AQA : GCSE specification 3451

Physics B (Coordinated)

Please ensure that you have selected the correct specification.

10 – Physical Processes

Electricity	1. Potential Difference in Circuits, 2. Energy in Circuits, 3. Mains Electricity, 4. The Cost of Using Electrical Appliances, 5. Electric Charge, 6. Control in Circuits*.
Forces and Motion	7. Representing and Measuring Motion, 8. Forces and Acceleration, 9. Frictional Forces and Non-Uniform Motion, 10. Moments and Centre of Mass*, 11. Momentum*, 12. Circular Motion*.
Waves	13. Characteristics of Waves, 14. The Electromagnetic Spectrum, 15. Optical Devices*, 16. Sound and Ultrasound, 17. Seismic Waves, 18. Tectonics.
The Earth and Beyond	19. The Solar System, 20. The Universe.
Energy Resources and Energy Transfer	21. Thermal Energy Transfer, 22. Efficiency, 23. Energy Resources, 24. Work, Power and Energy, 25. Electromagnetic Forces, 26. Electromagnetic Induction.
Radioactivity	27. Types, Properties and Uses of Radioactivity, 28. Atomic Structure and Nuclear Fission.

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.

Electricity		page numbers in **Physics for You**
10.1	**Potential Difference in Circuits**	
KS3	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 different across a component, the bigger the current that flows through it. 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. The p.d. across a component in a circuit is measured in volts (V) using a voltmeter connected across the component. The current flowing through a component in a circuit is measured in amperes (A) using an ammeter connected in series with the component.	p. 254 - 261
FT & HT	Current-voltage graphs are used to show how the current through a component varies with the voltage across it. *[insert 3 current-voltage graphs, for: resistor, filament lamp and diode]*	p. 265, worksheets
	When components are connected in series: • 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: • There is the same potential difference across each component; • The current through each component depends on its resistance; the greater the resistance of the component, 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. *[insert symbols of: switch, lamp, cell, battery, ammeter, voltmeter, resistor, variable resistor, fuse, diode, thermistor, L.D.R.]*	p. 254

FT & HT	Potential difference, current and resistance are related as shown: Potential difference = current × resistance (volt, V) (ampere, A) (ohm, Ω) The current through a resistor (at constant temperature) is proportional to the voltage across the resistor. The resistance of a filament lamp increased as the temperature of the filament increases. The current through a diode flows in one direction only. The diode has a very high resistance in the reverse direction. The resistance of a light dependent resistor decreases as the light intensity increases. The resistance of a thermistor decreases as the temperature increases. *[i.e. knowledge of negative temperature coefficient thermistors only is required.]*	p. 259, 265, 322 p. 325, 265
10.2 Energy in Circuits		
KS3	As an electric current flows through a circuit, energy is transferred from the battery or power supply to the components in the electrical circuit.	p. 112, 270
FT & HT	An electric current is a flow of charge. When electrical charge flows through a resistor, electrical energy is transferred as heat. The rate of energy transfer (power) is given by: power = potential difference × current (watt, W) (volt, V) (ampere, A) 1 watt is the transfer of 1J of energy in 1s.	p. 255, 267 p. 270 p. 272 p. 118, 272
HT	The higher the voltage of a supply, the greater the amount of energy transferred for a given amount of charge which flows. energy transferred = potential difference × charge (joule, J) (volt, V) (coulomb, C) 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. 266-7

10.3 Mains Electricity

FT & HT	The UK mains supply is about 230 volts. Mains electricity can kill if it is not used safely. Most electrical appliances are connected to the mains using cable and a 3-pin plug. To make them safe to use: cable comprises: • two or three inner cores of copper, because copper is a good conductor; • outer layers of flexible plastic, because plastic is a good insulator. a plug has: • 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. 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. When connecting an appliance to a 3-pin plug: • 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. **Candidates should be able**, when provided with appropriate diagrams: • To recognise errors in the wiring of a mains (3-pin) plug; • To recognise dangerous practice in the use of mains electricity.	p. 274-5
	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
	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. The fuse should have a value higher than, but as close as possible to, the current through the appliance when it is working normally. 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. 275
	Candidates should be able to, when provided with appropriate information explain how a circuit breaker works.	p. 270, 312, 345, worksheet
	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
10.4 The Cost of Using Electrical Appliances		
FT & HT	Much of the energy translated in homes and industry is electrical energy. This is because electrical energy is readily transferred as: • Heat (thermal energy); • Light; • Sound; • Movement (kinetic energy). **Candidates should be able**: • 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. How much electrical energy an appliance transfers depends on: • How long the appliance is switched on; • How fast the appliance transfers energy (its power). The power of an appliance is measured in watts (W) or kilowatts (1kW = 1000W). The amount of energy transferred from the mains is measured in kilowatt-hours, called Units. energy transferred = power × time (kilowatt hour, kWh) (kilowatt,kW) (hour, h) **Candidates should be able**, when provided with suitable diagrams of a digital domestic electricity meter, to calculate the number of Units used. The cost of this energy can be calculated using: total cost = number of Units × cost per Unit The total amount of energy, in joules, transferred by an electrical device can be calculated as follows: energy transferred = power × time (joule, J) (watt, W) (second, s)	p. 9-10, 112, 270 p. 272-3, 119 p. 119, 273

<table>
<tr><th>10.5</th><th colspan="2">Electrical Charge</th></tr>
<tr><td rowspan="10">FT & HT</td><td>When certain different insulating materials are rubbed against each other they become electrically charged. Electrically charged objects attract small objects placed near to them.</td><td>p. 247-8</td></tr>
<tr><td>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).</td><td></td></tr>
<tr><td>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.</td><td></td></tr>
<tr><td>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.</td><td></td></tr>
<tr><td>Electrostatic charges can be useful in everyday life.</td><td></td></tr>
<tr><td>For example, in a photocopier:
A copying plate is electrically charged;
An image of the page you want to copy is projected on to the plate;
Where light falls on the plate, the electrical charge leaks 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</td><td>p. 252, 321, worksheet</td></tr>
<tr><td>When printing with an inkjet printer:
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.</td><td>p. 321, worksheet</td></tr>
<tr><td>A charged conductor can be discharged by connecting it to earth with a conductor.

Candidates should be able, when provided with 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.</td><td>p. 249 – 252</td></tr>
<tr><td>In solid conductors, an electric current is a flow of electrons.</td><td>p. 255</td></tr>
<tr><td>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.</td><td>p. 277</td></tr>
</table>

HT	The greater the charge on an isolated object, the greater the voltage (potential difference) between the 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. Metals are good conductors of electricity because some of the electrons from their atoms can move freely throughout the metal structure. During electrolysis the mass and / or volume of the substance deposited or released at the electrode increases in proportion to: • The current; • The time for which the current flows.	p. 251 p. 255 p. 278

continued . . .

10.6	Control in circuits	
FT & HT	When a switch is closed (on) a current can flow through it. When a switch is open (off) a current cannot flow through it. **Candidates should be able**, when presented with simple circuit diagrams involving switches, to show an understanding of the way switches control devices in the circuit.	p. 254
	A relay can be used as a switch. A small current in the relay coil can switch on a circuit in which larger current flows.	p. 326-7
	The flow of electricity through a circuit (the current) can be controlled by using a fixed or a variable resistor. **Candidates should be able** to use (but will not be expected to recall) the resistor colour code.	p. 261, worksheet in Support Pack
	Electronic systems have: • 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
	Input sensors include: • 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
	Output devices include: • lamps and LEDs which produce light; • buzzers which produce sound; • motors which produce movement; • heaters which produce heat.	p. 324
	Processors can be made using logic gates • 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; For the output of a NOT gate to be on, the input must <u>NOT</u> be on.	p. 336-7
	Candidates should be able, when presented with a block diagram of a simple electronic system, to describe: • what each part of the system does; • what the system does.	p. 327-331

FT & HT	The way logic gates behave can be shown in truth tables: Inputs / outputs can be ON (high or 1) or OFF (low or 0). AND gate	p. 336-7

AND gate

First input	Second input	Output
0	0	0
1	0	0
0	1	0
1	1	1

OR gate

First input	Second input	Output
0	0	0
1	0	1
0	1	1
1	1	1

NOT gate

First input	Output
0	1
1	0

Candidates should be able to use truth tables to determine the output of a combination of not more than 3 gates.

Candidates should be able to use truth tables to represent appropriate problems stated in words (limited to 3 separate inputs).

p. 338

Candidates should be able to recall the symbols for

AND gate, OR gate, NOT gate

capacitor, LED, relay (normally open)

[insert symbols]

p. 338, 251, 331, 327

A potential divider is used to provide a required voltage.

[insert diagram of potential divider]

p. 264, 339

Candidates should be able to use the potential divider equation as applied to the circuit:

$$V_{out} = V_{in} \times \frac{(R_2)}{(R_1 + R_2)}$$

FT & HT	When a current flows into an uncharged capacitor, charge is stored and the p.d. across the capacitor increases. When a conductor is connected across a charged capacitor a current flows from the capacitor and the p.d. across the capacitor decreases. 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. 251, 331
HT	Capacitors can be used as simple timers in electronic circuits. **Candidates should be able** to explain how a capacitor can be used as an 'input sensor' for a time delay switch.	p. 331
	The circuit shown can be used as a light dependent switch. *[insert diagram of light-sensor circuit with a transistor driving a relay]* Candidates are **not** expected to know the operation of the transistor but should know that a transistor acts as a switch. To protect the transistor when the relay is switched off, a reverse-biased diode is placed across the relay. **Candidates should be able,** when provided with the above circuit, to: • 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. 339 (expt 38.28)
	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: • 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

10.7	**Representing and Measuring Motion**	
KS3	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: speed (metre/second, m/s) $= \dfrac{\text{distance travelled (metre, m)}}{\text{time taken (second, s)}}$	p. 130
FT & HT	If an object moves in a straight line, how far it is from a certain point can be represented by a **distance-time graph**. **Candidates should be able** to construct and recognise the shape of a distance-time graph when a body is: • Stationary; • Moving with a steady speed. The steeper the slope of the graph, the greater the speed it represents.	p. 134
	The velocity of an object is its speed in a given direction. **Velocity-time graphs** can represent the motion of a body. **Candidates should be able** to recognise the shape of the velocity-time graph when a body is moving with: • Constant velocity; • Constant acceleration. The steeper the slope of the graph, the greater the acceleration it represents. The acceleration of an object is the rate at which its velocity changes. 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: acceleration (metre/second squared, m/s^2) $= \dfrac{\text{change in velocity (metre/second m/s)}}{\text{time taken for change (second, s)}}$	p. 130-3
HT	**Candidates should be able** to calculate the gradient of a distance-time graph.	p. 134, 380
	The gradient of a velocity-time graph represents acceleration. The area under a velocity-time graph represents the distance travelled. **Candidates should be able** to calculate: • The gradient of a velocity-time graph and interpret this as acceleration; • The area under a velocity-time graph; for an object moving with constant acceleration.	p. 132-3

10.8	Forces and Acceleration	
KS3	The forces acting on an object may cancel each other out (balance). When an object rests on a surface: • 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. 95
FT & HT	Whenever two bodies interact, the forces they exert on each other are equal and opposite. 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. 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: • 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 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. 94-5 p. 77 p. 96, 138
HT	One newton is the force needed to give a mass of one kilogram an acceleration of one metre per second squared. Force, mass and acceleration are related as shown: Force = mass × acceleration (newton, N) (kilogram, kg) (metre/second squared, m/s^2)	p. 138-9

10.9	Frictional Forces and Non-uniform Motion	
KS3	A force of friction acts: • When an object moves through air or water; • When solid surfaces slide (or tend to slide) across each other. 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. The friction between solid surfaces is used in brakes which slow down and stop moving vehicles.	p. 92-3
FT & HT	The greater the speed of a vehicle: • The greater the braking force needed to stop it in a certain distance; • 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: • 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: • 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 as gas or a liquid (a fluid) the greater the force of friction which acts on it. When a body falls: • 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. When a vehicle has a steady speed the frictional forces balance the driving force.	p. 99, 136

10.10	Moments and Centre of Mass	
KS3	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. If a force is applied at a distance from the pivot it has a turning effect (moment). A force has a greater turning effect (moment): • 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	If suspended, an object will come to rest with its centre of mass directly below the point of suspension. 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. How big a turning effect a force has (its moment) can be calculated as shown: moment = force × perpendicular distance between line of action and pivot (newton metre, Nm) (newton, N) (metre, m)	p. 102-3 p. 100
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: • 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 it 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

10.11	Momentum	
FT & HT	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. Momentum, mass and velocity are related as shown: momentum = mass × velocity (kilogram metre/second, kg m/s) (kilogram, kg) (metre/second, m/s)	p. 144
HT	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. Each object suffers a change in momentum which is equal in size but opposite in direction. When a force acts on a moving object a change in momentum occurs. The force, change in momentum and the time taken for the change are related as shown: $\text{force (newton, N)} = \dfrac{\text{change in momentum (kilogram metre/second, kg m/s)}}{\text{time (second, s)}}$	p. 144-5, 94
	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. When objects collide, the total kinetic energy after the collision in a particular direction is normally less than before the collision. Elastic collisions are those involving no overall change in kinetic energy. **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. 145-6
10.12	**Circular Motion**	
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: • 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

10.13	**Characteristics of Waves**	
KS3	Sounds bounce back (reflect) from hard surfaces. Echoes are sound reflections. 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. 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). 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. 230 p. 185 p. 192-3, 245
FT & HT	Waves can be produced in ropes and springs and on the surface of water. When waves travel along ropes or springs or across the surface of water they set up regular patterns of disturbances: • 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 measure in hertz (Hz). Wave speed, wavelength and frequency are related as follows: wave speed = frequency × wavelength (metre/second, m/s) (hertz, Hz) (metre, m) Waves transfer energy from a source to other places without any matter being transferred. Waves travelling along a rope or spring, or across the surface of water, can be reflected. Waves travelling across the surface of water can also be refracted. The change in the speed of water waves when the cross the boundary between two different substances causes a change in their direction (refraction), unless the direction of travel of the waves is along a normal. This behaviour of waves suggest that light and sound: • Also travel as waves; • Are refracted because they travel at different speeds in different substances (media).	p. 174-6, 193

FT & HT	When a ray of light travels from glass, Perspex or water into air, some of the light is also reflected from the boundary. 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. When light travels down an optical fibre, all the light may stay inside the fibre until it emerges from the other end. This is because light travels down optical fibres by repeated total internal reflection. **Candidates should be able** to describe, using a suitable diagram, one other use of total internal reflection.	p. 195-7, 200
	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. 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. 174
	Sound waves travel through solids, liquids and gases as longitudinal waves.	p. 229
	Light waves are transverse waves and can travel through a vacuum, i.e. they do not need a medium.	p. 179, 219
	When a wave moves through a gap, or past an obstacle, it spreads out from the edges. This is called diffraction. Electromagnetic radiation and sound are also diffracted which supports the idea that they travel as waves. Because of diffraction: • Sounds can sometimes be heard in the shadow of buildings; • Radio signals can sometimes be received in the shadow of hills. Waves having a longer wavelength are more strongly diffracted.	p. 177, 240

10.14	The Electromagnetic Spectrum	
KS3	When rays of light pass through prisms their direction may be changed. When white light is used, a spectrum is produced. 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. 216-7
FT & HT	Light is one type of electromagnetic radiation. All types of electromagnetic waves travel at the same speed through space. The various types of electromagnetic radiation form a continuous spectrum extending far beyond each end of the visible spectrum. Highest Frequency — shortest wavelength gamma rays X-rays ultraviolet rays light infra red rays microwaves radio waves Lowest Frequency — longest wavelength	p. 218-9
	Different wavelengths of electromagnetic radiation are reflected, absorbed or transmitted differently by different substances and types of surface. When radiation is absorbed, the energy it carries: • Makes the substance which absorbs it hotter; • May create an alternating current with the same frequency as the radiation itself.	p. 226-7, 335
	The uses and effects of different types of radiation depend on these and other properties.	p. 218-9
	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. 221
	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 home networks. Microwave radiation, with wavelengths strongly absorbed by water molecules is used for cooking.	p. 221, 320, 227
	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. 227, 320, 50, 270
	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. 200, 333
	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.	

FT & HT	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: • 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: • 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. High does 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. **Candidates should be able**, when provided with appropriate information, to evaluate: • 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. Signals can also be coded as a series of pulses. The signal then has only two states, on or off. Signals of this type are called digital signals.	p. 312, 332, worksheet
	The advantages of digital signals are: • 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, optical fibre or carrier wave than with analogue signals.	p. 333

HT	As signals travel they become weaker. Random additions to the signal (noise) may also be picked up. 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. 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. 333
10.15	**Optical devices**	
FT & HT	There are converging and diverging lenses. **Candidates should be able** to: • 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
	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. 206
HT	**Candidates should be able** to: • 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

10.16	Sound and Ultrasound	
KS3	Sounds are produced when objects vibrate. The greater the size (amplitude) of vibrations the louder the sound. The number of complete vibrations each second is called the frequency (hertz, Hz). The higher the frequency of a sound the higher the pitch.	p. 228, 234
FT & HT	**Candidates should be able** to compare the amplitudes and frequencies of sounds from diagrams of oscilloscope traces. 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. Ultrasonic waves can be used: • In industry for cleaning and for quality control; • In medicine for pre-natal scanning.	p. 234-5 p. 230, 240-1
HT	Ultrasonic waves are partly reflected when the 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. Ultrasonic waves in liquids can also be used for cleaning delicate mechanisms without having to disassemble them.	p. 240-1

10.17	Seismic Waves	
FT & HT	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. The Earth is nearly spherical and has a layered structure comprising: • 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. 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, than of the crust.	p. 154
HT	Earthquakes produce surface waves that can cause earthquake damage and two types of waves that can travel through the Earth: • 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. 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. It is by observing the path of these waves that scientists have been able to work out details of the Earth's layered structure: **Candidates should be able** to interpret diagrams of the paths of seismic waves inside the Earth in terms of: • The liquid nature of the Earth's outer core; • Refraction at the boundaries between layers; • Refraction due to change in speed within a particular layer.	p. 154 - 155

10.18	Tectonics	
FT & HT	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): • Have shapes which fit quite closely; • Have similar patterns of rocks and fossils. This suggest that they were once part of a single land mass which has been split and been moved apart. 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. Earthquakes and/or volcanic eruptions occur at the boundaries between tectonic plates. **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. 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. **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. 156 – 157
HT	Tectonic plates: • 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 driven 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 - 157

The Earth and Beyond		page numbers in **Physics for You**
10.19	**The Solar System**	
KS3	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. 158
	The Earth moves round (orbits) the Sun once every year (just over 365 days).	
	The stars in the night sky stay in fixed patterns (called constellations).	p. 164
	The planets which are visible to the naked eye look just like stars. They move very slowly across the constellations.	p. 161
	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.	
	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.	
	Satellites can be put into orbit around the Earth. They can be used: • To send information between places which are a long way apart on 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	The orbits of the planets are slightly squashed circles (ellipses) with the Sun quite close to the centre.	p. 161
	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. 163
	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. 162, 158-9, 78
	A smaller body with stay in orbit around a larger one because of the combination of its high speed and the force of gravity between the bodies.	p. 162, 168
	To stay in orbit at a particular distance, smaller bodies, including planets and satellites, must move at a particular speed around larger bodies.	
	The further away an orbiting body is the longer it takes to make a complete orbit.	
	Communications satellites, including those used for television programmes, are usually put into an 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 only about 400 geostationary satellites or they would interfere with each other's signals.	p. 169, 162, worksheet
	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. 168

10.20	The Universe	
FT & HT	Our Sun is just one of many millions of stars in a group of stars called the Milky Way galaxy. The stars in a galaxy are often millions of times further away from each other than the planets in the solar system. The Universe as a whole is made up of at least a billion galaxies. Galaxies are often millions of times further apart than the stars within a galaxy.	p. 165-7
	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. 163
	If there is, or has been, life on other planets, in our own solar system or around other stars: • 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 received signals from other species with technologies that are at least as advanced as our own. The search for extra-terrestrial intelligence (SETI), using radio telescrops to try to find meaningful signals in a narrow band of wavelengths (i.e. not just “noise”), has gone on form more than forty years, so far without success. **Candidates should be able**, when provided with appropriate information to evaluate: • The methods scientists use to discover whether there is life elsewhere in the Universe; • Evidence that such life exists.	p. 167
	Individual stars, including the Sun, do not stay the same forever. 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 extends 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. If a red giant is massive enough, it may eventually rapidly contract and then explode (become a supernova) throwing dust and gas into space. The matter that is left behind may form a very dense neutron star.	p. 165

HT	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. During a star's lifetime, nuclei of light 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. 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 suggest that the solar system was formed from the material produced when earliers stars exploded. Theories of the origin of the Universe have had to take into account: • 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'. The current way of explaining this is: • 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. This suggest 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. 165, 368 p. 164 p. 165 p. 166, 369. worksheets

Energy Resources and Energy Transfer		page numbers in **Physics for You**
10.21	**Thermal Energy Transfer**	
KS3	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. 42-3
	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. 43-44
	Liquids and gases can flow and so can carry energy from places where the temperature is higher to places where the temperature is lower. Transfer of energy by liquids or gases moving in this way is called convection.	p. 46-7
	Energy is continually being transferred to and from all objects by radiation, even through empty space (a vacuum).	p. 48-50
FT & HT	Hot bodies emit mainly infra red radiation.	
	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. 48-9, 219, 221
	Dark matt surfaces are good absorbers (poor reflectors) of radiation. Light, shiny surfaces are good reflectors (poor absorbers) of radiation.	
	Candidates should be able: • To describe various ways in which heat energy is transferred from buildings; • To describe and explain ways in which the rate of these energy transfers can be reduced.	p. 45, 50
	Candidates should be able, when given appropriate information, to evaluate the effectiveness and cost-effectiveness of methods used to reduce energy consumption in buildings.	
HT	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. 43
	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. 46
	Thermal radiation is the transfer of energy by waves.	p. 48, 219

10.22	Efficiency	
FT & HT	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. **Candidates should be able** to describe the intended energy transfers and the main energy wastages which occur when using a range of everyday devices. 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. The energy becomes increasingly spread out and becomes increasingly more difficult to use for further useful energy transfers. The more of the energy supplied to a device that is usefully transferred, the more efficient we say the device is. **Candidates should be able**, when provided with appropriate information, to evaluate methods of reducing wasteful transfers of energy. The efficiency of a device can be calculated using: $\text{efficiency} = \dfrac{\text{useful energy transferred by device}}{\text{total energy supplied to device}}$	p. 112-3, 122, 9-10, worksheet
10.23	**Energy Resources**	
KS3	Coal, oil, gas and wood are all fuels. They release energy when they are burned. 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. More trees can be grown to replace trees that are cut down to provide wood for fuel. Wood is a renewable energy resource. Renewable energy resources include sunlight, the wind, the waves, running water and the tides. These energy resources with not run out. Electricity is a very convenient and widely used energy source. It is generated in power station using some other energy resource.	p. 11-13
FT & HT	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. 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: • 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. In some volcanic areas, 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. Electricity can be produced directly from the Sun's radiation using solar cells.	p. 111 – 113, 12 – 13 p. 12, 114

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<td>FT & HT</td>
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Using different energy sources has different effects on the environment.

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.

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Energy sources also differ in when they are available for generating electricity.

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:
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. Each of these energy sources can generate electricity only at certain times; they are all to some extent unreliable.
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.

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<td>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).</td>
<td>p. 113, 114</td>
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<td>Candidates should be able to compare and contrast the particular advantages and disadvantages of using different energy sources to generate electricity.</td>
<td>p. 115, 359</td>
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HT	**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: • 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. 113 – 115
10.24	**Work, Power and Energy**	
FT & HT	Energy is measured in joules (J). When a force moves an object, energy is transferred and work is done: work done = energy transferred The amount of work done, force and distance are related as shown: work done = force applied × distance moved in direction of force (joule, J) (newton, N) (metre, m) Power is a measure of how fast energy is transferred. The greater the power, the more energy is transferred in a given time. $\text{power (watt, W)} = \dfrac{\text{work done (joule, J)}}{\text{time taken (second, s)}}$ 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. On Earth the gravitational field strength is about 10 N/kg. weight = mass × gravitational field strength (newton, N) (kilogram, kg) (newton/kilogram, N/kg) change in gravitational potential energy = weight × change in vertical height (joule, J) (newton, N) (metre, m) Elastic potential energy is the energy stored in an elastic object when work is done on the object to change its shape. Kinetic energy is the energy an object has because of its movement. An object has more kinetic energy: • the greater its mass; • the greater its speed. Kinetic energy = ½ × mass × speed^2 (joule, J) (kilogram, kg) [(metre/second)^2, (m/s)^2]	p. 37, 107 p. 109 p. 107 p. 118-9 p. 116 p. 8, 108 p. 117

10.25	Electromagnetic Forces	
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). 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 electromagnetic.	p. 284, 287 p. 293
FT & HT	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: • Increasing the strength of the magnetic field; • Increasing the size of the current. The direction of the force is reversed if either the direction of the current or the direction of the magnetic field is reversed. **Candidates should be able** – when provided with diagrams and/or other appropriate information – to explain how electromagnetic effects are used in simple d.c. motors and circuit breakers. *[Details of the split ring, for reversing the current to a d.c. motor each half turn, will not be required.]*	p. 296 – 299

continued . . .

10.26	Electromagnetic Induction	
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. 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 customers. 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. 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. The size of the induced voltage increases when: • 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. 303 p. 308-9 p. 304-6
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. A changing magnetic field will also produce an induced voltage in a coil. This is how a transformer works. The higher the voltage, the smaller the current needed to transmit energy at the same rate. Less energy is wasted by heating up the power lines. 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). The voltages across the primary and secondary coils of a transformer are related as shown: $\frac{\text{Voltage across primary (volt, V)}}{\text{Voltage across secondary (volt,V)}} = \frac{\text{number of turns on primary}}{\text{number of turns on secondary}}$	p. 304 p. 307-9

Radioactivity		page numbers in **Physics for You**
10.27	**Types, Properties And Uses of Radioactivity**	
FT & HT	Some substances give out radiation all the time, whatever is done to them. These substances are said to be radioactive. There are three types of radiation emitted by radioactive sources: • 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. 350-1
	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. 360
	When radiation from radioactive materials collides with neutral atoms or molecules these may become charged (ionised).	p. 348
	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. Higher doses of ionising radiation can kill cells; they are used to kill cancer cells and harmful microorganisms.	p. 356-7
	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. 351, 357
	When sources of radiation are outside the body: • Beta and gamma radiation are the most dangerous because they can reach the cells of organs and may be absorbed by them; • Alpha radiation is least dangerous because it is unlikely to reach living cells. 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. The badge is a small packet containing photographic film. The more radiation a worker has been exposed to, the darker the film is when it has been developed.	p. 356, 360
	When sources of radiation are inside the body: • 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: • 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: • The type(s) of radiation emitted; • Their half-lives.	p. 356-7, 362

10.28	Atomic Structure and Nuclear Fission	
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: • 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
	The relative masses of protons, neutrons and electrons and their relative electric charges are as shown: Mass / Charge Proton: 1 / +1 Neutron: 1 / 0 Electron: negligible / –1 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. All atoms of a particular element have the same number of protons. 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. Atoms of the same element which have different numbers of neutrons are called isotopes.	p. 352-3
	Radioactive isotopes (radioisotopes or radionuclides) are atoms with unstable nuclei. When an unstable nucleus splits up (disintegrates): • 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. This idea can be used to date materials, including rocks.	p. 354, 357

HT	Alpha radiation consists of helium nuclei, particles made up of two protons and two neutrons. 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 a 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: • 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. *[Details of nuclear reactors are not required.]* 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. 358
	During one half-life, half of the radioactive atoms initially present in a sample decay. This idea can be used to date materials. 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.	p. 354, 362, worksheet

End of syllabus content