is from a certain point can be represented by a distance-time graph.</p> <p>Candidates should be able to construct and recognise the shape of a distance-time graph when a body is:</p> <ul style="list-style-type: none"> • stationary; • moving with a steady speed. <p>The steeper the slope of the graph, the greater the speed it represents.</p>	p. 134

FT & HT	<p>The velocity of an object is its speed in a given direction.</p> <p>Velocity-time graphs can represent the motion of a body.</p> <p>Candidates should be able to recognise the shape of the velocity-time graph when a body is moving with:</p> <ul style="list-style-type: none"> • constant velocity; • constant acceleration. <p>The steeper the slope of the graph, the greater the acceleration it represents.</p> <p>The acceleration of an object is the rate at which its velocity changes.</p>	<p>p. 130-3</p>
	<p>For objects moving in a straight line with a steady acceleration, the acceleration, the change in velocity and the time taken for the change are related as shown:</p> $\text{acceleration (metre/second squared, m/s}^2\text{)} = \frac{\text{change in velocity (metre/second, m/s)}}{\text{time taken for change (second, s)}}$	<p>p. 130</p>
HT	<p>Candidates should be able to calculate the gradient of a distance-time graph.</p> <p>The gradient of a velocity-time graph represents acceleration. The area under a velocity-time graph represents the distance travelled.</p> <p>Candidates should be able to calculate:</p> <ul style="list-style-type: none"> • the gradient of a velocity-time graph and interpret this as acceleration; • the area under a velocity-time graph; <p>for an object moving with a constant acceleration.</p>	<p>p. 134, 380</p> <p>p. 132-133</p>
12.2	<p>How do we make things speed up or slow down?</p> <p><i>To change the speed of a body an unbalanced force must act on it.</i></p> <p><i>We use the force of friction between two solid surfaces to slow down and stop bicycles and motor vehicles safely.</i></p> <p><i>[Because of friction, a driving force is needed to keep a body moving at a steady speed.]</i></p>	
KS3	<p>The forces acting on an object may cancel each other out (balance).</p> <p>When an object rests on a surface:</p> <ul style="list-style-type: none"> • the weight of the object exerts a downward force on the surface; • the surface exerts an upwards force on the object; • the sizes of the two forces are the same. 	<p>p. 95</p>
	<p>A force of friction acts:</p> <ul style="list-style-type: none"> • when an object moves through the air or water; • when solid surfaces slide, or tend to slide, across each other. <p>The direction of this force of friction is always opposite to the direction in which the object or surface is moving. Friction causes objects to heat up and to wear away at their surfaces.</p> <p>The friction between solid surfaces is used in brakes which slow down and stop moving vehicles.</p>	<p>p. 92-3</p>

FT & HT	Whenever two bodies interact, the forces they exert on each other are equal and opposite.	p. 94-5
	Balanced forces will have no effect on the movement of an object: it will remain stationary or, if it is already moving it will continue to move at the same speed and in the same direction.	p. 77
	If the forces acting on an object do not cancel each other out, an unbalanced force will act on the object. This unbalanced force will affect the movement of the object. How the movement is affected depends on the direction and the size of the unbalanced force: <ul style="list-style-type: none"> • a stationary object will start to move in the direction of the unbalanced force; • an object moving in the direction of the force will speed up; • an object moving in the opposite direction to the force will slow it down; • the greater the size of the unbalanced force, the faster the object will speed up or slow down. • when an unbalanced force acts on an object in a particular direction its speed changes (it accelerates) in that direction. The greater the force, the greater the acceleration. The bigger the mass of an object, the greater the force needed to give the object a particular acceleration. 	p. 96, 138
	Falling bodies are accelerated by gravity.	p. 136
	On Earth the gravitational field strength is about 10 N/kg. $\text{weight} = \text{mass} \times \text{gravitational field strength}$ (newton, N) (kilogram, kg) (newton/kilogram, N/kg)	p. 75, 139
	The greater the speed of a vehicle: <ul style="list-style-type: none"> • the greater the braking force needed to stop in a certain time; • the greater the distance needed to stop it with a certain braking force. If too great a braking force is applied, friction between a vehicle's tyres and the road surface may not be great enough to prevent skidding. The stopping distance of a vehicle depends on: <ul style="list-style-type: none"> • the distance the vehicle travels during the driver's reaction time; • the distance the vehicle travels under the braking force. The overall stopping distance is greater if: <ul style="list-style-type: none"> • the vehicle is initially travelling faster; • the driver's reactions are slower (due to tiredness, drugs, alcohol); • there are adverse weather conditions (wet/icy roads, poor visibility); • the vehicle is poorly maintained (e.g. worn brakes/tyres). 	p. 98
	The faster an object moves through a gas or a liquid (a fluid) the greater the force of friction which acts on it.	p. 99

FT & HT	<p>When a body falls:</p> <ul style="list-style-type: none"> initially it accelerates due to the force of gravity; frictional forces increase until they balance the gravitational forces; the resultant force eventually reaches zero and the body falls at its terminal velocity. <p>When a vehicle has a steady speed the frictional forces balance the driving force.</p>	p. 99, 136
HT	One newton is the force needed to give a mass of one kilogram an acceleration of one metre per second squared.	p. 138
	<p>Force, mass and acceleration are related as shown:</p> $\text{force} = \text{mass} \times \text{acceleration}$ <p>(newton, N) (kilogram, kg) (metre/second squared, m/s²)</p>	p. 138-9
12.3	<p>What happens to the movement energy when things speed up or slow down?</p> <p><i>When a body speeds up or slows down, its kinetic energy increases or decreases. The forces which cause the change in speed do so by transferring energy to, or from, the body.</i></p>	
FT & HT	<p>When a force moves an object, energy is transferred and work is done:</p> $\text{work done} = \text{energy transferred}$	p. 109
	<p>The amount of work done, force and distance are related as shown:</p> $\text{work done} = \text{force applied} \times \text{distance moved in direction of force}$ <p>(joule, J) (newton, N) (metre, m)</p>	p. 107
	Elastic potential energy is the energy stored in an elastic object when work is done on the object to change its shape.	p. 8, 108
HT	<p>Kinetic energy is the energy an object has because of its movement.</p> <p>An object has more kinetic energy:</p> <ul style="list-style-type: none"> the greater its mass; the greater its speed. <p>Work done against frictional forces is transferred mainly as heat.</p> $\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times \text{speed}^2$ <p>(joule, J) (kilogram, kg) [(metre/second)², (m/s)²]</p>	p. 117

12.4	<p>How do planets and artificial satellites stay in orbit?</p> <p><i>Astronomers believe that the planets, like Earth, orbit the Sun.</i></p> <p><i>Satellites which orbit Earth are used for communications and to monitor events on Earth.</i></p> <p><i>All these bodies can remain in orbit only because of gravitational forces.</i></p>	
KS3	<p>The Earth spins on its own axis once every day (24 hours). The half of the Earth which faces the sun is in daylight; the other half of the Earth is in night.</p> <p>The Earth moves round (orbits) the Sun once each year (just over 365 days).</p>	p. 158
	<p>The stars in the night sky stay in fixed patterns (called constellations).</p>	p. 164
	<p>The planets which are visible to the naked eye look just like stars.</p> <p>They move very slowly across the constellations.</p> <p>The planets do not give out their own light. Like the Earth, they move in orbits around the Sun. We can see planets because they reflect light from the Sun.</p> <p>Where we see the planets against the background of the stars depends on exactly where they, and the Earth, are in their orbits round the Sun.</p>	p. 161
	<p>Satellites can be put into orbit around the Earth. They can be used:</p> <ul style="list-style-type: none"> • to send information between places which are a long way apart from the Earth; • to monitor conditions on Earth, including the weather; • to observe the Universe without the Earth's atmosphere getting in the way. 	p. 168-9, 162
FT & HT	<p>The orbits of the planets are slightly squashed circles (ellipses) with the Sun quite close to the centre.</p>	p. 161
	<p>Comets have orbits which are far from circular. They are very much closer to the Sun at some times than at others. This is when they can be seen.</p>	p. 163
	<p>The Earth, the Sun, the Moon and all other bodies attract each other with a force called gravity. As the distance between two bodies increases, the force of gravity between them decreases more than in proportion to the increase in distance.</p>	p. 162, 158-9, 78
	<p>A smaller body will stay in orbit around a larger one because of the combination of its high speed and the force of gravity between the bodies.</p> <p>To stay in orbit at a particular distance, smaller bodies, including planets and satellites, must move at a particular speed around larger bodies.</p> <p>The further away an orbiting body is the longer it takes to make a complete orbit.</p>	p. 162, 168
	<p>Communication satellites, including those used for television programmes, are usually put in to orbit high above the equator so that they move around the Earth at exactly the same rate as the Earth spins. This means that they are always in the same position when viewed from Earth (a geostationary orbit). There is space for about only 400 geostationary satellites or they would interfere with each other's signals.</p>	p. 169, 162, worksheet
	<p>Monitoring satellites are usually put into a low polar orbit so that the Earth spins beneath them and they can scan the whole Earth each day from much closer range than a geostationary satellite.</p>	p. 168

12.5	<p>What do we know about the origins of the Universe and the life histories of stars?</p> <p><i>Astronomers also believe that gravitational forces are responsible for the formation of galaxies of stars and for stars like the Sun having a long stable period. The speed with which other galaxies appear to be moving away from us suggests how the Universe might have begun.</i></p>	
FT & HT	<p>Our Sun is just one of many millions of stars in a group of stars called the milky way galaxy.</p> <p>The stars in a galaxy are often millions of times further away from each other than the planets in the solar system.</p> <p>The Universe as a whole is made up of at least a billion galaxies.</p> <p>Galaxies are often millions of times further apart than the stars within a galaxy.</p>	p. 165-7
	<p>Stars, including the Sun, form when enough dust and gas from space is pulled together by gravitational attraction. Smaller masses may also form and be attracted by a larger mass to become planets.</p>	p. 163
	<p>If there is, or has been, life on other planets, in our own solar system or around other stars:</p> <ul style="list-style-type: none"> • we may be able to observe living organisms (e.g. microbes), or their fossilised remains, directly, for example, by actually going to Mars or Europa (a satellite of Jupiter), by using robots to send back pictures or by using robots to collect samples to bring back to Earth; • we may be able to detect living organisms by the chemical changes they produce in a closed system (e.g. inside a closed container or in the atmosphere of their planet); Because of living organisms, the atmosphere of the Earth is very different from what it would be purely from chemical and geological processes; for example, there is much more oxygen; • we may be able to receive signals from other species with technologies that are at least as advanced as our own. <p>The search for extra-terrestrial intelligence (SETI), using radio telescopes to try to find meaningful signals in a narrow band of wavelengths (i.e. not just “noise”), has gone on for more than forty years, so far without success.</p> <p>Candidates should be able, when provided with appropriate information to evaluate:</p> <ul style="list-style-type: none"> • the methods scientists use to discover whether there is life elsewhere in the universe; • evidence that such life exists. 	p. 167

FT & HT	<p>Individual stars, including the Sun, do not stay the same forever.</p> <p>Stars are very massive so that the force of gravity which tends to draw together the matter from which they are made is very strong. The very high temperatures create forces which tend to make them expand. During the main stable period of a star, which may last for billions of years, these forces are balanced. The Sun is at this stage of its life. The star then expands to become a red giant. At a later point in its history it contracts under its own gravity to become a white dwarf. The matter from which the star is made may then be millions of times denser than any matter on Earth.</p> <p>If a red giant is massive enough, it may eventually rapidly contract and then explode (become a supernova) throwing dust and gas into space.</p> <p>The matter that is left behind may form a very dense neutron star.</p>	p. 165
HT	<p>If enough matter is left behind, this may be so dense, and its gravitational field so strong that nothing can escape from it, not even light or other forms of electromagnetic radiation. It is then called a black hole. We cannot see black holes but we can sometimes observe their effects on their surroundings, for example, the X-rays emitted when gases from a nearby star spiral into a black hole.</p> <p>During a star's lifetime, nuclei of lighter elements (mainly hydrogen and helium) gradually fuse to produce nuclei of heavier elements. These nuclear fusion reactions release the energy which is radiated by stars.</p> <p>Nuclei of the heaviest elements are present in the Sun and atoms of these elements are present in the inner planets of the solar system. This suggests that the solar system was formed from the material produced when earlier stars exploded.</p> <p>Theories of the origin of the Universe have to take into account:</p> <ul style="list-style-type: none"> • that light from other galaxies is shifted to the red end of the spectrum; • that the further away galaxies are, the bigger this 'red-shift'. <p>The current way of explaining this is:</p> <ul style="list-style-type: none"> • that other galaxies are moving away from us very quickly; • that the further away from us a galaxy is, the faster it is moving away from us. <p>This suggests that the whole Universe is expanding and that it might have started, billions of years ago, from one place with a huge explosion ('big bang').</p>	<p>p. 165, 368</p> <p>p. 164</p> <p>p. 165</p> <p>p. 166, 369, worksheets in the Teacher Support Pack</p>

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13	Module 12 – Waves and Radiation	Physics for You
	<p><i>This module includes the following:</i></p> <p><i>Comparing the behaviour of waves we can actually see (e.g. water waves) with the behaviour of light and sound. This leads to the suggestion that light and sound might also travel as waves with the same relationship between wave-speed, frequency and wavelength.</i></p> <p><i>Investigating the different types of waves in the electromagnetic spectrum in terms of their wavelengths/frequencies, properties and uses.</i></p> <p><i>Examining the properties, uses and dangers of the radiation emitted by radioactive substances.</i></p> <p><i>Explaining radioactive decay (and, for the higher tier only, nuclear fission) in terms of atomic structure.</i></p> <p><i>Extending the study of sound waves to include:</i></p> <ul style="list-style-type: none"> • <i>ultrasound and its uses;</i> • <i>what seismic waves reveal about the internal structure of the Earth.</i> 	<p>Chapters 21, 22 29, 39</p>
13.1	<p>Why do scientists talk about light and sound as waves?</p> <p><i>Water waves, and other waves that we can see, behave in the same way as light and sound. This suggests that light and sound might also travel as waves.</i></p>	
KS3	Sounds bounce back (reflect) from hard surfaces. Echoes are sound reflections.	page 230
	When a ray of light is reflected from a flat, shiny surface (plane mirror) the angle at which it leaves the surface is the same as the angle at which it meets the surface.	p. 185
	<p>Rays of light change direction (are refracted) when they cross the boundary between one transparent substance and another, unless they meet the boundary at right angles (along a normal).</p> <p>Sounds are also refracted, i.e. their direction is changed when they cross the boundary between two different substances at an angle other than a right angle.</p>	p. 192-3, 245
FT & HT	<p>Waves can be produced in ropes and springs and on the surface of water.</p> <p>When waves travel along ropes or springs or across the surface of water they set up regular patterns of disturbances:</p> <ul style="list-style-type: none"> • the maximum disturbance caused by a wave is called its amplitude; • the distance between a particular point on one disturbance and the same point on the next is called the wavelength; • the number of waves each second produced by a source (or passing a particular point) is called the frequency, and is measured in hertz (Hz). 	p. 174-5
	<p>Wave speed, wavelength and frequency are related as follows:</p> $\begin{array}{ccccccc} \text{wave speed} & = & \text{frequency} & \times & \text{wavelength} \\ \text{(metre/second, m/s)} & & \text{(hertz, Hz)} & & \text{(metre, m)} \end{array}$	p. 175

FT & HT	<p>Waves transfer energy from a source to other places without any matter being transferred.</p> <p>Waves travelling along a rope or spring, or across the surface of water, can be reflected.</p> <p>Waves travelling across the surface of water can also be refracted.</p> <p>The change in the speed of water waves when they cross the boundary between two different depths causes a change in their direction (refraction), unless the direction of travel of the waves is along a normal.</p> <p>This behaviour of waves suggest that light and sound:</p> <ul style="list-style-type: none"> • also travel as waves; • are refracted because they travel at different speeds in different substances (media). 	<p>p. 174, 176, 193</p>
	<p>When a ray of light travels from glass, Perspex or water into air, some of the light is also reflected from the boundary.</p>	<p>p. 195</p>
	<p>The waves which travel along ropes and across the surface of water are transverse waves: the disturbances in the substance through which the waves travel is at right angles to the direction in which waves themselves travel.</p>	<p>p. 174</p>
	<p>The waves which travel through springs may also be longitudinal: the disturbances in the spring are along the same direction as that in which the waves themselves travel.</p> <p>Sound waves travel through solids, liquids and gases as longitudinal waves.</p>	<p>p. 174, 229</p>
	<p>Light waves are transverse waves and can travel through a vacuum, i.e. they do not need a medium.</p>	<p>p. 179, 219</p>
	<p>When a wave moves through a gap, or past an obstacle, it spreads out from the edges. This is called diffraction.</p> <p>Electromagnetic radiation and sound are also diffracted which supports the idea that they travel as waves.</p> <p>Because of diffraction:</p> <ul style="list-style-type: none"> • sounds can sometimes be heard in the shadow of buildings; • radio signals can sometimes be received in the shadow of hills. <p>Waves having a longer wavelength are more strongly diffracted.</p>	<p>p. 177, 240</p>
13.2	<p>Is there radiation we cannot see beyond the ends of the spectrum?</p> <p><i>White light can be split up into a spectrum of different colours. There are many other types of radiation beyond the ends of the visible spectrum. Each type of radiation in this extended spectrum – known as the electromagnetic spectrum – has its own special properties and uses.</i></p>	
KS3	<p>When rays of light pass through prisms their direction may be changed.</p> <p>When white light is used, a spectrum is produced.</p> <p>The spectrum is produced because white light is made up of many different colours. Different colours of light are refracted by different amounts; red light is refracted least and violet light most.</p>	<p>p. 216-7</p>

FT & HT	<p>Light is one type of electromagnetic radiation.</p> <p>All types of electromagnetic waves travel at the same speed through space.</p> <p>The various types of electromagnetic radiation form a continuous spectrum extending far beyond each end of the visible spectrum:</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>highest frequency</p> </div> <div style="text-align: center;"> <p>gamma rays</p> <p>X-rays</p> <p>ultraviolet rays</p> <p>light</p> <p>infra red rays</p> <p>microwaves</p> <p>radio waves</p> </div> <div style="text-align: center;"> <p>shortest wavelength</p> </div> </div> <div style="display: flex; justify-content: space-around; align-items: center; margin-top: 10px;"> <div style="text-align: center;"> <p>lowest frequency</p> </div> <div style="text-align: center;"> <p>longest wavelength</p> </div> </div>	p. 218-219
	<p>Different wavelengths of electromagnetic radiation are reflected, absorbed or transmitted differently by different substances and types of surface.</p> <p>When radiation is absorbed, the energy it carries:</p> <ul style="list-style-type: none"> • makes the substance which absorbs it hotter; • may create an alternating current with the same frequency as the radiation itself. 	p. 226-7, 335
	<p>The uses and effects of different types of radiation depend on these and other properties.</p>	p. 218-219
	<p>Radio waves are used to transmit radio and TV programmes between different points on the Earth's surface. Longer wavelength radio waves are reflected from an electrically charged layer in the Earth's upper atmosphere. This enables them to be sent between distant points despite the curvature of the Earth's surface.</p>	p. 221
	<p>Microwave radiation of wavelengths which can pass easily through the Earth's atmosphere is used to send information to and from satellites, and within mobile phone networks. Microwave radiation, with wavelengths strongly absorbed by water molecules is used for cooking.</p>	p. 221, 320, 227
	<p>Infra red radiation is used in grills, toasters and radiant heaters, in optical fibre communication and for the remote control of TV sets and VCRs.</p>	p. 227, 320, 50, 270
	<p>Light is not only used for seeing but can also be sent along optical fibres, for example, in endoscopes used by doctors to see inside patients' bodies.</p>	p. 200
	<p>If the angle between the ray and a normal is greater than a certain angle (called the critical angle), all of the light is reflected inside the glass, Perspex or water. This is called total internal reflection.</p> <p>When light travels down an optical fibre, all the light may stay inside the fibre until it emerges from the other end.</p> <p>This is because light travels down optical fibres by repeated total internal reflection.</p>	p. 195, 197, 200
	<p>Candidates should be able to describe, using a suitable diagram, one other use of total internal reflection.</p>	p. 196-7

FT & HT	More information can be carried than by sending electrical signals through cables of the same diameter. There is also less weakening of the signal in optical fibres.	p. 200
	Ultraviolet radiation is used in sunbeds. Special coatings which absorb ultraviolet radiation and emit the energy as light, are used in fluorescent lamps and security coding.	p. 218, 220, 226
	X-radiation is used to produce shadow pictures of materials which X-rays do not easily pass through including bones and metals.	p. 218, 220, 226, 318
	Gamma radiation is used to: <ul style="list-style-type: none"> kill harmful bacteria in food; sterilise surgical instruments; kill cancer cells. 	p. 218, 220, 357
	Different types of radiation have different effects on living cells: <ul style="list-style-type: none"> microwaves are absorbed by the water in cells, which may be damaged or killed by the heat released; infra red radiation is absorbed by skin and is felt as heat; ultra violet radiation can pass through skin to deeper tissues. The darker the skin, the more ultra violet it absorbs and the less reaches into deeper tissues; X-radiation and gamma radiation mostly pass through soft tissues, but some is absorbed by the cells. <p>High doses of ultra violet radiation, X-radiation and gamma radiation can kill normal cells. Lower doses of these types of ionising radiation can cause normal cells to become cancerous.</p> <p>Candidates should be able, when provided with appropriate information, to evaluate:</p> <ul style="list-style-type: none"> the dangers, or possible dangers, of exposure to different types of electromagnetic radiation and to radiation from radioactive substances; measures that can be taken to reduce such exposure. 	p. 227, 220, 356, 360, worksheet
	Information such as speech or music can be converted into electrical signals so that they can be sent long distances through cables or using electromagnetic waves as carriers. Information can also be converted into light or infrared signals and sent along optical fibres.	p. 295, 335, 200, 332
	Signals which vary continuously in amplitude and/or frequency, in the same way that the sound waves of speech or music do, are called analogue signals.	p. 312, 332, worksheet
	Signals can also be coded as a series of pulses. The signal then only has two states, on or off. Signals of this type are called digital signals.	
The advantages of digital signals are: <ul style="list-style-type: none"> their higher quality – the signals do not change their information during the transmission process; their information carrying capacity – more information can be sent in a given time via a given cable, optic fibre or carrier wave than with analogue signals. 	p. 333	

HT	<p>As signals travel they become weaker. Random additions to the signal (noise) may also be picked up.</p> <p>With analogue signals, different frequencies within the signal may weaken to different extents. Each time the signal is amplified, these differences, and any noise that has been picked up, are also amplified. This means that the signal becomes less and less like the original signal; its quality deteriorates.</p> <p>With digital signals, even though pulses weaken with distance, they are still recognisable as “on” states, whereas noise is generally of low amplitude and is ignored (i.e. interpreted as “off”). The quality of a digital signal is maintained, therefore, during the transmission process.</p>	p. 333
13.3	<p>What do we know about the radiation from radioactive substances?</p> <p><i>Radioactive substances, which emit radiation all the time, are very useful but also very dangerous. It is important to understand the properties of the different types of radiation they emit.</i></p>	
FT & HT	<p>Some substances give out radiation all the time, whatever is done to them. These substances are said to be radioactive.</p> <p>There are three types of radiation emitted by radioactive sources:</p> <ul style="list-style-type: none"> • alpha (α) radiation – which is easily absorbed by a few centimetres of air or a thin sheet of paper; • beta (β) radiation – which easily passes through air or paper but is mostly absorbed by a few millimetres of metal; • gamma (γ) radiation – which is very penetrating and requires many centimetres of lead or metres of concrete to absorb most of it. <p>There are radioactive substances all around us, including in the ground, in the air, in building materials and in food. Radiation also reaches us from space. The radiation from all these sources is called background radiation.</p> <p>When radiation from radioactive materials collides with neutral atoms or molecules these may become charged (ionised).</p> <p>When radiation ionises molecules in living cells it can cause damage, including cancer. The larger the dose of radiation the greater the risk of cancer.</p> <p>Higher doses of radiation can kill cells; they are used to kill cancer cells and harmful microorganisms.</p> <p>As radiation passes through a material it can be absorbed. The greater the thickness of a material the greater the absorption. The absorption of radiation can be used to monitor/control the thickness of materials.</p> <p>When sources of radiation are outside the body:</p> <ul style="list-style-type: none"> • beta and gamma radiation are the most dangerous because they can reach the cells or organs and may be absorbed by them; • alpha radiation is least dangerous because it is unlikely to reach living cells. <p>Workers who are at risk from radiation often wear a radiation badge to monitor the amount of radiation they have been exposed to over a period of time. This is a small packet containing photographic film.</p> <p>The more radiation a worker has been exposed to, the darker the photographic film is when it has been developed.</p>	<p>p. 350-1</p> <p>p. 360</p> <p>p. 348</p> <p>p. 356, 357</p> <p>p. 351, 357</p> <p>p. 356, 360</p> <p>p. 360</p>

FT & HT	When sources of radiation are inside the body: <ul style="list-style-type: none"> • alpha radiation is the most dangerous because it is so strongly absorbed by cells; • beta and gamma radiation are less dangerous because cells are less likely to absorb the radiation. 	p. 356											
	The half-life of a radioactive substance: <ul style="list-style-type: none"> • is the time it takes for the number of parent atoms in a sample to halve; • is the time it takes for the count rate from the original substance to fall to half its initial level. 	p. 354											
HT	Candidates should be able to evaluate the appropriateness of radioactive sources for particular uses including as tracers, in terms of: <ul style="list-style-type: none"> • the type(s) of radiation emitted; • their half-lives. 	p. 356-7, 362											
13.4	What happens to radioactive substances when they decay or are used in nuclear reactors? <i>To understand what happens to radioactive substances when they decay, or when we use them in nuclear reactors, we need to understand the structure of the atoms from which they are made.</i>												
FT & HT	Radioactivity occurs as a result of changes in the nuclei of atoms (nuclear changes). Atoms have a small central nucleus made up of protons and neutrons around which there are electrons.	p. 352-3, 355											
	Candidates should be able , when provided with appropriate information, to: <ul style="list-style-type: none"> • explain how the Rutherford and Marsden scattering experiment led to the current model of the atom replacing the earlier “plum pudding” model; • suggest why the new model very quickly became widely accepted. 	p. 352, 368 worksheets											
	The relative masses of protons, neutrons and electrons and their relative electric charges are as shown: <table style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th></th> <th><u>Mass</u></th> <th><u>Charge</u></th> </tr> </thead> <tbody> <tr> <td>Proton</td> <td>1</td> <td>+1</td> </tr> <tr> <td>Neutron</td> <td>1</td> <td>0</td> </tr> <tr> <td>Electron</td> <td>negligible</td> <td>-1</td> </tr> </tbody> </table> <p>In an atom, the number of electrons is equal to the number of protons in the nucleus. The atom as a whole has no electrical charge.</p> <p>All atoms of a particular element have the same number of protons.</p> <p>Atoms of different elements have different numbers of protons. The total number of protons and neutrons (nucleons) in an atom is called its mass (nucleon) number.</p> <p>Atoms of the same element which have different numbers of neutrons are called isotopes.</p>		<u>Mass</u>	<u>Charge</u>	Proton	1	+1	Neutron	1	0	Electron	negligible	-1
	<u>Mass</u>	<u>Charge</u>											
Proton	1	+1											
Neutron	1	0											
Electron	negligible	-1											

FT & HT	Radioactive isotopes (radioisotopes or radionuclides) are atoms with unstable nuclei. When an unstable nucleus splits up (disintegrates): <ul style="list-style-type: none"> • it emits radiation; • a different atom, with a different number of protons, is formed. 	p. 355
	The older a particular radioactive material, the less radiation it emits.	p. 354
	This idea can be used to date materials, including rocks.	p. 357
HT	Alpha radiation consists of helium nuclei, particles made up of two protons and two neutrons.	p. 350-1, 355
	Beta radiation consists of high-energy electrons emitted from the nuclei of atoms. For each electron emitted, a neutron in the nucleus becomes a proton.	p. 350-1, 355
	Gamma radiation is very short wavelength electromagnetic radiation.	p. 218
	Nuclear reactors use a process called nuclear fission. When an atom with a very large nucleus is bombarded with neutrons: <ul style="list-style-type: none"> • The nucleus splits into two smaller nuclei; • Further neutrons are released which may cause further nuclear fission resulting in a chain reaction; • The new atoms which are formed are themselves radioactive. <p><i>[Details of nuclear reactors are not required].</i></p> <p>The energy released by an atom during radioactive disintegration or nuclear fission is very large compared to the energy released when a chemical bond is made between two atoms.</p>	p. 358
	During one half-life, half of the radioactive atoms initially present in a sample decay. This idea can be used to date materials.	p. 354, 362
	Uranium isotopes, which have a very long half-life, decay via a series of relatively short-lived radioisotopes to produce stable isotopes of lead. The relative proportions of uranium and lead isotopes in a sample of igneous rock can, therefore, be used to date the rock.	
	The proportions of the radioisotope potassium-40 and its stable decay product argon can also be used to date igneous rocks from which the gaseous argon has been unable to escape.	
	Candidates should be able to make such calculations when provided with appropriate data.	
13.5	What is ultrasound and how can it be used?	
	Just as there is electromagnetic radiation with frequencies we cannot see, there are “sound” waves with frequencies we cannot hear. These ultrasounds have several important uses.	
KS3	Sounds are produced when objects vibrate.	p. 228
	The greater the size (amplitude) of vibrations the louder the sound.	p. 234
	The number of complete vibrations each second is called the frequency (hertz, Hz). The higher the frequency of a sound the higher its pitch.	p. 234

FT & HT	<p>Candidates should be able to compare the amplitudes and frequencies of sounds from diagrams of oscilloscope traces.</p>	p. 234-5
	<p>Electronic systems can be used to produce electrical oscillations with any frequency. These electrical oscillations can be used to produce ultrasonic waves which have a frequency higher than the upper limit of the hearing range for humans.</p> <p>Ultrasonic waves can be used:</p> <ul style="list-style-type: none"> • in industry for cleaning and quality control; • in medicine for pre-natal scanning. 	p. 230, 240-1
HT	<p>Ultrasonic waves are partly reflected when they meet a boundary between two different media. The time taken for the reflections of ultrasonic pulses to reach a detector (usually placed near to the source) is a measure of how far away such a boundary is. This idea is used in industry to detect flaws in metal castings and in medicine for pre-natal scans. Information about the time taken for reflections to travel is usually processed to produce a visual display.</p> <p>Ultrasonic waves in liquids can also be used for cleaning delicate mechanisms without having to disassemble them.</p>	p. 240-1
13.6	<p>What do the shock waves from Earthquakes tell us about the Earth?</p> <p><i>By studying the shock waves from earthquakes scientists have learnt a great deal about the internal structure of the Earth.</i></p>	
FT & HT	<p>Our knowledge of the structure of the Earth comes mainly from studying how the shockwaves from earthquakes (seismic waves) travel through it. These waves are detected using seismographs.</p>	p. 154
HT	<p>Earthquakes produce surface waves that can cause earthquake damage and two types of waves that can travel through the Earth.</p> <ul style="list-style-type: none"> • Faster travelling P waves, which are longitudinal and travel through liquids as well as solids; • Slower travelling S waves, which are transverse and travel only through solids. <p>The speed of both types of wave increases with depth through the mantle. The waves travel in curved paths as their speed changes gradually through a material. When the state of the transmitting medium changes abruptly, e.g. when moving from solid to liquid, the wave direction also changes abruptly.</p> <p>It is by observing the path of these waves that scientists have been able to work out details of the Earth's layered structure.</p> <p>Candidates should be able to interpret diagrams of the paths of seismic waves inside the Earth in terms of:</p> <ul style="list-style-type: none"> • the liquid nature of the Earth's outer core; • refraction at the boundaries between layers; • refraction due to changes in speed within a particular layer. 	p. 154-5

page numbers in **Physics for You**

14	Module 23 – Physics in Action	Page Numbers
	<p><i>Physics, like other sciences, doesn't only help us to <u>understand</u> the world better, but also enables us to <u>do</u> things such as making electronic control circuits and optical devices.</i></p> <p><i>This module includes the following:</i></p> <ul style="list-style-type: none"> • <i>interpreting the behaviour of control circuits represented in the form of input block circuit diagrams of the form : sensor ➔ processor ➔ output device;</i> • <i>representing the behaviour of logic gates by means of truth tables;</i> • <i>explaining the operation of a potential divider and its use in input sensors;</i> • <i>investigating the charging and discharging of capacitors (and, for Higher Tier, exploring their use in electronic circuits);</i> • <i>comparing the behaviour of converging and diverging lenses;</i> <p><i>and for Higher Tier students,</i></p> <ul style="list-style-type: none"> • <i>explaining the behaviour of a light dependent switch in terms of the components shown using symbols in a standard circuit diagram;</i> • <i>considering the advantages and disadvantages of electronic control systems;</i> • <i>using ray diagrams to explain the image formation of real and virtual images by a converging lens.</i> 	Chapters 38, 31, 26
	Electronic control circuits	
14.1	<p>What are the basic parts of any electronic control circuit?</p> <p><i>We often control electric circuits manually. For example, when it is dark we use a switch to turn on the electric currents to a lamp. Electronic control systems can switch devices on or off automatically.</i></p>	
KS3	<p>When a switch is closed (on) a current can flow through it.</p> <p>When a switch is open (off) a current cannot flow through it.</p> <p>Switches control devices in simple circuits.</p>	page 254
FT & HT	<p>The flow of electricity through a circuit (the current) can be controlled by using a fixed or a variable resistor.</p> <p>Candidates should be able to use (but will not be expected to recall) the resistor colour code.</p>	p. 261, worksheet in Support Pack
	<p>Electronic systems have:</p> <ul style="list-style-type: none"> • input sensors which detect changes in the environment; • a processor which decides what action is needed; • an output device which is controlled by the processor. 	p. 327

FT & HT	<p>A relay can be used as a switch. A small current from the electronic system flows through the coil of the relay. This then switches on a larger current through the output device.</p> <p>Candidates should be able to recall the following symbol: <i>[insert symbol of relay (normally open)]</i></p>	p. 326-7
	<p>Input sensors include:</p> <ul style="list-style-type: none"> • thermistors which detect changes in temperature; • LDRs which detect changes in light; • switches which respond to pressure, tilt, magnetic fields or moisture. 	p. 325-6, 328
	<p>Output devices include:</p> <ul style="list-style-type: none"> • lamps and LEDs which produce light; <p>Candidates should be able to recall the symbol for an LED.</p> <ul style="list-style-type: none"> • buzzers which produce sound; • motors which produce movement; • heaters which produce heat. 	p. 324
	<p>Processors can be made using logic gates</p> <ul style="list-style-type: none"> • for the output of an AND gate to be on, the first input <u>AND</u> the second input must both be on; • for the output of an OR gate to be one, the first input <u>OR</u> the second input, <u>OR</u> both, must be on; <p>For the output of a NOT gate to be on, the input must <u>NOT</u> be on.</p>	p. 336-7
	<p>Candidates should be able, when presented with a block diagram of a simple electronic system, to describe:</p> <ul style="list-style-type: none"> • what each part of the system does; • what the system does. 	p. 327-331

continued

<p>14.2</p>	<p>What's the most useful way of showing the inputs and outputs of logic gates?</p> <p><i>To produce a processor that behaves in the way that we want it to, we often have to use a combination of several logic gates. We need a way of showing the input(s) and output(s) of each gate that makes it easy to work out how a combinations of gates will behave.</i></p>																																					
<p>FT & HT</p>	<p>The way logic gates behave can be shown in truth tables: Inputs / outputs can be ON (high or 1) or OFF (low or 0).</p> <p>AND gate</p> <table border="1" data-bbox="480 517 1177 748"> <thead> <tr> <th>First input</th> <th>Second input</th> <th>Output</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>0</td></tr> <tr><td>1</td><td>1</td><td>1</td></tr> </tbody> </table> <p>OR gate</p> <table border="1" data-bbox="480 808 1177 1039"> <thead> <tr> <th>First input</th> <th>Second input</th> <th>Output</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>1</td></tr> </tbody> </table> <p>NOT gate</p> <table border="1" data-bbox="480 1095 946 1249"> <thead> <tr> <th>First input</th> <th>Output</th> </tr> </thead> <tbody> <tr><td>0</td><td>1</td></tr> <tr><td>1</td><td>0</td></tr> </tbody> </table>	First input	Second input	Output	0	0	0	1	0	0	0	1	0	1	1	1	First input	Second input	Output	0	0	0	1	0	1	0	1	1	1	1	1	First input	Output	0	1	1	0	<p>p. 336-7</p>
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	<p>Candidates should be able to use truth tables to determine the output of a combination of not more than 3 gates.</p> <p>Candidates should be able to use truth tables to represent appropriate problems stated in words (limited to 3 separate inputs).</p> <p>Candidates should be able to recall the symbols for AND gate, OR gate, NOT gate <i>[insert 3 symbols]</i></p>	<p>p. 338</p>																																				

continued

<p>14.3</p>	<p>How is an input sensor used to control the input to a processor?</p> <p><i>For use in an electronic control system, an input sensor must provide the correct input to the processor depending on how it is being affected by its surroundings. To make the sensor do this we use it as part of a circuit called a potential divider.</i></p>	
<p>FT & HT</p>	<p>So that it can provide the correct input to the processor in an electronic circuit, an input sensor is used as one of the resistors in a potential divider circuit and a variable resistor is used as the other resistor.</p> <p>The voltage that is supplied to the potential divider (V_{in}) is shared across the two resistors. If either resistance is increased (or reduced), the share of the voltage across it also increases (or reduces).</p> <p><i>[insert diagram of potential divider]</i></p> <p>V_{out} is fed to the processor.</p> <p>Changes in the surroundings change the resistance of the input sensor. This changes the value of V_{out}. If V_{out} changes enough, the input to the processor will change from being high to being low (or vice versa).</p> <p>You can adjust the variable resistor so the V_{out} changes from high to low when the surroundings that the input sensor detects are at a particular level.</p> <p>Candidates should be able to use the potential divider equation as applied to the circuit shown:</p> $V_{out} = V_{in} \times \frac{(R_2)}{(R_1 + R_2)}$	<p>p. 264, 339</p>

continued

<p>14.4</p>	<p>How can we work out what an electronic system does from a symbol circuit diagram?</p> <p><i>To be able to make actual electronic control circuits and to explain in detail how they work, you need to know what each of the components in the full circuit diagram is doing.</i></p>	
<p>HT</p>	<p>The circuit shown can be used as a light dependent switch.</p> <p><i>[insert diagram of light-sensor circuit with a transistor driving a relay]</i></p> <p>Candidates are not expected to know the operation of the transistor but should know that a transistor acts as a switch.</p> <p>To protect the transistor when the relay is switched off, a reverse-biased diode is placed across the relay.</p> <p>Candidates should be able, when provided with the above circuit, to:</p> <ul style="list-style-type: none"> • explain how the LDR supplies the required input to the gate; • explain how different light intensities affect the output device; • explain how to modify it to do a different job; • draw a modified circuit diagram. 	<p>p. 339 (expt 38.28)</p>
	<p>Candidates should be able to recall the symbol for an LDR:</p> <p><i>[insert symbol of LDR]</i></p>	<p>p. 325</p>
<p>14.5</p>	<p>How can a timer be added to an electronic control circuit?</p> <p><i>Sometimes you want a circuit to have a time delay, for example so that a device stays on for a few minutes after the input sensor has sent the signal for switching it off. A capacitor can be used to cause such a delay.</i></p>	
<p>FT & HT</p>	<p>When a current flows into an uncharged capacitor, charge is stored and the p.d. across the capacitor increases.</p> <p>When a conductor is connected across a charged capacitor a current flows from the capacitor and the p.d. across the capacitor decreases.</p> <p>The greater the resistance of the charging / discharging circuit and the greater the value of the capacitor, the longer it takes for the capacitor to charge / discharge.</p> <p>Candidates should be able to recall the symbol for a capacitor:</p> <p><i>[insert symbol of capacitor]</i></p> <p>Capacitors can be used as simple timers in electronic circuits.</p>	<p>p. 251, 331</p>
<p>HT</p>	<p>Candidates should be able to explain how a capacitor can be used as an ‘input sensor’ for a time delay switch.</p>	<p>p. 331</p>

14.6	<p>What are the advantages and disadvantages of using electronic systems?</p> <p><i>As with any other technology, using electronic systems has some advantages and some disadvantages.</i></p>	
HT	<p>Candidates should be able to compare and contrast the advantages and disadvantages of advances in electronic systems. In doing so, candidates should be aware of examples of the following kinds:</p> <ul style="list-style-type: none"> • The benefits for security of CCTV and the drawback involved in its potential for the invasion of privacy; • The benefits for working practices in the development of mobile phone technology and the drawbacks in terms of the potential for intrusion and health hazards; • The benefits of the Internet in terms of its educative value and the drawbacks of allowing unsuitable material to be transmitted to children. 	Worksheet in the Teacher Support Pack
Optical devices		
14.7	<p>What do lenses do to light?</p> <p><i>Lenses can be used to form image in optical devices such as cameras.</i> <i>There are basically two different types of lens which affect a parallel beam of light in different ways.</i></p>	
FT & HT	<p>There are converging and diverging lenses.</p> <p>Candidates should be able to:</p> <ul style="list-style-type: none"> • identify the difference between converging and diverging lenses; • draw how parallel rays of light pass through these lenses; • identify the position of the focus of both a converging and diverging lens; • know the difference between a real and a virtual image. 	p. 202-3
	<p>In a camera, a converging lens is used to produce an image of an object on a film. The image is smaller than the object and nearer to the lens.</p>	p. 206
HT	<p>Candidates should be able to:</p> <ul style="list-style-type: none"> • construct ray diagrams to show the formation of real images by converging lenses; • construct ray diagrams to show the formation of virtual images by converging lenses; • explain the use of a converging lens as a magnifying glass, and in a camera. 	p. 204

page numbers in **Physics for You**

15	Module 24 – Forces and Motion	Page Numbers
	<p><i>This module includes the following:</i></p> <ul style="list-style-type: none"> • <i>appreciating what causes turning forces and what factors affect how big turning forces are;</i> • <i>explaining the position that a suspended object comes to rest in terms of turning forces;</i> • <i>explaining what must happen for an object standing on a surface to fall over (higher tier only);</i> • <i>understanding the force that is needed to keep an object moving in a circular path;</i> • <i>calculating the momentum of a moving object and (for higher tier only) using the idea of momentum to explain what happens in explosions and collisions;</i> • <i>considering the Earth’s internal structure and the evidence that Earth’s crust consists of tectonic plates that are constantly moving;</i> • <i>examining what happens at the boundaries between tectonic plates because they are moving.</i> 	Chapters 15, 19, 20
15.1	<p>How do forces have a turning effect?</p> <p><i>Even if the forces acting on an object are balanced in the sense that they do not cause the object to speed up, slow down or change direction they can still make the object turn.</i></p>	
KS3	<p>The weight of a pivoted object can have a turning effect. If the pivot passes through its centre of mass, the object does not turn, clockwise or anticlockwise.</p> <p>If a force is applied at a distance from the pivot it has a turning effect (moment).</p> <p>A force has a greater turning effect (moment):</p> <ul style="list-style-type: none"> • the greater the size of the force; • the greater the perpendicular distance between the line of action of the force and the pivot. 	p. 100
FT & HT	<p>How big a turning effect a force has (its moment) can be calculated as shown:</p> $\text{moment} = \text{force} \times \text{perpendicular distance between line of action and pivot}$ <p>(newton metre, Nm) (newton, N) (metre, m)</p>	p. 100

15.2	When do things stop turning? <i>We can use the idea of turning forces to explain the position that a suspended object comes to rest. We can also use the idea of turning forces to explain what must happen for an object standing on a surface to fall over.</i>	
FT & HT	The centre of mass of an object is the point through which its weight acts. If suspended, an object will come to rest with its centre of mass directly below the point of suspension. The weight of the object does not then exert any turning force (moment) on the object. The centre of mass of a symmetrical object is along the axis of symmetry. Candidates should be able to describe how to find the centre of mass of a thin sheet of material.	p. 102-3
HT	If an object is not turning, the total moments of forces tending to turn it in the clockwise direction must be exactly balanced by the total moments of forces tending to turn it in the anticlockwise direction. Candidates should be able to use the law of moments to calculate the size of a force or its distance from the pivot, when an object is balanced under the turning effects of: <ul style="list-style-type: none"> • two forces (for an object with a pivot through its centre of mass); • the weight of the object and one other force (for an object with a pivot not passing through its centre of mass). 	p. 101
	If the line of action of the weight of an object lies outside the base of the object, a turning effect will result and the object will tend to fall over. Candidates should be able to apply this idea to the stability of objects.	p. 103-5
15.3	What keeps objects moving in a circle? <i>Unless an unbalanced force is acting on them, objects remain stationary or keep moving at the same speed in a straight line. If an object, for example a satellite, moves in a circular path there must be a force acting on it all the time.</i>	
FT & HT	When an object moves in a circle at a steady speed, the direction of its motion is constantly changing. A force towards the centre of the circle (a centripetal force) is needed to produce this constant change in velocity. The centripetal force needed is greater: <ul style="list-style-type: none"> • the greater the mass of the object; • the greater the speed of the object; • the smaller the radius of the circle. Candidates should be able to explain how forces applied at a distance e.g. electrostatic forces in atoms and gravitational forces between astronomical bodies, can sustain motion in a circle and interpret data on objects moving in circular (or near circular) paths.	p. 78, 142, 158, 162, 168

15.4	<p>What is momentum?</p> <p><i>The faster an object is moving the more kinetic energy it has. But it also has momentum. When working out what happens to objects as a result of explosions or collisions it is more useful to think in terms of momentum than in terms of energy.</i></p>	
FT & HT	<p>The greater the mass of an object and the greater its speed in a particular direction (its velocity), the more momentum the object has in that direction. Momentum has both magnitude (size) and direction.</p> <p>Momentum, mass and velocity are related as shown:</p> $\text{momentum} = \text{mass} \times \text{velocity}$ <p>(kilogram metre/second, kg m/s) (kilogram, kg) (metre/second, m/s)</p>	p. 144
HT	<p>When an object collides with another the two objects exert a force on each other. These forces are equal in size but opposite in direction.</p> <p>Each object suffers a change in momentum which is equal in size but opposite in direction.</p> <p>When a force acts on a moving object a change in momentum occurs.</p> <p>The force, change in momentum and the time taken for the change are related as shown:</p> $\text{force} = \frac{\text{change in momentum (kilogram metre/second, kg m/s)}}{\text{time (second, s)}}$ <p>(newton, N)</p>	p. 144-5, 94
	<p>In any collision / explosion, the momentum after the collision / explosion in a particular direction is the same as the momentum in that direction before the collision / explosion. Momentum is conserved when no forces act.</p> <p>When objects collide, the total kinetic energy after the collision in a particular direction is normally less than before the collision.</p> <p>Elastic collisions are those involving no overall change in kinetic energy.</p> <p>Candidates should be able to use the conservation of momentum (in one dimension) to calculate the mass, speed or momentum of an object involved in an explosion or collision.</p>	p. 145-6
15.5	<p>How do we know that the Earth's crust is moving?</p> <p><i>Although we can't see it, scientists think that pieces of the Earth's crust are slowly moving all the time. Earthquakes and volcanoes occur at the boundaries between the moving pieces.</i></p>	
FT & HT	<p>The Earth is nearly spherical and has a layered structure comprising:</p> <ul style="list-style-type: none"> • a thin crust; • a mantle extending almost halfway to the Earth's centre, which has all the properties of a solid except that it can flow very slowly; • a core, with just over half of the Earth's radius, made of nickel and iron, the outer part of which is liquid and the inner part of which is solid. <p>The overall density of the Earth is much greater than the mean densities of the rocks which form the crust. This indicates that the interior of the Earth is made of material different from, and denser than, that of the crust.</p>	p. 154

	<p>The edges of land masses (continents) which are separated by thousands of kilometres of ocean (e.g. the east coast of South America and the west coast of Africa):</p> <ul style="list-style-type: none"> • have shapes which fit quite closely; • have similar patterns of rocks and fossils. <p>This suggests that they were once part of a single land mass which has split and been moved apart.</p> <p>The Earth's lithosphere (the crust and the upper part of the mantle) is cracked into a number of large pieces (tectonic plates) which are constantly moving at relative speeds of a few centimetres per year as a result of convection currents within the Earth's mantle driven by heat released by natural radioactive processes.</p> <p>Earthquakes and / or volcanic eruptions occur at the boundaries between tectonic plates.</p> <p>Candidates should be able, when provided with information about the complex probable causes of earthquakes and volcanic eruptions and the difficulty of making measurements of many of the factors involved, to explain why scientists cannot yet accurately predict when they will occur.</p> <p>At one time it was believed that the major features of the Earth's surface were the result of the shrinking of the crust as the Earth cooled down following its formation.</p>	p. 156
	<p>Candidates should be able, when provided with appropriate additional information, to explain why Wegener's theory of crustal movement (continental drift) was not generally accepted until more than 50 years after it was proposed.</p>	p. 156, 369
HT	<p>Tectonic plates:</p> <ul style="list-style-type: none"> • may slide past each other. This is happening along the Californian coast giving rise to earthquakes; • may move towards each other. As this happens, a thinner, denser oceanic plate can be drive down (subducted) beneath a thicker granitic continental plate where it partially melts. The continental crust is compressed, causing folding, faulting and metamorphism. Earthquakes are produced and magma may rise through the continental crust to form volcanoes. This is happening along the western side of South America (the Andes); • may move away from each other. This causes fractures which are filled by magma producing new, basaltic, oceanic crust. This is known as sea floor spreading and is happening along oceanic ridges, including the mid-Atlantic ridge. The iron-rich minerals in the magma record the direction of the Earth's magnetic field at the time when the rising magma solidified. Magnetic reversal patterns in oceanic crust occur in stripes parallel to oceanic ridges, matching the period reversals of the Earth's magnetic field and so supporting the concept of sea floor spreading. 	p. 156-7

End of syllabus content