

OCR : GCSE 21st Century Science Specification J635

Physics A

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Name : _____

Module P1: The Earth in the Universe

P1.1 What do we know about the Earth and Space?	Page numbers in New Physics For You
1. recall that rocks provide evidence for changes in the Earth (erosion and sedimentation, fossils, folding, radioactive dating, craters);	
2. understand that continents would be worn down to sea level, if mountains were not being continuously formed;	
3. understand that the rock processes seen today can account for past changes;	
4. understand that the Earth must be older than its oldest rocks, which are about 4 thousand million years old ;	(p. 352)
5. label on a given diagram of the Earth its crust, mantle and core;	146, worksheet
6. recall that the solar system was formed over very long periods from clouds of gases and dust in space, about 5 thousand million years ago ;	152
7. distinguish between planets, moons, the Sun, comets, asteroids and be aware of their relative sizes and motions;	150-2
8. recall that fusion of hydrogen nuclei is the source of the Sun's energy;	152
9. understand that all chemical elements larger than helium were made in earlier stars;	153
10. discuss the probability and possible consequences of an asteroid colliding with the Earth, including the extinction of the dinosaurs;	worksheet
11. in relation to the above, or when provided with relevant additional information: <ul style="list-style-type: none"> • can identify statements which are data and statements which are (all or part of) an explanation; • can recognise data or observations that are accounted for by (or conflict with) an explanation; • can identify imagination and creativity in the development of explanations; • can justify accepting or rejecting a proposed explanation on the grounds that it: <ul style="list-style-type: none"> ○ accounts for observations; ○ and/or provides an explanation that links things previously thought to be unrelated; ○ and/or leads to predictions that are subsequently confirmed. 	
12. recall that light travels at a high but finite speed, 300 000 km/s ;	171
13. understand that the speed of light means distant objects are observed as younger than they are now;	158
14. recall a light-year is the distance travelled by light in a year;	157, 171
15. compare the relative ages of the Earth, the Sun and the Universe;	152, 158
16. compare the relative diameters of the Earth, the Sun and the Milky Way;	150-1, 157
17. relate uncertainty in the distance of stars and galaxies to the difficulty of observations.	

Module P2: Radiation and Life

P2.1 What types of electromagnetic radiation are there? What happens when radiation hits an object?	Page numbers in New Physics for You
1. recall that light is one of a family of radiations, the electromagnetic spectrum;	p. 208-9, worksheet
2. understand that a beam of electromagnetic radiation delivers energy in 'packets' called photons;	
3. list the electromagnetic radiations in order of the energy delivered by each photon – radio waves, microwaves, infrared, ^{red} light ^{violet} , ultraviolet, X-rays, gamma rays;	208-9, worksheet
4. interpret a situation in which one object affects another some distance away in terms of the general model of electromagnetic radiation: <ul style="list-style-type: none"> • one object (a source) emits radiation; • the radiation travels from the source and can be reflected, transmitted or absorbed by materials on its journey; • radiation may be absorbed by another object (a detector) some distance away; 	46-7, 211, 213
5. understand that the energy deposited by a beam of electromagnetic radiation depends on both the number of photons arriving and the energy that each photon delivers;	
6. recall that the intensity of electromagnetic radiation is the energy arriving at a surface each second;	214
7. understand that the intensity of a beam of electromagnetic radiation decreases with distance and be able to explain why ;	214
8. understand that ionising radiation is able to break molecules into bits (called ions), which can then take part in other chemical reactions ;	(338, 274, 244)
9. recall that ionising radiation includes: <ul style="list-style-type: none"> • ultraviolet radiation; • X-rays; • gamma rays; 	214, 212, 210 214, 312 214, 346
10. understand that microwaves heat materials containing particles that the microwaves can vibrate;	213, 216
11. relate the heating effect of non-ionising radiation to its intensity and duration ;	(214)
12. recall an example of the way in which each of infrared, microwaves and radio waves are used for transmitting information.	211, 213, 217, 314, 331, worksheet
P2.2 Which types of electromagnetic radiation harm living tissue and why?	Page numbers in New Physics for You
1. recall that the heating effect of absorbed radiation can damage living cells;	214
2. recall that low intensity microwave radiation, for example from mobile phone hand sets and masts, may be a health risk, but this is disputed;	216-7, worksheets
3. recall that ionising radiation can damage living cells;	214, 346, 350
4. recall examples of how exposure to different amounts of ionising radiation can affect living cells;	214, 346, 350
5. recall that the metal cases and door screens of microwave ovens protect users from the radiation;	213
6. recall that physical barriers protect people from ionising radiation, for example, sun-screens and clothing can be used to absorb most of the ultraviolet radiation from the Sun.	214

P2.3 How does electromagnetic radiation make life on Earth possible?	Page numbers in New Physics for You
<ol style="list-style-type: none"> 1. recall that the Earth is surrounded by an atmosphere which allows light radiated from the Sun to pass through; 2. recall that this radiation: <ul style="list-style-type: none"> • provides the energy for photosynthesis; • warms the Earth's surface; 3. recall that photosynthesis removes carbon dioxide from the atmosphere and adds oxygen, and that this reverses the effect of respiration; 4. understand that the Earth emits electromagnetic radiation that is absorbed by some gases in the atmosphere, so keeping the Earth warmer than it would otherwise be. This is called the greenhouse effect; 5. understand that the ozone layer absorbs ultraviolet radiation, producing reversible chemical changes in that part of the atmosphere; 6. understand that the ozone layer protects living organisms, specially animals, from the harmful effects of ultraviolet radiation 	<p style="text-align: center;">107, 48, worksheet</p> <p style="text-align: center;">214</p> <p style="text-align: center;">214</p>
P2.4 What is the evidence for global warming, why might it be occurring, and how serious a threat is it?	Page numbers in New Physics for You
<ol style="list-style-type: none"> 1. recall that one of the greenhouse gases in the Earth's atmosphere is carbon dioxide, present in small amounts; 2. recall that other greenhouse gases include methane, present in trace amounts, and water vapour; 3. interpret simple diagrams representing the carbon cycle; 4. use the carbon cycle to explain: <ul style="list-style-type: none"> • why for thousands of years the amount of carbon dioxide in the Earth's atmosphere was approximately constant; • how decomposers play an important part in the recycling of carbon; • that during the past two hundred years, the amount of carbon dioxide in the atmosphere has been steadily rising; • that the rise in atmospheric carbon dioxide is largely the result of: <ul style="list-style-type: none"> ○ burning increased amounts of fossil fuels as an energy source; ○ burning forests to clear land; 5. understand that computer climate models provide evidence that human activities are causing global warming; 6. understand that global warming could result in: <ul style="list-style-type: none"> • climate change and how this could make it impossible to continue growing some food crops in particular regions; • extreme weather conditions in some regions; • rising sea levels due to melting continental ice and expansion of water in the oceans, which would cause flooding of low-lying land. 	<p style="text-align: center;">107</p> <p style="text-align: center;">107</p> <p style="text-align: center;">107</p> <p style="text-align: center;">107, worksheet</p>

P2.5 What ideas do citizens and scientists have about risk?	Page numbers in New Physics for You
<p>1. when provided with necessary additional information about alleged health risks due to radiation (P2.2) or global warming (P2.4) can:</p> <ul style="list-style-type: none"> • identify examples of risk which arise from new scientific or technological advances; • suggest ways of reducing specific risks; • interpret and discuss information on the size of risks, presented in different ways; • discuss a given risk, taking account of both the chance of it occurring and the consequences if it did; • identify, or propose, an argument based on the precautionary principle; • use the ideas of correlation and cause appropriately when discussing historical events or topical issues in science; • explain why a correlation between a factor and an outcome does not necessarily mean that one causes the other, and give an example to illustrate this; • suggest factors that might increase the chance of an outcome, but not invariably lead to it; • explain that individual cases do not provide convincing evidence for or against a correlation; • use data to develop an argument that a factor does/does not increase the chance of an outcome; • identify the presence (or absence) of a plausible mechanism as significant for the acceptance (or rejection) of a claimed causal link. <p>2. when provided with necessary additional information about alleged health risks due to radiation emitted from technological devices, or ultraviolet radiation from the Sun (P2.2), can:</p> <ul style="list-style-type: none"> • explain why it is impossible for anything to be completely safe; • suggest benefits of activities with known risk; • offer reasons for peoples willingness (or reluctance) to accept the risk of a given activity; • discuss personal and social choices in terms of a balance of risk and benefit; • distinguish between actual and perceived risk, when discussing personal and social choices; • suggest reasons for given examples of differences between actual and perceived risk; • explain what the ALARA (as low as reasonably achievable) principle means, and how it applies in a given situation; • identify the outcome and the factors that may affect it; • suggest how an outcome might be affected when a factor is changed; • give an example from everyday life of a correlation between a factor and an outcome; • evaluate the design for a study to test whether or not a factor increases the chance of an outcome, by commenting on sample size and how well the samples are matched. 	<p>214, 216, worksheet</p> <p>216</p> <p>216</p> <p>216-7, (214)</p> <p>216</p> <p>361, 364</p>

Module P3: Radioactive Materials

P3.1 Why are some materials radioactive?	Page numbers in New Physics for You
1. recall that some elements emit ionising radiation all the time and are called radioactive;	p. 340-1
2. understand that radioactive elements are naturally found in the environment, emitting background radiation;	340, 350
3. recognise, in given text, the terms electron, proton, neutron and nucleus;	342, 242
4. understand that an atom has a nucleus, made of protons and neutrons;	342-3, worksheet
5. understand that every atom of any element has the same number of protons but the number of neutrons may differ;	343
6. understand that the behaviour of radioactive materials cannot be changed by chemical or physical processes;	
7. recall three types of ionising radiation (alpha, beta and gamma) emitted by radioactive materials;	340-1
8. recall the penetration properties of each type of radiation;	340-1
9. describe radioactive materials in terms of the instability of the nucleus, radiation emitted and the element left behind;	345
10. understand that, over time, the activity of radioactive sources decreases;	344
11. understand the meaning of the term half-life;	344, worksheet
12. understand that radioactive elements have a wide range of half-life values;	344
13. carry out simple calculations involving half-life.	344
P3.2 How can radioactive materials be used and handled safely, including wastes?	Page numbers in New Physics for You
1. understand that ionising radiation can damage living cells;	346, 214
2. understand that ionising radiation is able to break molecules into bits (called ions), which can then take part in other chemical reactions;	346
3. understand that when ionising radiation strikes living cells these may be killed or may become cancerous;	346-7
4. recall how ionising radiation can be used to: <ul style="list-style-type: none"> • treat cancer; • sterilise surgical instruments; • sterilise food; 	347 347 347
5. recall that radiation dose (in sievert) (based on both amount and type of radiation) is a measure of the possible harm done to your body;	
6. interpret given data on risk related to radiation dose;	
7. understand that radioactive materials expose people to risk	350
8. understand that we are irradiated and contaminated all the time and name some sources of this background radiation;	350
9. relate ideas about half life and background radiation to the time taken for a radioactive source to become safe;	344
10. recall categories of people who are regularly exposed to risk of radiation and that their exposure is carefully monitored.	350

P3.3 How can electricity be generated? What can be done with nuclear wastes?	Page numbers in New Physics for You
1. understand why electricity is called a secondary energy source;	
2. understand that electricity is convenient because it is easily transmitted over distances and can be used in many ways;	p. 105
3. label a block diagram showing the basic steps by which electricity is generated;	104, 349
4. interpret a Sankey diagram of electricity generation and distribution to include the efficiency of energy transfers;	104, 102, worksheet
5. recall two examples to show that we can use renewable energy sources instead of fuels to generate electricity;	14-15, 103, 106
6. recall that power stations which burn carbon fuels will produce carbon dioxide;	106
7. understand that a nuclear fuel is one where energy is released from changes in the nucleus;	348
8. know that in nuclear fission a neutron splits a large and unstable nucleus (limited to uranium) into two smaller parts, roughly equal in size, releasing more neutrons;	348
9. compare the amount of energy released during nuclear fission with that released in a chemical reaction;	348
10. understand how the nuclear fission process in nuclear power stations is controlled, and use the terms chain reaction, fuel rod, control rod and coolant;	348-9
11. understand that nuclear power stations produce radioactive waste;	350
12. understand that nuclear wastes are categorised as high level, intermediate level and low level, and relate this to disposal methods;	350
13. interpret and evaluate information about different energy sources for generating electricity, considering efficiency, economic and environmental costs, power output and lifetime.	105-7, 349, worksheet

P3.4 What are the health risks from radioactive materials?	Page numbers in New Physics for You
<p>1. when provided with additional information on the health risks associated with radioactive materials, and the steps taken to limit these:</p> <ul style="list-style-type: none"> • can explain why it is impossible for anything to be completely safe; • can identify examples of risks which arise from new scientific or technological advances; • can suggest ways of reducing specific risks; • can interpret and discuss information on the size of risks, presented in different ways; • can discuss a given risk, taking account of both the chance of it occurring and the consequences if it did; • can suggest benefits of activities with known risk; • can offer reasons for people's willingness (or reluctance) to accept the risk of a given activity; • can discuss personal and social choices in terms of a balance of risk and benefit; • can identify, or propose, an argument based on the 'precautionary principle'; • can distinguish between actual risk and perceived risk, when discussing personal and social choices; • can suggest reasons for given examples of differences between actual and perceived risk; • can explain what the ALARA (as low as reasonably achievable) principle means and how it applies to the issue in question; <p>2. in the context of health risks associated with radioactive materials:</p> <ul style="list-style-type: none"> • can identify the groups affected and the main benefits and costs of a course of action for each group; • can explain the idea of sustainable development, and apply it to specific situations; • shows awareness that scientific research and applications are subject to official regulations and laws; • can distinguish what can be done (technical feasibility), from what should be done (values); • can explain why different courses of action may be taken in different social and economic contexts. 	<p>(349, worksheets)</p>

Module P4: Explaining motion

P4.1 How can we describe motion?	Page numbers in New Physics for You
1. apply the following equation to situations where an average speed is involved:	
$\text{speed (m/s)} = \frac{\text{distance travelled (m)}}{\text{time taken (s)}}$	p. 122
① Candidates should be able to apply the above equation to situations where an average speed is involved.	122
2. distinguish between average speed and instantaneous speed (in effect, an average over a short time interval) for examples of motion where speed is changing;	122
3. understand that distances measured in one direction are positive, and in the other, negative;	126
① Candidates are not expected to recall or use the term 'displacement'.	
4. draw and interpret the shape of a distance-time graph for an object that is:	126, worksheet
• stationary;	126, worksheet
• moving at constant speed;	126, worksheet
• moving with increasing or decreasing speed;	126, worksheet
5. interpret a steeper gradient of a distance-time graph as a higher speed;	126
6. calculate a speed from the gradient of a straight section of a distance-time graph;	126, worksheet
7. recall that the velocity of an object at any instant is its speed plus an indication of the direction;	122
8. understand that the velocity of an object moving in a straight line is positive if it is moving in one direction and negative if it is moving in the opposite direction;	122
9. draw and interpret the shape of a velocity-time graph for an object that is:	124-5, worksheet
• stationary;	124-5, worksheet
• moving in a straight line with constant speed;	124-5, worksheet
• moving in a straight line with steadily increasing or decreasing speed;	124-5, worksheet
10. relate these ideas about recording motion to applications such as lorry tachographs.	

P4.2 What are forces?	Page numbers in New Physics for You
1. recall that a force arises from an interaction between two objects;	p. 65-7, 82
2. understand that when one object exerts a force on another, it always experiences a force in return;	84-5
3. in simple everyday situations	
• identify forces arising from an interaction between two objects;	84-5
• identify the 'partner' of a given force (i.e. the other force of the interaction pair);	84-5
• specify, for each force, the object which exerts it, and the object on which it acts;	84-5
• use arrows to show the sizes and directions of forces acting;	84-5
4. understand that the two forces in an interaction pair are equal in size and opposite in direction; and that they act on different objects;	84-5
5. recall that some forces (for example friction, reaction of a surface) arise in response to the action of an applied force;	82, 84
6. describe the interaction between an object and a surface it is resting on: the object pushes down on the surface; the surface pushes up on the object with an equal force; this is called the reaction of the surface;	84-5
7. describe the interaction between two surfaces which slide (or tend to slide) relative to each other: each surface experiences a force in the direction which prevents (or tends to prevent) relative movement; this interaction is called friction;	82
① Candidates should be able to apply these ideas to explain situations such as walking, or the driving force on vehicles.	86-7
8. be able to use the idea of a pair of equal and opposite forces to explain in outline how rockets and jet engines work.	85, 114, 160

P4.3 What is the connection between forces and motion?	Page numbers in New Physics for You
1. be able to interpret situations in which several forces act on an object;	86-7
2. recall that the resultant force on an object is the sum of all the individual forces acting on it, taking their directions into account;	86
3. recall that if a resultant force acts on an object, it causes a change of momentum in the direction of the force;	136
4. use the definition: <ul style="list-style-type: none"> • momentum = mass × velocity (kg m/s) (kg) (m/s); 	136, worksheet
5. understand that the size of the change of momentum is related to the size of the resultant force and the time for which it acts in the following way: <ul style="list-style-type: none"> • change of momentum = resultant force x time for which it acts (kg m/s) (N) (s) 	136, worksheet
6. understand how the horizontal motion of objects (like cars and bicycles) can be analysed in terms of a driving force (produced by the engine or the cyclist), and a counter force (due to friction and air resistance);	87
7. recall that for a moving object, if the driving force is: <ul style="list-style-type: none"> • greater than the counter force, the vehicle will speed up; • equal to the counter force, the vehicle will move at constant speed in a straight line; • smaller than the counter force, the vehicle will slow down; 	87, 69 87, 69 87, 69
8. understand that, in situations involving a change in momentum (such as a collision), the longer the duration of the impact, the smaller the average force for a given change in momentum;	136
9. use this idea to discuss and explain the action of road safety measures, such as car seat-belts, crumple zones, air bags, cycle and motorcycle helmets;	136, 138, worksheet
10. understand that, if the resultant force on an object is zero, its momentum does not change (if it is stationary, it stays at rest; if it is already moving, it continues at a steady speed in a straight line).	69

P4.4 How can we describe motion in terms of energy changes?	Page numbers in New Physics for You
1. recall that the energy of a moving object is called kinetic energy ;	p. 10-11
2. recall that as an object falls, its gravitational potential energy decreases;	10-11
3. recall that when a force causes movement of an object, work is done;	97
4. use the equation: <ul style="list-style-type: none"> • work done by a force = force × distance moved by the force (joule, J) (newton, N) (metre, m) 	97, worksheet
5. understand that when work is done on an object, the energy of the object increases and when work is done by an object, the energy of the object decreases according to the relationship: <ul style="list-style-type: none"> • change in energy = work done (joule, J) (joule, J) 	99, worksheet
6. understand that when an object is lifted to a higher position above the ground, work is done by the lifting force against the gravitational force acting on the object (its weight); this increases the object's gravitational potential energy (GPE);	98
7. use the equation: <ul style="list-style-type: none"> • change in GPE = weight × vertical height difference (joule, J) (newton, N) (metre, m) 	108, worksheet
8. understand that when a force acting on an object makes its velocity increase, the force does work on the object and this results in an increase in its kinetic energy;	109
9. understand that the greater the mass of an object and the faster it is moving, the more kinetic energy it has;	109
10. use the equation: <ul style="list-style-type: none"> • kinetic energy = $\frac{1}{2} \times \text{mass} \times [\text{velocity}]^2$ (joule, J) (kilogram, kg) (metre per second, m/s)² 	109, worksheet
11. explain that if friction and air resistance can be ignored, an object's kinetic energy increases by an amount equal to the work done on it by an applied force;	109
12. understand that air resistance or friction will cause the gain in an object's kinetic energy to be less than the work done on it by an applied force, because some energy is dissipated through heating;	82
13. recall that energy is always conserved;	98
14. calculate the gain in kinetic energy, and the speed, of an object that has fallen through a given height.	109

Module P5: Electric circuits	
P5.1 Electric current - a flow of what?	Page numbers in New Physics for You
1. explain that when two objects are rubbed together and become charged, electrons are transferred from one object to the other;	p. 241
2. recall that there are repulsive forces between objects with similar charges, and attractive forces between objects with opposite charges;	241
3. explain simple electrostatic effects in terms of attraction and repulsion between charges;	242
4. recall that electrons are negatively charged;	242
5. recall that electric current is a flow of charge;	245, 249
6. recall that electric current is measured in amperes;	250
7. explain that in an electric circuit the components and wires are full of charges that are free to move;	249
8. explain that when a circuit is made the battery causes these free charges to move, and that they are not used up but flow in a continuous loop;	249
9. recall that in metallic conductors an electric current is a movement of free electrons;	249
10. explain that in metal conductors there are lots of charges free to move but in an insulator there are few charges free to move.	249
P5.2 What determines the size of the current in an electric circuit?	Page numbers in New Physics for You
1. recall that the larger the voltage of the battery in a given circuit, the bigger the current;	252-3
2. explain that components (for example resistors, lamps, motors) resist the flow of charge through them;	253-5
3. recall that the larger the resistance in a given circuit, the smaller the current will be;	253
4. recall that the resistance of connecting wires is so small that it can usually be ignored;	253
5. recall that resistors get hotter when electric current passes through them, and that this heating effect is caused by collisions between the moving charges and stationary atoms in the wire;	264
6. recall that this heating effect makes a lamp filament hot enough to glow;	265
7. describe how the resistance of an LDR varies with light intensity;	319, worksheet
8. describe how the resistance of a thermistor (ntc only) varies with temperature;	319, 259
9. recognise and use the electrical symbols for a cell, power supply, filament lamp, switch, LDR, fixed and variable resistor, thermistor, ammeter and voltmeter;	248, 250, 252, 255, 319

10. explain that two (or more) resistors in series have more resistance than one on its own, because the battery has to push charges through both of them;	p. 256
11. explain that two (or more) resistors in parallel provide more paths for charges to flow along than one resistor on its own, so the total resistance is less and the current is bigger;	257
12. use the equation: <ul style="list-style-type: none"> resistance (ohm, Ω) = $\frac{\text{voltage (volt, V)}}{\text{current (ampere, A)}}$ 	255, worksheet
① Rearrangement of the equation is expected only on higher tier.	
13. describe in words, or using a sketch graph, how the current varies with voltage in components whose resistance stays constant.	259
P5.3 How do parallel and series circuits work?	Page numbers in New Physics for You
1. describe how a voltmeter should be connected to measure the potential difference between any two chosen points;	252
2. recall that the voltage of a battery (measured in V) provides a measure of the 'push' of the battery on the charges in the circuit;	252
3. recall that potential difference is another term for voltage;	252
4. relate the potential difference between two points in the circuit to the energy transferred to, or from, a given amount of charge as it moves between these points;	261
5. describe the effect on voltage and current of adding further batteries in series and in parallel with original one;	253
6. understand that when several components are connected in series to a battery: <ul style="list-style-type: none"> the current through each component is the same; the potential differences across the components add up to the potential difference across the battery (because the total energy transferred to each unit of charge by the battery must equal the amount transferred from it to other components); the potential difference is largest across the component with the greatest resistance, because more energy is transferred by the charge flowing through a large resistance than through a small one; 	256, worksheet 256 256, 261
7. recall that when several components are connected in parallel directly to a battery: <ul style="list-style-type: none"> the potential difference (voltage) across each component is equal to the potential difference of the battery; the current through each component is the same as if it were the only component present; the total current from (and back to) the battery is the sum of the currents through each of the parallel components; the current is smallest through the component with the largest resistance, because the same battery voltage causes more current through a smaller resistance than a bigger one. 	257, worksheet 261 257

P5.4 How is mains electricity produced?	Page numbers in New Physics for You
Candidates will be assessed on their ability to:	
1. recall that mains electricity is produced by generators;	(p. 298)
2. recall that generators produce a voltage by a process called electromagnetic induction;	296
3. recall that when a magnet is moving into a coil of wire a voltage is induced across the ends of the coil;	297
4. recognise that if the ends of the coil are connected to make a closed circuit, a current will flow round the circuit;	297
5. recall that if the magnet is moving out of the coil, or the other pole of the magnet is moving into it, there is a voltage induced in the opposite direction;	297
6. explain that a changing magnetic field caused by changes in the current in one coil of wire can induce a voltage in a neighbouring coil;	301
7. describe the construction of a transformer as two coils of wire wound on an iron core;	301-2
8. recall that a transformer can change the size of an alternating voltage;	301-2
9. be able to use the equation: $\frac{V_p}{V_s} = \frac{N_p}{N_s}$	302, worksheet
10. describe how, in a generator, a magnet or electromagnet is rotated within a coil of wire to induce a voltage across the ends of the coil;	298, 300
11. understand that the size of this induced voltage can be increased by:	
• increasing the speed of rotation of the magnet or electromagnet;	300
• increasing the strength of its magnetic field;	300
• increasing the number of turns on the coil;	300
• placing an iron core inside the coil;	300
12. describe how the induced voltage across the coil of a generator changes during each revolution of the magnet or electromagnet and explain that the current produced in an external circuit is an alternating current (a.c.);	299
13. understand that the current from a battery is always in the same direction: it is a direct current (d.c.);	348
14. recall that mains electricity is an a.c. supply;	299, 268
15. explain that a.c. is used because it is easier to generate than d.c., and can be distributed more efficiently;	303
16. recall that the mains supply voltage to our homes is 230 volts.	268, 299, 303

P5.5 How much electrical energy do we use at home?	Page numbers in New Physics for You
1. explain that when electric charge flows through a component (or device), energy is transferred to the component;	p. 261
2. recall that the power (in watt, W) is a measure of the rate at which an appliance or device transfers energy;	110, 266
3. use the following equation to calculate energy transfer in joules and kilowatt-hours:	
<ul style="list-style-type: none"> energy transferred = power x time (joule, J) (watt, W) (second, s) (kilowatt hour, kWh) (kilowatt, kW)(hour, h) 	266, worksheet
4. use the equation:	
power = potential difference (voltage) × current (watt, W) (volt, V) (ampere, A)	266, worksheet
① Transformation of these equations is only required on the higher tier.	
5. know that a joule is a very small amount of energy, so a domestic electricity meter measures the energy transfer in kilowatt hours;	97, 267
6. calculate the cost of electrical energy given the power, the time and the cost per kilowatt hour;	267
7. use the following equation in the context of different electrical appliances:	264, 103, worksheet
<ul style="list-style-type: none"> efficiency = $\frac{\text{energy usefully transferred}}{\text{total energy supplied}} \times 100\%$ 	

Module P6: The wave model of radiation

P6.1 What are waves?	Page numbers in New Physics for You
1. recall that a wave consists of disturbances that transfer energy in the direction that the wave travels, without transferring matter;	p. 166
2. describe the differences between a transverse and a longitudinal wave;	166
3. recall that the frequency of the waves, in hertz (Hz), is the number of waves each second that are made by the source, or that pass through any particular point in the medium;	167
4. recall that the wavelength of waves is the distance between the same point on two adjacent disturbances;	167
5. recall the amplitude of waves is the distance from the top of the crest or bottom of the trough to the undisturbed position;	167
6. draw and interpret diagrams showing the amplitude and the wavelength of waves;	167-8
7. use the equation: $\begin{array}{ccccc} \text{wave speed} & = & \text{frequency} & \times & \text{wavelength} \\ \text{(metre per second m/s)} & & \text{(hertz, Hz)} & & \text{(metre, m)} \end{array}$	167, worksheet
① Rearrangement of the equation is only expected on the higher tier.	
8. recall that the speed of a wave is usually independent of its frequency and amplitude.	167
P6.2 Why do scientists think that light and sound are waves?	Page numbers in New Physics for You
1. draw and interpret diagrams showing the reflection of plane water waves and narrow beams of sound or light from a plane reflector;	168
2. recognise that wave speed is affected by what waves are travelling along or through (the medium) and that the speed will change if a wave moves from one medium into another;	168
3. explain how a change in the speed of a wave causes a change in wavelength since the frequency of the waves cannot change, and how this may cause a change in direction;	168
4. draw and interpret diagrams showing the refraction of plane water waves, or beams of light or sound, when they cross a boundary between different media, relating the change of direction to the change in wave speed;	168, worksheet
5. recall that the refraction of light waves and sound waves can be explained by a change in their speed when they pass into a different medium;	168, 185
6. recall that light rays for which the angle of refraction would be greater than 90 degrees cannot leave the medium they are in, and are reflected and that this is known as total internal reflection;	187
7. recall that waves can spread out at a narrow gap and that this is called diffraction;	169, worksheet
8. draw and interpret diagrams showing wave diffraction through gaps;	169

9. recall that light can be diffracted but needs a very small gap, comparable to the wavelength of the wave;	169
10. recall that where two waves meet, their effects add and that this is called interference;	worksheet
11. recall that where two waves arrive in step they reinforce and where they arrive out of step they cancel out;	worksheet
12. recall that two light beams can be shown to produce an interference pattern;	worksheet
13. explain interference patterns in terms of constructive and destructive interference;	worksheet
14. explain how the diffraction and interference of light and sound are evidence of their wave natures.	169
P6.3 Do all types of electromagnetic radiation behave in the same way?	Page numbers in New Physics for You
1. recall that the different colours of light in the spectrum have different frequencies (and therefore wavelengths);	206-7
2. list the parts of the whole electromagnetic spectrum in order of frequency or wavelength (radio waves, microwave, infrared, visible light, ultraviolet , X-rays, gamma radiation);	208-9
3. recall that the energy delivered by each photon in a beam of electromagnetic radiation increases with the frequency of the electromagnetic waves;	208-9
4. understand that the intensity of a beam of electromagnetic radiation (the energy it delivers per second) depends on the number of photons arriving every second and the amount of energy carried by each photon;	(214)
5. know that all types of electromagnetic radiation travel at exactly the same, very high, speed through space (a vacuum);	209
6. recall an important difference between electromagnetic waves and sound waves: electromagnetic waves can travel through empty space, but sound waves can only travel through a substance (solid, liquid or gas);	209, 225
7. understand that different frequencies of electromagnetic radiation are used for different purposes due to the difference in reflection, absorption or transmission by different materials to include:	208-9
<ul style="list-style-type: none"> • radio waves are not strongly absorbed by the atmosphere so can be used to carry information for radio and TV programmes; 	211
<ul style="list-style-type: none"> • some microwaves are strongly absorbed by water molecules and so can be used to heat objects containing water; 	213
<ul style="list-style-type: none"> • satellite dishes are made of metal because metals reflect microwaves well; 	213, (183)
<ul style="list-style-type: none"> • X-rays are absorbed by dense materials so can be used to produce shadow pictures of bones in our bodies or of objects in aircraft passengers' luggage; 	210, 312
<ul style="list-style-type: none"> • light and infrared radiation can be used to carry information along optical fibres because they travel through without becoming significantly weaker. 	189, 192

P6.4 How is information added to a wave?	Page numbers in New Physics for You
1. recall that signals can be carried not only by radio waves and microwaves through the Earth's atmosphere and through space but also by light waves and infrared waves through optical fibres;	p. 189, 192, 314
2. understand that if a wave is to carry information the waves must be made to vary in amplitude or frequency, and that the information is carried by the pattern of the variation, recall that this process is called modulation;	331, 218
3. interpret diagrams showing how a sound wave can be used to vary the amplitude or frequency of a radio wave, with a pattern that matches its own frequency;	331
4. recall that a signal which varies continuously is called an analogue signal;	218
5. recall that the job of the receiver is to reproduce the original sound from the pattern of the variation;	
① Details of any transmission or receiver systems are not required.	
6. recall that sound (or other information) can be transmitted digitally (digital signal);	218
7. recall that, in digital transmission, the sound is often converted into a digital code made up from just two symbols (0 and 1);	218
8. recall that this coded information can be used to control the short bursts of waves (pulses) produced by a source (0 = no pulse, 1 = pulse);	218
9. recall that when the waves are received, the pulses are decoded to produce a copy of the original sound wave;	218-9
10. know that an important advantage of digital signals over analogue signals is that they can transmit information with higher quality, i.e. the signal is less affected by the transmission process;	219
11. understand that all signals, as they travel, decrease in intensity (their amplitude becomes smaller), so they may have to be amplified;	219, 331
12. know that random additions to the original signal (noise) may be picked up as a signal travels, reducing its quality;	219
13. know that, when a signal is amplified, any noise it has picked up is also amplified;	219
14. understand that, with digital signals, 'on' and 'off' states can usually still be recognised despite any noise that is picked up. The signal can therefore be cleaned up to remove the noise and restore the original pattern of 'on's and 'off's;	219, worksheet
15. be able to use these ideas to interpret information about analogue and digital transmission and to explain why information can be transmitted digitally with higher quality.	219

Module P7: Further physics - Observing the Universe

P7.1 Observing the sky with the naked eye.	Page numbers in New Physics for You
1. recall that the Sun appears to travel east-west across the sky once every 24 hours; that the stars appear to travel east-west across the sky once in a very slightly shorter time period (23 h 56 min); that the Moon appears to travel east-west across the sky once in a slightly longer time period (about 25 hours), and that the naked-eye planets (Mercury, Venus, Mars, Jupiter and Saturn) appear to move with the stars but change their positions in complicated patterns;	p. 148, 151
2. explain the apparent motions of Sun, stars, Moon and planets in terms of rotation of the Earth and the orbits of the Earth, Moon and planets;	148-9, 151
3. explain the phases of the Moon in terms of the relative positions of the Sun, Moon and Earth;	149
4. explain eclipses in terms of the positions of the Sun and Moon and explain the low frequency of eclipses in terms of the relative tilt of the orbits of the Moon about the Earth and the Earth about the Sun;	173
5. explain that the positions of astronomical objects are measured in terms of angles as seen from Earth;	
6. explain why a sidereal day, a rotation of 360° of the Earth, is different from a solar day due to the orbital movement of the Earth and that a sidereal day is 4 minutes less than a solar day;	
7. explain why different stars are seen in the night sky at different times of the year, in terms of the movement of the Earth and the sun;	
8. recall that planets move in complicated patterns relative to the 'fixed' stars.	151, worksheet
P7.2 How does a telescope work?	Page numbers in New Physics for You
1. recall that convex/converging lenses bring parallel light to a focus;	194
2. recall that more powerful lenses of the same material have more curved surfaces;	195
3. calculate the power of a lens from: <div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: right; margin-right: 10px;">power =</div> <div style="text-align: center;"> $\frac{1}{\text{focal length}}$ <div style="display: flex; justify-content: center; gap: 5px;"> (diopetre) (metre) </div> </div> </div>	
4. draw and interpret diagrams showing the formation of a real image of a distant point source (off the principal axis of a lens) and of a distant extended source;	196, worksheet
5. understand that astronomical objects are so distant that light from them is effectively parallel;	215, 195
6. recall that a simple telescope has two converging lenses of different powers, with the more powerful lens as the eyepiece;	worksheet

<p>7. calculate the angular magnification of a telescope from the powers of the two lenses using:</p> <p>magnification = $\frac{\text{focal length of objective lens}}{\text{focal length of eyepiece lens}}$</p> <p>8. recall that most astronomical telescopes have concave mirrors, not convex lenses, as their objectives;</p> <p>9. understand how concave mirrors bring parallel light to a focus.</p>	<p>(195)</p> <p>215</p> <p>215, 181</p>
<p>P7.3 What are the objects we see in the night sky and how far away are they?</p>	<p>Page numbers in New Physics for You</p>
<ol style="list-style-type: none"> 1. explain how parallax makes some stars seem to move relative to others over the course of a year; 2. define the parallax angle of a star as half the angle moved against a background of distant stars in 6 months; 3. explain that a smaller parallax angle means that the star is further away; 4. define a parsec (pc) as the distance to a star with a parallax angle of one second of arc; 5. calculate distances in parsecs for simple parallax angles expressed as fractions of a second of arc; 6. recall that a parsec is similar in magnitude to a light-year; 7. recall that typical interstellar distances are a few parsecs; 8. recall that the intrinsic brightness of a star depends on its temperature and its size; 9. explain qualitatively why the observed brightness of a star (as seen on Earth) depends on its intrinsic brightness and its distance from Earth; 10. recall that Cepheid variable stars pulse in brightness, with a period related to their brightness; 11. explain qualitatively how this relationship enables astronomers to estimate the distance to Cepheid variable stars; 12. understand the role of observations of Cepheid variable stars in establishing the scale of the Universe and the nature of most nebulae as distant galaxies. (1aS 1.3, 1, 4); 13. recall that telescopes revealed that the Milky Way consists of very many stars and led to the realisation that the Sun was a star in the Milky Way galaxy; 14. recall that telescopes revealed the existence of many fuzzy objects in the night sky, and that these were originally called nebulae; 15. recall the main issue in the Curtis-Shapley debate: whether nebulae were objects within the Milky Way or separate galaxies outside it; 16. recall that Hubble's observations of Cepheid variables in one nebula indicated that it was much further away than any star in the Milky Way, and hence that this nebula was a separate galaxy; 	

<p>17. recall that intergalactic distances are typically measured in megaparsecs (Mpc);</p> <p>18. recall that Cepheid variable data in distant galaxies has given accurate values of the Hubble constant;</p> <p>19. use the following equation to calculate, given appropriate data, the speed of recession, the Hubble constant and the distance to distant galaxies:</p> $\text{speed of recession (km/s)} = \text{Hubble constant (s}^{-1}\text{)} \times \text{distance (km)}$	
<p>P7.4 What are stars?</p>	<p>Page numbers in New Physics for You</p>
<p>1. recall that all hot objects (including stars) emit a continuous range of electromagnetic radiation, whose total intensity and peak frequency increases with temperature;</p>	<p>(207)</p>
<p>2. recall that the removal of electrons from atoms is called ionisation and that electron movement within atoms produces line spectra;</p>	<p>(244, 274, 338)</p>
<p>3. recall that the spectrum of a star also contains some specific spectral lines, and that these provide evidence of the chemical elements present in it;</p>	<p>158</p>
<p>4. use data on the spectrum of a star, together with data on the line spectra of elements, to identify elements present in it;</p>	
<p>5. recall that when the volume of a gas is reduced its pressure increases and be able to explain this using a molecular model;</p>	<p>29, 34</p>
<p>6. explain why the pressure or volume of a gas varies with temperature and interpret absolute zero using a molecular model;</p>	<p>30-3, 34</p>
<p>7. recall that -273°C is the absolute zero of temperature, and be able to convert temperatures in K to temperatures in $^{\circ}\text{C}$ (and vice versa);</p>	<p>27</p>
<p>8. explain the formation of a protostar in terms of the effects of gravity compressing a cloud of gas;</p>	<p>152</p>
<p>9. understand that nuclear processes discovered in the early 20th Century provided a possible answer to the mystery of the Sun's energy source;</p>	<p>156</p>
<p>10. explain that compressing the gas, e.g. in a protostar, will raise its temperature;</p>	<p>152</p>
<p>11. describe the results of the Rutherford-Geiger-Marsden alpha particle scattering experiment as indicating that a gold atom contains a small, massive, positive region (the nucleus);</p>	<p>342, 372</p>
<p>12. recall that the nucleus contains positive protons and neutral neutrons;</p>	<p>342-3</p>
<p>13. explain that protons are held together in the nucleus by a strong force much greater than the repulsive electrical force between them;</p>	<p>(worksheet)</p>

14. recall that hydrogen nuclei can fuse into helium nuclei, releasing energy, if brought close together;	p. 156
15. recall that a star contains: a hotter core, where fusion takes place; a convective zone, where energy is transported to the surface by convection; the photosphere, where energy is radiated into space;	156
16. understand that all stars change when there is insufficient hydrogen in the core for fusion to continue;	157
17. recall that small stars like our Sun become red giants when the core hydrogen is depleted, while larger stars become red supergiants;	157
18. understand that red giants and red supergiants liberate energy by fusing helium into larger nuclei such as carbon, nitrogen and oxygen;	157
19. explain that red giants lack the mass to compress the core further at the end of the helium fusion, and they then shrink into hot white dwarfs, which gradually cool;	157
20. explain that fusion in red supergiants continues to larger nuclei due to the higher pressures in the core;	157
21. recall that fusion in large stars ceases when the core has been largely converted into iron, and the star then explodes in a supernova, leaving a dense neutron star or black hole.	157