SINGLE SCIENCE GCSE

PHYSICS

CORE KNOWLEDGE
KEYWORDS and
SPECIFICATION

Physics GCSE resources on-line

To help you access my resources you can email me (rmacpherson@aylshamhigh.norfolk.sch.uk) and request this information with the **links** or you can use the **QR codes**.

Revision videos on YouTube

My Channel is called **Revision with Miss Mac**

(P1, P2, top 10 tips, core practicals and physics other things playlists):

Quizlet for interactive revision

My account is called **Revisionwithmissmac**

Core knowledge, keywords and some Maths bits too:

https://www.youtube.com/results?search_query=revision+with+miss+mac

https://quizlet.com/Revisionwithmissmac

Google drive:

I have now uploaded all the **core questions** for the 9-1 GCSE, all the **checklists** and all the **keywords**. I have made a new **homework** folder (for students who lose their booklets). I have made an **assessments** folder (for students who need to repeat them). All the **past papers** I have are uploaded and there are other things like the textbook and the answers booklet etc.

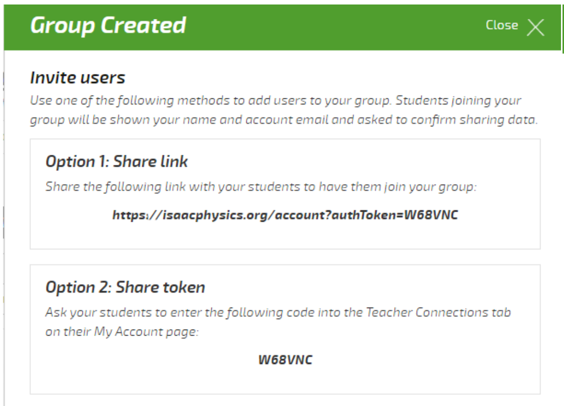
There is just one link to everything now and it is:

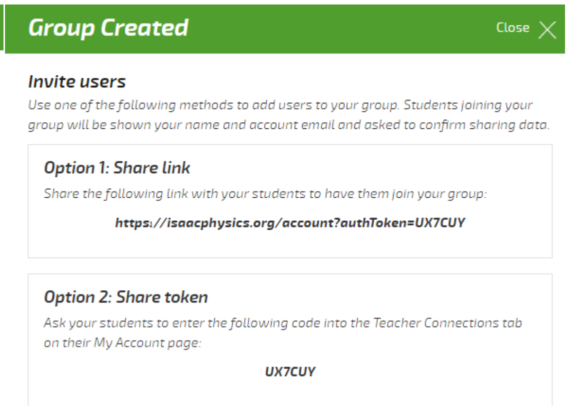
https://drive.google.com/drive/folders/11LgrxteJKXLuFFacHuWPd5Weorxh8nMJ

QR code:

Isaac Physics

If you want to focus on extending your mathematical physics application try my tasks on Isaac physics. Please turn over for codes ……….





Year 11 only

Year 10 and 11

Please let me know if you cannot make anything work or to tell me what you find useful, by e-mailing me **rmacpherson@aylshamhigh.norfolk.sch.uk**

GCSE Physics (9-1)

Assessment will be 2 (1hr 45min) exams at the end of year 11 both worth 50% each.

Physics exams will be:
A mixture of different question styles, including multiple-choice questions, short answer questions, calculations and extended open-response questions.

55% on a selection of core knowledge and applications of core knowledge via multiple choice, long answer and extended writing questions (6*).

30% mathematical applications.

15% on practical skills.

Paper 1 (*Paper code: 1PH0/1F and 1PH0/1H)
Written examination: 1 hour and 45 minutes ***50% of the qualification*** ***100 marks***
Content overview • Topic 1 – Key concepts of physics • Topic 2 – Motion and forces • Topic 3 – Conservation of energy • Topic 4 – Waves • Topic 5 – Light and the electromagnetic spectrum • Topic 6 – Radioactivity • Topic 7 – Astronomy
Assessment overview A mixture of different question styles, including multiple-choice questions, short answer questions, calculations and extended open-response questions.

Paper 2 (Paper code: 1PH0/2F and 1PH0/2H)
Written examination: 1 hour and 45 minutes ***50% of the qualification*** ***100 marks***
Content overview • Topic 1 – Key concepts of physics • Topic 8 – Energy - Forces doing work • Topic 9 – Forces and their effects • Topic 10 – Electricity and circuits • Topic 11 – Static electricity • Topic 12 – Magnetism and the motor effect • Topic 13 – Electromagnetic induction • Topic 14 – Particle model • Topic 15 – Forces and matter
Assessment overview A mixture of different question styles, including multiple-choice questions, short answer questions, calculations and extended open-response questions.

Students should be able to recall and apply all the following equations

Students may be asked to recall, recall and apply, or only apply these equations in the exam papers. If students are required to only apply an equation from this section the equation will be given in the question.

Equations required for higher tier only are shown in bold text. Higher tier only equations will not be required in the foundation tier papers.

Specification reference	Equation
2.6b	distance travelled = average speed × time
2.8	acceleration = change in velocity ÷ time taken $a = \frac{(v - u)}{t}$
2.15	force = mass × acceleration $F = m \times a$
2.16	weight = mass × gravitational field strength $W = m \times g$
2.24	**momentum = mass × velocity** $\boldsymbol{p = m \times v}$
3.1 and 8.8	change in gravitational potential energy = mass × gravitational field strength × change in vertical height $\Delta GPE = m \times g \times \Delta h$
3.2 and 8.9	kinetic energy = $\frac{1}{2}$ × mass × (speed)^2 $KE = \frac{1}{2} \times m \times v^2$
3.11 and 8.15	efficiency = $\frac{\text{(useful energy transferred by the device)}}{\text{(total energy supplied to the device)}}$
4.6	wave speed = frequency × wavelength $v = f \times \lambda$

	wave speed = distance ÷ time $v = \frac{x}{t}$
Specification reference	**Equation**
8.6	work done = force × distance moved in the direction of the force $E = F \times d$
8.13	power = work done ÷ time taken $P = \frac{E}{t}$
9.7P	moment of a force = force × distance normal to the direction of the force
10.6	energy transferred = charge moved × potential difference $E = Q \times V$
10.9	charge = current × time $Q = I \times t$
10.13	potential difference = current × resistance $V = I \times R$
10.29	power = energy transferred ÷ time taken $P = \frac{E}{t}$
10.31	electrical power = current × potential difference $P = I \times V$
	electrical power = current squared × resistance $P = I^2 \times R$
14.2	density = mass ÷ volume $\rho = \frac{m}{V}$

15.3	force exerted on a spring = spring constant × extension $F = k \times x$
15.11P	pressure = force normal to surface ÷ area of surface $P = \frac{F}{A}$

Students should be able to select and apply the following equations

Students may be asked to select and apply these equations in the exam papers. These equations will be given in a formulae sheet at the end of the exam papers.

Equations required for higher tier only are shown in bold text. Higher tier only equations will not be given in the formulae sheet for the foundation tier papers.

Specification reference	Equation
2.9	(final velocity)^2 – (initial velocity)^2 = 2 × acceleration × distance $v^2 - u^2 = 2 \times a \times x$
2.26	**force = change in momentum ÷ time** $\boldsymbol{F = \frac{(mv - mu)}{t}}$
10.27	energy transferred = current × potential difference × time $E = I \times V \times t$
12.13	**force on a conductor at right angles to a magnetic field carrying a current = magnetic flux density × current × length** $\boldsymbol{F = B \times I \times l}$
13.7P	$\frac{\textit{potential difference across primary coil}}{\textit{potential difference across secondary coil}} = \frac{\textit{number of turns in primary coil}}{\textit{number of turns in secondary coil}}$ $\boldsymbol{\frac{V_p}{V_s} = \frac{N_p}{N_s}}$

13.10	For transformers with 100% efficiency, potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil $V_P \times I_P = V_S \times I_S$
14.8	change in thermal energy = mass × specific heat capacity × change in temperature $\Delta Q = m \times c \times \Delta\theta$
14.9	thermal energy for a change of state = mass × specific latent heat $Q = m \times L$
14.19P	$P_1 \times V_1 = P_2 \times V_2$ to calculate pressure or volume for gases of fixed mass at constant temperature
15.4	energy transferred in stretching = 0.5 × spring constant × $(\text{extension})^2$ $E = \frac{1}{2} \times k \times x^2$
Specification reference	**Equation**
15.14P	**pressure due to a column of liquid = height of column × density of liquid × gravitational field strength** $\boldsymbol{P = h \times \rho \times g}$

Core practical		Description
2.19	*Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*	Different masses must be used to investigate the effect of varying masses on the acceleration of a trolley down a ramp. Appropriate methods must be used to measure the force and time taken for the trolley to travel down the ramp, and data analysis must include calculating the acceleration.
4.17	*Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*	This investigation involves looking at the characteristics of waves and using the equation speed = frequency x wavelength It is expected that students will have looked at waves in a liquid using a ripple tank, and waves in a solid using a metal rod and a method of measuring the frequency. Suitability of apparatus to take these measurements must also be considered.
5.9	*Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter*	A light source with grating must be used to produce a beam of light, which must then be used to investigate the effect of refraction using a glass block. An appreciation of the interaction of the light ray with the glass block and the effect of changing medium on the light ray (moving towards and away from the normal) must be included.
5.19P	*Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*	A minimum of four different beakers or test tubes must be covered in different materials (different colours, or shiny/dull surfaces). The same volume of hot water must then be poured into each container, and covered with a lid. Using a thermometer the temperature can be monitored and recorded at fixed times using a stopwatch.
10.17	*Construct electrical circuits to:* *a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp* *b test series and parallel circuits using resistors and filament lamps*	This investigation involves constructing a circuit to investigate potential difference, current and resistance for a resistor and a filament lamp. The behaviour of parallel and series circuits must also be included, and this must be done using filament lamps. A series circuit should be set up initially with a resistor, ammeter and voltmeter. The current must be recorded at different voltages. This must then be repeated using a filament lamp instead of a resistor. To investigate series and parallel circuits, a parallel circuit must be set up with ammeters, voltmeters, and filament lamps. Readings from this circuit must then be compared with series circuits used initially. Analysis must include use of the equation voltage = current x resistance

14.3	*Investigate the densities of solid and liquids*	The density of a solid object must be determined by measuring the mass and volume of the object, and then using the equation density = mass /volume The volume must be determined by putting the object into water, and measuring the volume of water that has been displaced. The density of a liquid can be calculated by weighing the liquid using a balance, and determining the volume.
14.11	*Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice*	The temperature of crushed ice must be recorded using a thermometer. This must then be melted using a Bunsen burner and beaker of water as a water bath. The temperature must be monitored as the ice melts. To determine specific heat capacity of water, the temperature of water using a thermometer must be monitored while heating it using a heat supply connected to a joulemeter. This must then be used to calculate the specific heat capacity.
15.6	*Investigate the extension and work done when applying forces to a spring*	The stretching of a spring must be investigated by measuring the length of a spring with no weights, followed by adding varying masses and measuring the new length. This must include calculating the work done and an appreciation of the forces involved.

Paper 1 (*Paper code: 1PH0/1F and 1PH0/1H)
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Physics Key Concepts

What is the standard unit and symbol for A) distance B) mass C) time D) temperature	 A) metre, m B) kilogram, kg C) second, s D) kelvin, K
What is the derived unit and symbol for A) Frequency B) Force C) Energy D) Power E) Pressure F) Electric charge G) Electric potential difference H) Electric resistance I) Magnetic flux density	 A) hertz, Hz B) newton, N C) joule, J D) watt, W E) pascal, Pa F) coulomb, C G) volt, V H) ohm, Ω I) tesla, T
Write the decimal of A) giga (G) B) mega (M) C) kilo (k) D) centi (c) E) milli (m) F) micro (μ) G) nano (n)	 A) 1,000,000,000 (10^9) B) 1,000,000 (10^6) C) 1000 (10^3) D) 0.01 ($10-^2$) E) 0.001 (10^{-3}) F) 0.000001 (10^{-6}) G) 0.000000001 (10^{-9})
How do you convert minutes into hours	Divide minutes value by 60
How do you convert minutes into seconds	Multiply minutes value by 60
Convert the following into standard form:	
In calculation questions what must you remember to do?	Substitute in values in standard units, show working out clearly and show the units on the answer. Triangles are a tool to help us re-arrange equations.

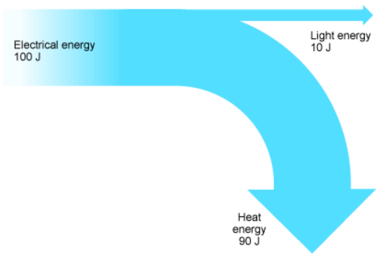
Core questions for topic 2 Motion and forces

Why are displacement, velocity, acceleration, forces and momentum all vector quantities and not scalar quantities?	Because they have size (magnitude) and direction. (scalar quantities only have size)
Is displacement a vector or a scalar?	Vector
Is distance a vector or a scalar?	Scalar
Is speed a vector or a scalar?	Scalar
Is velocity a vector or a scalar?	Vector
Is acceleration a vector or a scalar?	Vector
Is force a vector or a scalar?	Vector
Is weight a vector or a scalar?	Vector
Is mass a vector or a scalar?	Scalar
Is momentum a vector or a scalar?	Vector
Is energy a vector or a scalar?	Scalar
What is velocity?	The speed in a particular direction.
What are the units for speed?	Metres per second (m/s)
What are the units for time?	Seconds (s)
What are the units for distance?	Metres (m)
What are the units for velocity?	Metres per second (m/s)
What are the units for displacement?	Metres (m)
What does the gradient of a distance-time graph tell you about the motion?	The speed.
What is the shape of a distance-time graph when the object is travelling at a constant velocity?	A straight diagonal line – the steeper the gradient, the faster the speed.
What is the shape of a distance-time graph when the object is stationary?	A horizontal straight line – distance is not changing with time.
What is the shape of a distance-time graph when the object is accelerating?	A curved line – as the speed increases the gradient of the curve gets steeper.
What are the units for acceleration?	m/s^2 (metres per second per second)
What is the shape of a velocity-time graph when the object is travelling at a constant velocity?	A horizontal straight line – velocity is not changing with time.
What is the shape of a velocity-time graph when the object is stationary?	A straight horizontal line along the x-axis at 0m/s.
What is the shape of a velocity-time graph when the object is accelerating?	A straight diagonal line going up– the steeper the gradient, the more rapid the acceleration.
What is the shape of a velocity-time graph when the object is decelerating?	A straight diagonal line going down – the steeper the gradient, the more rapid the deceleration.
How do you calculate the acceleration or deceleration from a velocity-time graph?	Work out the gradient of the line.
How do you work out the distance travelled using a velocity-time graph?	Calculate the area under the line on the graph.

What equipment can be used to experimentally find the speed of a moving object?	You can time it with a stopwatch over a set distance but this will be subject to human error. A more accurate way would be to use light gates. As the object passes the first gate, the timing starts and as it crosses the second gate the timing stops. If the distance is known between the two points, the average speed can be calculated. Using a card of known length, to interrupt the light beam, the actual speed at each light gate can be calculated. This would allow changes in speed to be measured, for example accelerations.
Estimate the speeds of these: a string breeze, sound in air, walking pace, cycling pace, car in built up area, car on motorway, a commuter train, a ferry, an aeroplane and light in a vacuum.	Strong breeze 25m/s, sound in air 330m/s, walking pace 1.4m/s, cycling pace 6m/s, car in built up area 10.5m/s, car on motorway 31m/s, commuter train 55m/s, a ferry 18m/s, an aeroplane 250 m/s and light in a vacuum 300000000m/s.
What is the acceleration due to gravity on earth? (g)	10 m/s^2
Estimate the accelerations of these: an ordinary car, a supercar, a person on a bicycle, a rollercoaster and the bullet from a gun	An ordinary car 3 m/s^2, a supercar 6 m/s^2, a person on a bicycle 0.5m/s^2, a rollercoaster 40m/s^2 and a bullet 1000000 m/s^2
What is a free-body diagram used to show?	The size and direction of the different forces acting on a single object.
What are action and reaction forces?	When 2 bodies interact (for example, your foot and a football) they exert forces on each other that are equal in size and opposite in direction.
What is the extra left over force called in an unbalanced situation?	Resultant
What are forces measured in?	Newtons (N).
How do you calculate the resultant force?	You subtract the total of the forces in one direction from the total force in the opposite direction.
What do resultant forces change?	The speed, direction and/or the shape of an object.
When the forces on an object are balanced, what is the resultant force and what effect will it have?	Zero – there is no resultant force and so there will be no change to the objects speed, direction or shape.
Name two common resistance forces that slow objects down.	Friction and air resistance.
If the resistance forces on a moving object are equal in size with the thrust forces exerted on it – what is the acceleration of the object?	There will be no acceleration – there is no resultant force to make any change so the object will continue to move at the same speed in a straight line.

If the resistance forces on a moving object are smaller in size with the thrust forces exerted on it – what is the acceleration of the object?	It will accelerate in the direction of the thrust force.
If the resistance forces on a moving object are greater in size with the thrust forces exerted on it – what is the acceleration of the object?	It will decelerate.
Which equation states Newton's second law?	F=ma (resultant force = mass x acceleration)
What are the units for mass?	Kg (kilograms)
What are the two different units for gravity and why are they different?	m/s^2 (metres per second per second) the acceleration due to gravity, and N/kg (newtons per kilogram) the gravitational field strength.
Why is mass a scalar quantity and weight a vector quantity?	Mass is the amount of matter. It is a scalar quantity because it only has size (measured in kg). Weight is a **force** due to gravity. It has a size (measured in N) and a direction.
How is weight calculated?	Weight (N) = Mass (kg) x g (m/s^2 or N/kg)
How can weight be measured?	Using a force meter (Newton meter).
How is weight affected by the gravitational field strength?	Weight will change depending on the gravitational field strength of the planet, moon etc that the object is on. The stringer the gravitational field strength, the heavier the weight. (For example a 1kg mass bag of sugar will weigh 9.8N on earth, and only 1.6N on the moon).
A coin and a feather are dropped from the same height on earth. Which will hit the ground first and why?	The coin because it will have less air resistance acting on it.
A coin and a feather are dropped from the same height on the moon. Which will hit the ground first and why?	They will hit the ground together because there is no air resistance on the moon (in a vacuum) and so both the coin and the feather will accelerate at the same rate.
As speed increases, what happens to air resistance?	As an object gets faster, air resistance increases.
Why does air resistance not continue to increase with speed indefinitely?	There will be a point at which the air resistance will be large enough to balance with the force that is moving the object. At this point the object can no longer accelerate, it can't get any faster and so air resistance cannot increase any more.
What is terminal velocity?	When the forces of a moving object are balanced and there is no resultant force, the object travels at a constant speed this is called terminal velocity.
What is the acceleration of an object that has reached terminal velocity?	0 m/s^2 (It cannot accelerate as there is no resultant force)

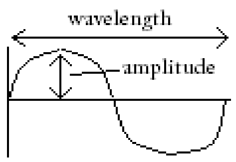
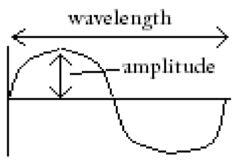
When an object moves in a circle at a constant speed, is the velocity constant? Explain!	No. The direction is changing and velocity is a vector quantity, the direction is important.
When an object moves in a circle at a constant speed, why is it accelerating?	There is a change of velocity over time, therefore the object is accelerating.
When an object moves in a circle at a constant speed, what causes the acceleration? (what must there be for an object to move in a circle?)	A resultant force.
What is this resultant force called?	Centripetal force.
What direction is the centripetal force in?	Towards the centre of the circle.
What is inertial mass?	It is a measure of how difficult it is to change the velocity of the object. It is defined as the ratio of resultant force over acceleration (m= F/a) as described by newton's second law.
What are the units for momentum?	Kilogram metres per second (Kg m/s)
Why is momentum a vector quantity?	It has a size and a direction.
What is meant by conservation of momentum?	The total momentum before a collision is equal to the total momentum after a collision. (Remember - direction is really important here!).
How do crumple zones, air bags and seat belts help protect passengers?	They all are designed to increase the time it takes to reduce the momentum of the vehicle to zero and so they reduce the force on the passengers. **F= (mv – mu)/t**
What is the thinking distance?	The distance travelled in the time it takes the driver to react. It is measured in m.
What is the braking distance?	The distance travelled in the time it takes between the driver applying the brakes and the vehicle stopping. It is measured in m.
How do you calculate stopping distance?	Thinking distance + Braking distance. It is measured in m.
Which factors affect the stopping distance?	Mass of the vehicle, speed of the vehicles, the driver's reaction time (age, drugs etc), the condition of the brakes and the road conditions (frictional forces).
Estimate the forces involved in a squash ball hitting a wall, a car hitting a wall and 2 cars hitting each other.	A squash ball hitting a wall 30N, a car hitting a wall 200 000N and 2 cars hitting each other 300 000N.

Question	Answer
State the 2 energy transfers that happen in a solar battery charger.	Light energy to electrical energy Electrical energy to chemical energy
If 200 J of electrical energy is supplied to a bulb and 50 J is transferred as light energy, how much energy is wasted as heat?	200 – 50 = 150 J
What is the law of conservation of energy?	Energy can never be created or destroyed, only transferred from one store (or form) to another.
Draw a Sankey diagram to show that 100J of electrical energy is transferred into 10J of light energy and ?J of thermal (or heat) energy.	
An objected is lifted upwards, what is the energy transfer that takes place?	Kinetic energy is transferred to gravitational energy.
A moving object crashes into a wall. What types of energy does its kinetic energy get transferred into?	Heat and sound
An object is accelerated by a force, what type of energy does it gain?	Kinetic energy
A moving vehicle applies its brakes, what type of energy does its kinetic energy get transferred into and where is most of this energy stored?	Heat, stored in the brakes
What happens to electrical energy when using a kettle to boil water?	Some is transferred usefully to heat energy in the water and some is wasted heating the surroundings.
When energy transfers happen in a closed system, what is the net change in the total energy of that system?	There is no net change (of total energy) in a closed system.
When a mechanical process wastefully transfers energy to heat, what happens to the heat?	Heat is dissipated, heating the surroundings.
A stiff bicycle chain wastefully dissipates some energy as heat and sound. Describe how this unwanted energy transfer can be reduced.	Lubricate the chain to reduce friction.
A boiler's hot water tank wastefully dissipates some of its heat energy to its surroundings. Describe how this unwanted energy transfer can be reduced.	Insulate the tank to slow down the rate at which heat is lost to the surroundings.
State the three ways that energy can be transferred by heating.	Conduction, convection, radiation.
If the thickness of a buildings walls are increased, what will happen to its rate of cooling?	Rate of cooling will decrease.
If a building is made of materials that have a decreased thermal conductivity, what will happen to its rate of cooling?	Rate of cooling will decrease.
State the equation for energy efficiency.	$\text{efficiency} = \frac{\text{(useful energy transferred by the device)}}{\text{(total energy supplied to the device)}}$
A bulb is supplied with 200 J of electrical energy, but only 50 J is transferred as useful	Efficiency = (useful energy transferred) ÷ (total energy supplied) = 50 ÷ 200 = 0.25 (or 25%)

light energy. Calculate the efficiency of the bulb.	
Explain how efficiency can be increased. Give an example.	**Efficiency can be increased by reducing the proportion of energy dissipated wastefully.** **E.g. Insulating a boiler tank reduces heat lost to surroundings, so a larger proportion of the input energy can be used to heat the water.**
State the equation for calculating a change in gravitational potential energy.	change in gravitational potential energy (J) = mass (kg) × gravitational field strength (N/kg) × change in vertical height (m) ΔGPE= m x g x Δh
A 25 kg object on Earth (g=10 N/kg) is lifted 2 m. Calculate its change in GPE.	ΔGPE= m x g x Δh = 25kg x 10N/kg x 2m = 500 J
State the equation for calculating the kinetic energy of an object.	kinetic energy (J) = $^1/_2$ × mass (kg) × speed^2 ((m/s)^2) KE = $^1/_2$ x m x v^2
A 10 kg object is travelling at 5 m/s. Calculate its kinetic energy.	KE = $^1/_2$ x m x v^2 = 0.5 x 10kg x (5m/s)^2 = 0.5 x 10 x 25 = 125 J
State 2 non-renewable energy sources.	Fossil fuels (oil, natural gas and coal) and nuclear power.
Why are many countries trying to reduce the amount of fossil fuels they use?	To reduce pollution and contribution to climate change. To make remaining supplies last longer.
Which type of fossil fuel power station releases the least pollution (per unit of electrical energy produced)?	Natural gas
State 3 renewable power sources.	Solar power, wind turbines, hydro-electricity, tidal power, bio-fuel/biomass & geothermal power.
Why are bio-fuels considered to be “carbon neutral”?	In theory, they release the same amount of carbon dioxide as was taken from the atmosphere by the plants (that they’re made from) as they grew.
State two ways of using solar power.	Solar cells convert energy from sunlight directly into electrical energy. Sunlight can be used to heat water in solar panels.
Why are bio-fuels not always completely “carbon-neutral”?	Additional carbon dioxide is released farming the bio-fuel crops and in the process of turning them into fuel.
Give one reason why is it currently impractical to use renewable resources and nothing else?	-Many renewable resources take up a lot of space. -Some renewables (e.g. solar) aren’t always available. -Renewables can be expensive to set up.

<u>Topic 4 waves - Core Questions</u>

You must learn the answers to each of these questions. **Bold indicates higher tier only.**

What do waves transfer?	Energy and information but **not** matter.
What evidence is there that waves do not transfer matter?	For water waves, a float on the surface of the water will move only up and down not across the water. For sound waves, an air particle will vibrate back and forth not travel across the room.
Give examples of longitudinal waves	Sound waves (including ultrasound and infrasound) and seismic P (primary) waves.
Which type of wave has the direction of the vibration parallel to the direction of energy travel?	Longitudinal
Give examples of transverse waves	All of the electromagnetic waves including light, seismic S (secondary) waves, water waves and waves on a string.
Which type of waves has the direction of the vibration is perpendicular to the direction of energy travel?	Transverse
What is the wavelength and what is it measured in?	The length of 1 complete wave cycle. It is measured in meters (m). 
What is the amplitude and what is it measured in?	The distance from the centre of a wave to the top of the wave. It is measured in meters (m). 
What is the frequency of a wave and what is it measured in?	The number of waves in 1 second and the unit is Hertz (Hz)
What is wave velocity and how is it different to wave speed?	Wave velocity describes both how fast the wave is travelling (m/s) and in which direction. It is a vector quantity. Wave speed is only how fast the wave is going (still m/s). It is a scalar quantity.
What is the period of a wave and what is it measured in?	The time for 1 complete wave. It is measured in seconds (s).
What is the name given to describe the surface over which a wave has maximum and minimum values (peaks and troughs)?	Wavefront.
As the wavelength of a wave increases, how is its frequency changed? (Assuming that it is travelling at a constant speed).	The frequency would decrease.
As the speed of a wave increases, what happens to the wavelength of the wave? (Assuming that the frequency is constant).	The wavelength would get longer.
What 2 variables affect the speed of a wave?	The kind of wave it is and what the wave is moving through.
What happens to the speed of sound as you move from gas to liquid to solid?	It increases. This is because there are more particles to pass on the vibrations.
What is the speed of sound in a vacuum?	0 m/s. Sound cannot travel through a vacuum as there are no particles to pass on the vibrations.

Which two equations can be used to find the velocity of a wave?	Distance / time and frequency x wavelength.
In calculation questions what must you remember to do?	Substitute in values in standard units, show working out clearly and show the units on the answer. Triangles are a tool to help us re-arrange equations.
What are the standard units for speed?	Metres per second (m/s).
What are the standard units for distance?	Metres (m).
What are the standard units for time?	Seconds (s).
Describe how to measure the velocity of sound in a gas like air.	Use a signal generator to produce a sound of known frequency. Connect 2 microphones to an oscilloscope to detect the sound waves in front of the speaker. Move 1 microphone away until the waveforms are aligned. Measure the distance between the microphones as this is the wavelength of the sound wave. The speed (in m/s) will be frequency (Hz) x wavelength (m).
Describe how to measure the velocity of a wave in a liquid like water.	Use a ripple tank to create water waves. Measure the distance between 2 peaks, this is the wavelength. Find the frequency by counting the number of waves past a point in 10s and divide by 10. The speed (in m/s) will be frequency (Hz) x wavelength (m). Alternatively, mark 2 points on the side of the ripple tank and time how long it takes 1 wave to travel between the 2 points. Measure the distance of the 2 points. The speed (in m/s) will be distance (m) divided by time (s).
Describe how to measure the velocity of sound in a solid like steel.	Suspend the steel rod and hit it with a hammer. Use a frequency app to record the peak frequency (or a microphone and oscilloscope). Measure the length of the steel rod. Wavelength = 2 x length and so divide the length by 2 to find wavelength. The speed (in m/s) will be frequency (Hz) x wavelength (m).
What type of substances absorb waves?	**Light waves are absorbed by black materials. Sound waves can be absorbed by soft furnishings.**
What type of substances reflect waves?	**Mirror and shiny materials reflect light waves. Hard flat surfaces reflect sound waves.**
What type of substances transmit waves?	**Clear materials like glass and plastic transmit light waves. Sound can be transmitted through thin materials like walls, doors and windows.**
What property of the wave is the behaviour (absorption, transmission, reflect or refract) dependent on?	**The wavelength of the wave.**
What happens to light as it passes from one material to another?	Some of it will be reflected (bounced off) and some will be refracted (bent through).
What is refraction and what causes it?	Refraction is the bending (change of direction) of a wave as it passes between different materials. **It is caused by the slowing down or speeding up of the wave as it travels from one density to a different density.**
As light travels from a more dense material to a less dense material, what direction will it bend in?	Away from the normal line.
If light is allowed the travel into a glass block and out of the other side again, what would you notice about the incident ray and the emergent ray?	They will be parallel to each other. You might also notice the incident ray is slightly brighter than the emergent ray as some energy may have been absorbed by the glass as the wave is transmitted through.

If a wave travels 90 ° to the surface (along the normal line) of a material what will not change and what will change?	**Direction will not change but speed still will. This means that the wavelength will change for a constant frequency but the direction of the wave will continue in a straight line and not bend.**
What happens to a water wave as it travels from shallow water to deeper water?	**It will speed up in deeper water. This will cause the wavelength to increase (for a fixed frequency) and if the waves arrive at the deep water at any angle other than 90 °, they will change direction.**

Core question topic 4 (part 2) Waves

What can happen to a wave when it reaches an interface between 2 different materials?	It can be reflected, refracted, transmitted or absorbed.
What is the difference between reflection and refraction?	Reflection is when the wave is bounced back (i=r). Refraction involves changing the speed and direction of the wave as it passes into the new material (slower speed towards the normal and faster speed away from the normal).
What is the difference between absorbed and transmitted?	A transmitted wave passes through a material but an absorbed wave cannot travel though as the energy it is carrying is transferred to the material.
How are pitch and frequency related?	The higher the frequency, the higher the pitch of the sound.
The pitch of a sound is not affected as the sound wave travels from one material to another but what must change?	The velocity of the wave changes in different materials and so ($c=f\lambda$) the wavelength must also change.
Give examples of longitudinal waves (where the direction of the vibration is the same as the direction of energy travel).	Sound waves (including ultrasound and infrasound) and seismic P (primary) waves.
Give examples of transverse waves (where the direction of the vibration is perpendicular to the direction of energy travel).	All of the electromagnetic waves including light etc and seismic S (secondary) waves.
What type of wave is a sound wave?	Longitudinal wave – vibrations of particles are parallel to the direction of energy transfer (wave movement).
How does a sound wave travel through air?	The particles of the air vibrate back and forth as the energy is transferred (as the wave passes).
How are sound waves affected as they move from air to solid steel?	When the sound wave reaches the steel, some of the energy is reflected and some is absorbed by it and some is transmitted through the steel. The sound wave causes a change in pressure on the surface of the steel which in turn causes the steel particles to vibrate. The speed of the wave will increase and the energy can be passed on as both longitudinal waves and transverse waves.
Where do sound waves enter the ear?	The ear canal
What is the eardrum and how does it help us hear?	It is a thin membrane which is caused to vibrate by sound waves, passing on the vibrations into the inner ear.
What do the tiny bones in the ear do?	The bones (hammer, anvil and stirrup) amplify the vibrations before they are passed on to the cochlea.

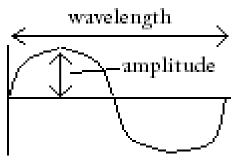
What is the cochlea?	A coiled tube containing a liquid that is about 9mm in diameter. The vibrations are passed on to the liquid and then tiny hairs inside the cochlea detect these vibrations and create electrical impulses. Each hair is connected to a neurone that sends an impulse to the brain.
What connects the ear to the brain?	The auditory nerve – electrical impulses travel along neurones here.
Which parts of the ear are the vibrations occurring in a solid?	Ear drum and ear bones
Which parts of the ear are the vibrations occurring in a liquid?	Cochlea
Which parts of the ear are the vibrations occurring in a gas?	Ear canal
What range of frequencies can the human ear detect?	20 Hz to 20,000 Hz
Why is the human ear limited to hearing a range of frequencies between 20 Hz and 20,000 Hz?	The membrane that the cochlea is made from differs in thickness and stiffness, so the part of the membrane that vibrates depends on the frequency of the sound. Different thicknesses of membrane vibrate best at different frequencies. The base is thickest and stiffest and so it detects high frequencies but only up to 20,000 Hz. The apex is thinnest and most flexible, detecting low frequencies but only as low as 20 Hz.
Define ultrasound	Sound with a frequency greater than 20,000 Hz.
Define infrasound	Sound with a frequency less than 20 Hz.
How do mice, use ultrasound?	To communicate with each other.
How do bats use ultrasound?	To detect objects around them using the reflection of ultrasonic waves.
What is sonar?	Sonar equipment can be used on boats and submarines to find the depth of the sea, or detect fish by sending out an ultrasonic pulse and timing how long it takes to receive the echo (reflected wave) back to the detector (microphone).
Which equation can be used to calculate the depth or distance from time and wave velocity (for example when using sonar equipment)?	Distance (or depth) in m = speed in m/s x time in s. It is important to remember that the distance calculated is there and back and so don't forget to divide it by 2!
Why is ultrasound used in sonar?	This high frequency sound wave travels long distances in water (much further than light) but also does not diffract (spread out) too much and so it is reflected straight back.
Give uses of ultrasound.	Sonar, communication between animals like mice, navigation for animals like bats, medical scanning and ultrasonic cleaners.
Where is ultrasound used in diagnosis?	Scanning during pregnancy and to locate kidney stones, cysts etc in internal organs
Why is a gel used in ultrasound scanning?	To help prevent the sound waves just being reflected off the skin.
How does ultrasound show a picture of a developing foetus?	A probe emits the ultrasound and then receives the echoes (reflections) which occur at each interface (ie between bone and fat) and uses the calculated time and intensity to build a picture as the ultrasound as it is reflected back differently from different types of tissue.

Where is ultrasound used in treatment?	To break up kidney stones and in treating muscle problems.
Give uses of infrasound.	Communication between animals, like elephants, detection of animal movement in remote places, detection of volcanic eruptions and meteors.
What causes seismic waves?	Earthquakes or explosions.
Why is it difficult to predict earthquakes?	The earth's tectonic plates are constantly moving and there are never two occasions when the amount of energy needed to move the surface is the same.
Name 2 types of seismic wave.	Longitudinal (P) waves and Transverse (S) waves. (Where P = primary and S = secondary).
What causes these seismic waves to reflect and refract?	Both waves move through the center of the Earth which is made of different materials. When these waves reach a boundary they can be reflected or refracted.
What is a seismometer?	A piece of equipment that can be used to detect seismic waves.
How can the epicentre of an earth quake be found?	We know that P waves travel faster than S waves. Both are produced at the same time so by measuring the time difference between their arrival at the seismometer, we can work out how far away the epicentre is from the monitoring station. If there are at least 3 monitoring stations the epicentre can then be triangulated.
How do seismic waves help us understand the structure of the Earth?	Infrasound can travel a long way, the whole diameter of the Earth. Using information about the time that the seismic waves arrive in different places around the world and the speed of the waves in different rocks, scientists have been able to model the paths taken by the waves through the Earth as they are reflected and refracted in the same patterns wherever the earthquake occurs.
What is the S-wave shadow zone?	A place where no S waves are detected. It will be on the opposite side of the Earth to the earthquake and is caused because S waves cannot travel through a liquid and so part of Earth's core must be liquid. The outer core is liquid.
What is the P-wave shadow zone?	An area where no P waves are detected (or very few and weak P waves). There is a big change of direction between a wave that just skims the outer core and one that enters it which leaves a shadow area where none are detected because of this greater diffraction. This confirms that the outer core must be a liquid. The detection of weak P waves in this area could only happen if the inner core was solid because something solid had to reflect these waves.
Why do the earths tectonic plates move?	There are convection currents in the earth's Mantle (Hot liquid rock underneath the earth's crust) that force liquid rock up between plate boundaries forcing the plates to move apart.
What can P-waves travel through?	P-waves can travel through solid and liquid at speeds of about 10km/s. So, these waves can travel from one side of earth through to the opposite point.

What can S-waves travel through?	S-waves can travel through solids but NOT liquids at speeds of about 6km/s. So, these waves cannot travel through the liquid outer core of the earth and cannot be detected at the opposite point on the earth.
What causes an earthquake?	At plate boundaries, tectonic plates slide past one another.

Topic 5 Light and the electromagnetic spectrum - Core Questions

You must learn the answers to each of these questions. **Bold indicates higher tier only.**

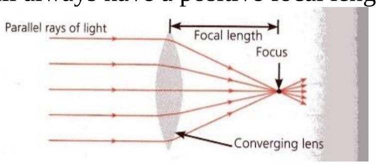
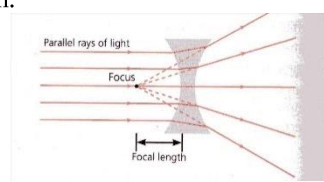
What do waves transfer?	Energy from the source to the observer. They can transfer information but **not** matter.
All of the electromagnetic waves including light are what type of wave?	Transverse waves
Which type of waves has the direction of the vibration is perpendicular to the direction of energy travel?	Transverse
What is the wavelength and what is it measured in?	The length of 1 complete wave cycle. It is measured in meters (m). 
What is the frequency of a wave and what is it measured in?	The number of waves in 1 second and the unit is Hertz (Hz)
What is wave velocity and how is it different to wave speed?	Wave velocity describes both how fast the wave is travelling (m/s) and in which direction. It is a vector quantity. Wave speed is only how fast the wave is going (still m/s). It is a scalar quantity.
What variable affects the speed of a light wave?	What the wave is moving through.
Which two equations can be used to find the velocity of a wave?	Distance / time and frequency x wavelength.
In calculation questions what must you remember to do?	Substitute in values in standard units, show working out clearly and show the units on the answer. Triangles are a tool to help us re-arrange equations.
Describe how to measure the velocity of sound in a solid like steel.	Suspend the steel rod and hit it with a hammer. Use a frequency app to record the peak frequency (or a microphone and oscilloscope). Measure the length of the steel rod. Wavelength = 2 x length and so divide the length by 2 to find wavelength. The speed (in m/s) will be frequency (Hz) x wavelength (m).
What happens to light as it passes from one material to another?	Some of it will be reflected (bounced off) and some will be refracted (bent through).
What is refraction and what causes it?	Refraction is the bending (change of direction) of a wave as it passes between different materials. **It is caused by the slowing down or speeding up of the wave as it travels from one density to a different density.**
As light travels from a more dense material to a less dense material, what direction will it bend in?	Away from the normal line.
If light is allowed the travel into a glass block and out of the other side again, what would you notice about the incident ray and the emergent ray?	They will be parallel to each other. You might also notice the incident ray is slightly brighter than the emergent ray as some energy may have been absorbed by the glass as the wave is transmitted through.
If a wave travels 90 ^{o}to the surface (along the normal line) of a material what will not change and what will change?	**Direction will not change but speed still will. This means that the wavelength will change for a constant frequency but the direction of the wave will continue in a straight line and not bend.**
What type of substances absorb waves?	**Light waves are absorbed by black materials.**
What type of substances reflect waves?	**Mirror and shiny materials reflect light waves.**

What type of substances transmit waves?	**Clear materials like glass and plastic transmit light waves.**
What property of the wave is the behaviour (absorption, transmission, reflect or refract) dependent on?	**The wavelength of the wave.**
How did Herschel and Ritter discover waves outside the limit of the visible spectrum?	Herschel noticed that if you split visible light up and measured the temperatures of the different colours the red light was hottest. He then moved the thermometer just outside the red colour where he could see no light and the thermometer recorded an even higher temperature. He called this wave energy Infrared. Ritter also split visible light up but looked for wave energy at the other end of the spectrum (the other side of the violet light). He tried to detect the presence of wave energy using silver chloride that he knew reacted with violet light faster than red light. He found that an unseen energy at this point in the spectrum made the silver chloride react even quicker. He called this energy Ultraviolet.
What are the colours of light in the visible spectrum? (Start with the longest wavelength)	Red, Orange, Yellow, Green, Blue, Indigo, Violet.
What is the order of waves in the electromagnetic spectrum? (Start with the longest wavelength)	Radio waves, Microwaves, Infrared waves, Visible light, Ultraviolet rays, X-rays, Gamma rays.
Which part or parts of the electromagnetic spectrum can we detect with our eyes?	Only visible light.
Which travels faster in a vacuum light or radio waves?	Neither, all electromagnetic waves travel at the same speed in a vacuum (3×10^8 m/s).
Which end of the electromagnetic spectrum has waves of the longest wavelength?	Radio waves
Which end of the electromagnetic spectrum has waves of the highest frequency?	Gamma rays
What are the harmful effects of excessive exposure to: 1. Microwaves 2. Infrared 3. Ultraviolet 4. X-rays and gamma rays?	1. Internal heating of body cells 2. Skin burns 3. Damage to surface cells and eyes, leading to skin cancer and eye conditions 4. Mutation or damage to cells in the body
What can happen to an atom if it is exposed to harmful electromagnetic waves?	The atom may gain enough energy to have an electron removed. This leaves it charged and so it becomes an ion.
As the frequency of a wave increases, what happens to the potential danger?	It increases too because of the increased energy.
What can be used to produce radio waves in a transmitter?	**Oscillations in electrical circuits in the transmitter. These oscillations can induce radio waves.**

Name some of the uses of: 1. Radio waves 2. Microwaves 3. Infrared 4. Visible light 5. Ultraviolet 6. X-rays 7. Gamma rays	1. Broadcasting, communications and satellite transmissions. 2. Cooking, communications and satellite transmissions 3. Cooking, thermal imaging, short range communications, optical fibres, TV remote controls and security systems. 4. Vision, photography and illumination. 5. Security marking, fluorescent lamps, detecting forged bank notes, disinfecting water. 6. Observing the internal structure of objects, airport security scanners and medical X-rays. 7. Sterilising food and medical equipment and the detection of cancer and its treatment.
Name 3 types of ionising electromagnetic radiation that transfer energy?	Short frequency UV rays, X-rays and gamma rays
What is a spectrometer?	A device that can split up the different wavelengths of light. (It splits light into its different colours).
Name a common object that could be used as a spectrometer.	A CD or DVD or a prism (a triangular shaped piece of glass).
What is the advantage of the Hubble space telescope?	As it is situated above the atmosphere so that light from distant objects enters it without being refracted or reflected which creates clearer images.

Core questions topic 5 (part 2) Light and the electromagnetic spectrum

When drawing a ray diagram, what should you remember?	Use a ruler and add an arrow to show the direction of the light ray.
How and why do we draw in the normal line?	Use a protractor to draw a dashed line 90˚to the surface because all angles are measured to this normal line
What is the law of reflection?	The angle of incident is equal to the angle of reflection
If light travels from a less dense material (like air) into a more dense material (like glass), what happens?	The light changes direction, it is refracted towards the normal line because one side of the light slows down before the other at the interface.
If light travels along the normal line from glass to air what happens?	The light speeds up but does not change direction as both sides of the light reach the interface together.
If light travels from a more dense material (like water) to a less dense material (like air), what happens (if the angle of incidence is less than the critical angle)?	The light is refracted. It changes direction by bending away from the normal line because one side of the light speeds up before the other at the interface. (Some light may also be reflected).
What is the name given to the incident angle when the angle of refraction is at 90˚?	The critical angle
What conditions must be met for total internal reflection to occur?	The angle of incidence must be greater than the critical angle and the light has to be travelling from a more dense material to a less dense material.
How do you see luminous objects?	They give out light which enters your eyes
How do you see non-luminous objects?	They reflect light into your eyes
What type of reflection do you get from rough surfaces?	Diffuse reflection where the light is scattered in all directions (but still obeys the law of reflection).
What surfaces do you get specular reflection from?	Very smooth surfaces.

What is white light?	A mixture of different wavelengths of visible light (ROYGBIV are the colours associated with each wavelength, red with the longest wavelength and violet with the shortest).
How do we see white objects?	All the wavelengths of visible light are reflected off the object together.
How do we see black objects?	All the wavelengths of visible light absorbed by the object.
How do we see yellow objects?	Only light with the wavelength of yellow light is reflected from the object, all the other wavelengths/colours of light are absorbed.
How does the colour of a filter affect the light transmitted through it?	Filters are transparent materials that only allow the wavelengths of that colour to be transmitted through and all other wavelengths are absorbed. For example, a blue filter only allows through blue light, all other colours are absorbed.
A red rose has a green stem. If white light is passed through a green filter to light up the rose, how will it appear?	The stem will look green and the flower head will look black. Only green light will be transmitted by the filter (ROYBIV will all be absorbed) and so the stem can reflect the green light, looking green but the red rose head will absorb the green light and reflect no light, appearing black.
What type of lens is a converging lens?	A lens that is thicker in the middle to refract the light rays together and focus them at a point behind the lens. It will always have a positive focal length. 
What type of lens is a diverging lens?	A lens that is thinner in the middle to refract the light rays away from each other and focus them at a point in front of the lens. It will always have a negative focal length. 
How is the power of a lens related to its shape?	The more curved the lens, the more powerful it is.
How is the power of a lens related to its focal length?	The more powerful the lens, the shorter the focal length.
What is a real image?	An image through which light rays pass, so that it can be seen on a screen placed at that point
What is a virtual image?	An image that light rays do not pass through; they only appear to come from the image.
Describe the image formed by a diverging lens	Virtual image, the right way up and diminished.
Describe the image formed by a converging lens if the object is more the 2 focal lengths away	Real image, inverted and diminished.
Describe the image formed by a converging lens if the object is between 1 and 2 focal lengths away	Real image, inverted and magnified.
Describe the image formed by a converging lens if the object is less than 1 focal length away	Virtual image, the right way up and magnified.
What is the relationship between temperature and intensity of radiation emitted?	As temperature increases the intensity of the emitted radiation increases.
How does temperature change the wavelength of the emitted radiation?	As the temperature increases, the wavelength gets shorter.

How can an object get warmer?	It must radiate less power (energy per second) than it absorbs.
How can an object get cooler?	It must radiate more power (energy per second) than it absorbs.
What must happen for an object to stay at the same temperature?	It must radiate the same amount of power as it absorbs.
Where does the Earth absorb energy from?	The Sun
What do the atmosphere, clouds and surface of Earth all do?	Reflect some energy away and absorb some energy and re-radiate energy back into space.
What affect do scientists believe greenhouse gases have on the temperature of Earth?	Extra greenhouse gases, like carbon dioxide, are absorbing more energy and the Earth is getting hotter.
Which part of the electromagnetic spectrum transfers energy by heating?	Infrared radiation
Which colour makes the best absorber of infrared radiation?	Matt black
Which colour makes the best emitter of infrared radiation?	Matt black
Which colour make the best reflector of infrared radiation?	Shiny white/silver

Topic 6 Radioactivity - Core questions

You must learn the answers to each of these questions.

What are the properties of alpha radiation?	Alpha particles are equivalent to a helium nucleus as they are made up from 2 protons and 2 neutrons. They have a charge of +2 and a relative mass of 4. They are highly ionising but not very penetrating. They are affected by electric and magnetic fields.
What are the properties of beta radiation?	Beta particles are high energy electrons that are released from the nucleus of the atom. They have a charge of +1 and a relative mass of 1/2000. They are ionising and fairly penetrating. They are affected by electric and magnetic fields.
What are the properties of gamma radiation?	Gamma is a high frequency electromagnetic wave. These waves have no charge or mass. They are weakly ionising but very penetrating. They are not affected by electric and magnetic fields. It is often released in alpha or beta decay to emit the excess energy.
What are the properties of positron radiation?	Positron particles are the anti-particle to the electron. They are released from the nucleus of the atom and have a charge of +1, They have a relative mass of 1/2000. They are ionising and fairly penetrating. They are affected by electric and magnetic fields.
What is the relationship between the number of protons and the number of electrons in an atom?	They are equal and the atom has no overall charge.
What happens in beta minus decay in terms of particles?	A neutron becomes a proton + an electron. This causes the atomic number (proton number) to increase by 1 while the mass number (nucleon number) stays the same.
What happens in beta plus decay in terms of particles?	A proton becomes a neutron + a positron. This causes the atomic number (proton number) to decrease by 1 while the mass number (nucleon number) stays the same.
What is the effect on the mass number (nucleon number) in alpha decay?	Decreases by 4.
What is the effect on the mass number (nucleon number) in gamma decay?	Nothing.
What is the effect on the mass number (nucleon number) in neutron decay?	Decreases by 1.
What is the effect on the atomic number (proton number) in alpha decay?	Decreases by 2.
What is the effect on the atomic number (proton number) in gamma decay?	Nothing.
What is the effect on the atomic number (proton number) in neutron decay?	Nothing.

In a nuclear equation what do you need to balance?	The mass number (nucleon number) before with the total mass numbers (nucleon numbers) of the new isotope and released particles after and the atomic number (proton number) before with the total atomic numbers (proton numbers) of the new isotope and released particles after.
When is gamma radiation emitted?	When a radioisotope undergoes decay by alpha or beta (+ or -) emission, the nuclear rearrangement usually results in the excess energy being released as gamma radiation.
What are the dangers of ionising radiation?	In low doses, can cause cancer as there may be damage to DNA. In high doses, can cause skin burns, radiation sickness and even death.
What precautions are taken to ensure the safety of patients and staff involving in using radiation medically?	Radiation is monitored, dose and exposure time are limited. People are also protected with screening and protective clothing.
What information does the atomic number (proton number) tell you?	How many protons there are in the nucleus of an atom, ion or isotope and so what type of atom it is.
What information does the mass number (nucleon number) tell you?	The total number of protons + neutrons in the nucleus of an atom.
What happens to an atom when an alpha particle is near?	Electrons are pulled out of the atom, attracted by the positive charge of the alpha particle and so the atom is no longer neutral it becomes a positive ion.
What happens to an atom when a beta particle is near?	An electron is pushed out of the atom, repelled by the negative charge of the beta - particle and so the atom is no longer neutral it becomes a positive ion. OR An electron is pulled out of the atom, attracted by the positive charge of the beta + particle and so the atom is no longer neutral it becomes a negative ion.
How ionising are alpha particles?	Highly ionising as they have a +2 charge.
How ionising are beta particles?	Moderately ionising as they have a -1 charge or +1.
How ionising are gamma rays?	Weakly ionising as they are uncharged.
What stops alpha particles?	A few cm of air or thin paper.
What stops beta particles?	A few mm of a metal like aluminium
What stops gamma rays?	A few cm of a dense metal like lead will significantly reduce the amount of gamma rays getting through.
What is meant by background radiation?	Radiation that is around us all the time.
Why are there regional variations in the levels of background radiation?	50% of the background radiation is due to radioactive radon gas. Granite rock contains uranium and as this radio-isotope breaks down it releases radon gas into the atmosphere. Some parts of the country such as Devon, Cornwall and Edinburgh have higher concentrations of granite in the ground and so greater amount of radon gas meaning the background count is greater there.
Where does most the background radiation come from?	Around 50% radon gas. Around 15% from rock, soil and building products emitting gamma rays. Around 10% medical uses like X-rays. Around 10% from cosmic rays from outer space and the sun. About 80% is from natural sources.
How much background radiation is due to the nuclear industry?	Less then 1%

What is meant by the activity of a source?	How many decays there are every second from a radio-isotope.
What is activity measured in?	Becquerels (Bq)
How does activity vary with time?	Activity decreases with time.
What is half-life?	The time it takes for half the un-decayed nuclei to decay
How do you calculate the half life from a graph?	Choose a point on the y-axis and then halve the number of un-decayed nuclei from the y-axis and count the corresponding amount of time on the x-axis.
How do you calculate half-life mathematically?	Calculate the amount of time it takes to halve the activity of a sample from the data provided.
What is the danger of ionising radiation?	Damage to cells and tissues causing cancers or mutations. Possible deformities at birth in future generations.
How should radioactive samples be handled safely?	Always point sources away from yourself and others, never handle sources with your fingers – use tongs, only remove sources from their lead lined box when in use and do not eat or drink when using radioactive sources.
Compare the three types of radiation outside the body.	Alpha cannot penetrate. Beta would be able to penetrate and would be absorbed by cells. Gamma would be able to completely pass through the body and would be absorbed by cells.
Compare the three types of radiation inside the body.	Alpha would not be able to escape from the body and would all be absorbed by localised cells. Beta would be absorbed by cells as it passed through the body. Gamma would be emitted from the body and would be absorbed by cells as it passed through the body.
Why did scientists change their ideas about radioactivity over time?	Scientific knowledge changed over time as more observations and data were collected.
Describe the Bohr model of the atom	It has a tiny, positively charged nucleus (containing almost all the mass in the form of protons and neutrons) surrounded by negatively charged electrons in fixed energy levels (orbits or shells).
What is the typical size of an atom?	1×10^{-10} m (0.1 nanometres)
Describe two ways of measuring and detecting radiation.	Geiger-Muller tube and photographic film.
Describe the plum pudding model of the atom	A sphere of positive charge with electrons spread through it.
Describe Rutherford experiment and state what it proved about the atom	Geiger and Marsden carried out an experiment where alpha particles were fired at some gold foil. Alpha particles are repelled by positive charge. It was detected that most of the alpha particles (7999/8000) went straight through the foil but a small number (1/8000) of the alpha particles were deflected through anything from 1^{o} to 180^{o} (straight back at them). Rutherford explained the results and said that most of the atom is empty space, the nucleus is tiny. The nucleus contains most of the mass and it is positively charged.

Explain why ideas about the structure of the atom have changed over time.	New discoveries were made (like the electron and the charge on it, the neutron, proton and the positron) both using mathematics and experimentation.
What is the difference between contamination and irradiation?	An object or person would be contaminated if unwanted radioactive particle get on them or into them. The object or person would be irradiated if exposed to radiation.

Topic 6 Radioactivity part 2 - Core questions

How does half-life effect the danger of radioactivity?	The longer the half-life, the longer there will be a danger from emitted ionising radiation. Isotopes with shorter half lives will have the higher activity.
Why is americium-241 used in smoke alarms?	It is an alpha emitter with a long half-life. It ionises the air in the gap in the circuit, all the while there is no smoke. It does not need to be replaced as it will emit alpha particles for a long time.
What happens when smoke enters a smoke alarm?	The smoke particles cause the current flowing across the air gap to be decreased. When the current drops below a certain level, the alarm sounds.
How is radioactivity used in gauging thickness?	A suitable source is used on one side of the material being measured and a detector is on the other side. If the material is too thick, the count rate decreases and the rollers are moved closer together. If the material is too thin, the count rate increases and the rollers are moved further apart.
Explain why food is irradiated with gamma rays.	The microorganisms in food, decompose the food. By using gamma rays to irradiate the food, these bacteria can be killed and the food preserved for longer, without the food becoming radioactive from the process.
Explain why surgical equipment, that is sterilised using gamma rays, is sealed into bags before irradiation.	The gamma rays can easily pass through the bag, sterilising any equipment in the bag. New microorganisms are kept away from the equipment, to keep it sterile, until it is needed.
How can a gamma source be used to help find a leak in a water pipe?	A source of gamma radiation is put into the water. The gamma source is being used as a **tracer**. Where the water leaks into the ground, there will be more radiation given off. A Geiger-Müller tube is used to locate the point where the radiation is highest.
How is radioactivity used in treating cancers?	Radiotherapy can be used to treat cancers by directing a number of gamma rays from different directions to destroy cancer cells while minimising damage to healthy cells.

How are gamma rays used in radiotherapy?	Radiotherapy is an external treatment. High energy gamma radiation or X-rays are used over a period of time to target cancerous cells using a multiple beam approach to limit the damage to healthy cells by reducing the intensity of the radiation through them while maintaining the higher intensity needed at the site. Brachytherapy is an internal treatment which is used in specialised cases. It has the advantage of treating the cancerous cells more directly but can require surgery.
What is brachytherapy?	Brachytherapy is an internal treatment which is used in specialised cases. It has the advantage of treating the cancerous cells more directly using a radioactive wire that is inserted into the body or implanting radioactive seeds directly into the cancerous tumour. It can require surgery.
How are radioactive sources used in medical tracers?	It is possible to trace the blood flow through an organ by being injected into the blood stream and monitored using a gamma camera. Gamma sources are used so that the radiation can escape from the body and be traced. The dose is kept as small as possible to minimise the effect of the ionising radiation. The half-life of the source needs to be short enough to make sure the patient does not remain radioactive but long enough to ensure the full investigation can be performed. Tracers are often tied to a compound that is attracted to cancerous cells like glucose.
What is a PET scan?	Positron emission tomography can be used to detect small changes in cells and identify rapidly growing cells, such as cancer cells. Fluorine-18 is used because it decays by positron emission. When the emitted positrons collide with electrons the two particles are annihilated releasing two gamma rays in opposite directions. A ring of gamma detectors detect the gamma rays and can calculate the point they were emitted from in the body. PET images and CT images can be combined to provide a very useful diagnostic tool.
Why is F-18 used in PET scanning?	Fluorine-18 is used because it decays by positron emission. The radioisotope needs to have a short half-life, F-18 has a half-life of 110 minutes. This is short enough to make sure the patient does not remain radioactive for long after the PET scan but is long enough to ensure the full investigation can be performed. The F-18 is tagged to glucose to form the radiopharmaceutical FDG.
Why do radioactive sources used in PET scanners need to be produced near to the scanner?	The half-life of the source needs to be short so that the patient is not still radioactive after the scan and so it needs to be produced nearby and relatively near to the time of the scan so that it remains radioactive for the duration of the scan. F-18 has a half-life of 110 minutes.
What are the advantages of using nuclear power to generate electricity?	No carbon dioxide emissions (greenhouse gas), No air pollutants like carbon monoxide or sulphur dioxide, low fuel costs, jobs created for local community, small quantity of waste produced.
What are the disadvantages of using nuclear power to generate electricity?	Risk of accident and public perception of the risks. The waste is radioactive and needs storage. Expensive to build and maintain, security threat, not nice to look at, wildlife habitats destroyed for building, carbon dioxide released in extraction of fuel and more traffic in area so noise and air pollution caused.

What are the levels of radioactive waste?	High level waste – for example spent fuel rods from the reactor core. Medium level waste – for example cladding around the fuel rods in the core of the reactor. Low level waste – for example protective clothing.
How is nuclear waste stored and disposed of?	HLW – Long term disposal required such as burying them in tightly sealed casks. MLW – Contained in steel drums and concrete stored in monitored areas above the ground. LLW – Compacted and stored containers then buried at sea. Some liquids and gases released into the environment.
What is fission?	The splitting apart of a large nucleus, that releases energy (and neutrons, forming daughter products) for example by the absorption of an additional neutron.
How is radioactive decay different from fission?	Radioactive decay is a natural process (where the unstable nucleus breaks down), fission is a process that can be controlled by man. Both release energy.
What happens to U-235 in fission?	A slow moving neutron collides with the uranium-235 nucleus and is absorbed. This makes the nucleus even more unstable and so it splits to form 2 daughter nuclei and 2 (or more) fast moving neutrons. Lots of energy is released.
What is a controlled chain reaction?	The neutrons produced in fission are allowed to go on and cause more fission reactions but this is controlled by using control rods (made from boron or cadmium) to absorb neutrons so that only 1 can carry on the chain reaction.
What are control rods?	Rods that are made from boron or cadmium and are used to absorb neutrons so that, on average, only 1 neutron from each fission reaction can carry on the chain reaction. They can be raised or lowered in the reactor core.
What are moderator rods?	Rods that are made from graphite and are used to slow the fast moving neutrons down so they have more chance of being absorbed by uranium atoms for the next fission reactions.
How is thermal energy converted into electrical energy in a nuclear power station?	Thermal energy released in the fusion reaction in the core is used to heat water to steam. The steam is used to turn a turbine (kinetic energy). The turbine turns a generator. The generator generates electrical energy.
Why do nuclear power stations have the disadvantage of producing nuclear waste?	When uranium undergoes fission, daughter nuclei are produced (for example barium and krypton). The daughter nuclei are radioactive isotopes and will break down to release radioactive particles over long periods of time until they have become new stable products. In addition to this, the materials in the core that absorb neutrons become radioactive too.
What is nuclear fusion?	The joining together of two small nuclei to form a larger nucleus. For example 2 isotopes of hydrogen (tritium and deuterium) fusing to form helium (and a neutron) and releasing energy.
Where does fusion happen now?	In the Sun and other stars.
What are the conditions for fusion to occur?	High temperature, high pressure and high density.

Why are the conditions required for fusion to occur?	There is an electrostatic repulsion between the isotopes of hydrogen because both nuclei have a positive +1 charge (tritium is 2 neutrons and 1 proton and deuterium is 1 neutron and 1 proton). Same charges repel and this force needs to be overcome.
Why is it difficult to make a fusion reactor that is economically viable?	Because we cannot create the densities and pressures needed to create and sustain the temperatures required for fusion, we need to put more energy into the reactor than we get from it.

Core questions - Topic 7 Astronomy

What can be found in our solar system?	The Sun (our star), 8 planets with natural satellites (moons), dwarf planets, asteroids and comets.
State the names of the planets in our solar system in order from the Sun	Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.
What is the difference between the geocentric and the heliocentric models of the universe?	The geocentric model has the Earth at the centre of the solar system and everything else orbiting around it. Whereas the heliocentric has the Sun at the centre with everything orbiting around it.
Why did Scientists change their opinion on the model of the solar system from the geocentric to the heliocentric?	Originally scientists thought the Earth was at the centre of everything, from observations by the naked eye, but by using telescopes to observe and plot the movements of other planets this was found to be incorrect.
Describe how Galileo's observations of Jupiter provided evidence in favour of the heliocentric model of the solar system in place of the geocentric model.	Using a telescope, Galileo plotted the movements of Jupiter's 4 moons around Jupiter thus proving not everything orbits the Earth. He also studied the phases of Venus.
How do Scientists observe the solar system and the milky way today?	Relatively close luminous objects in the solar system give out visible light that can be observed using telescopes on the Earth or in orbit. Objects further away in the Milky way may give out only small amounts of visible light and so are better observed using other types of telescopes that pick up other electromagnetic waves.
What other regions of the electromagnetic spectrum, other than visible light, are used by modern telescopes?	Most objects that astronomers observe give out energy in all parts of the electromagnetic spectrum and modern telescopes can detect almost all of it. Gamma rays, X-rays, ultra violet, Infra-red, microwaves and radio waves are all commonly detected as well as visible light.
What methods are used to search for life beyond earth?	Space probes orbit other planets like Mars photographing the surface so scientists can decide where water might have been. Some space probes fly by. The scientists can then use Landers to do soil experiments and look for life in the most promising spots. Rovers are also used to move around collecting data.
What is the advantage of the Hubble space telescope?	As it is situated above the atmosphere so that light from distant objects enters it without being refracted or reflected from our atmosphere which creates clearer images. There are also not the problems of light pollution in orbit.

How does the use of photography improve our study of astronomy?	Images can be shared and/or enlarged to look in more detail and measurements can be taken from them.
Why do radio telescopes not need to be in orbit but X-ray telescopes do?	The Earth's atmosphere absorbs some types of electromagnetic radiation including X-rays and so the X-ray telescope would not receive any X-rays on Earth. However, radio waves can be transmitted through the atmosphere and so radio waves can reach radio telescopes on Earth.
What 2 variables affect the gravitational field strength at the surface of a planet?	The mass of the planet and the radius of the planet.
As the mass of planets increases, what happens to the gravity of planets?	g increases.
As the radii of planets increases, what happens to the gravity of planets?	g decreases.
Why does the gravity of an object differ between the surface of Earth and the surface of other places in the Solar System, for example the moon?	Different planets have different masses and radii (they are different sizes). Both variables affect the value of g at their surface.
Why does the weight of an object differ between the surface of Earth and the surface of other places in the Solar System, for example the moon, but the mass of the object does not?	Weight is a force and can be calculated by multiplying the mass by the gravitational field strength (w = mg). On Earth g = 9.81 N/kg which we round up to 10. As the value of g changes, in different places in the Solar system, the weight of a fixed mass would also change, even though there was the same amount of matter.
Describe the orbit of a planet, like Earth.	An almost circular orbit around a star (like the Sun).
Describe the orbit of a natural satellite, like the moon.	An almost circular orbit around a planet (like the Earth).
Describe the orbit of a comet.	A highly elliptical orbit around a star (like the Sun).
Describe the orbit of an artificial satellite.	An orbit around a planet (like the Earth). Most satellites are in circular orbits but they are at different heights, depending on their uses. Some orbits are tilted and some are elliptical.
Describe what is special about the orbit of a geostationary satellite.	The height of the orbit, means that the speed of the orbit (3070 m/s), keeps the satellite moving relative to Earth at the same point above the surface. These are very useful in broadcasting.
Explain how the radius of an orbit must change if the orbital speed increases.	The orbiting object would move away from the planet it was orbiting until it settles in a higher orbit.

Explain how the radius of an orbit must change if the orbital speed decreases.	The object would fall downward, towards the planet, accelerating as it falls until it is moving fast enough to orbit at a lower height.
Explain how that an object moving in the same circular orbit changes velocity but does not change its speed.	Speed is a scalar quantity; it is just a measure of how fast the satellite is going. To stay in the same orbital path, the satellite will travel at the same speed constantly. Velocity is a vector quantity; it tells us about how fast the satellite is going and its direction too. To move in a circular path, direction must keep changing (or the satellite would move off at a tangent to the circle) therefore, velocity is changing.

Keywords topic 2 Motion and forces

Acceleration	A measure of how quickly the velocity of something is changing. It can be positive if the object is speeding up or negative if the object is slowing down.
Action	One of a pair of forces. The reaction force acts in the opposite direction.
Air bag	Road safety device in which a bag suddenly inflates with gas to act as a cushion and reduce injury.
Air resistance	The force opposing the motion of an object moving through the air, sometimes called the drag.
Balanced forces	When the forces in opposite directions are the same size so that there is no resultant force.
Braking distance	The distance travelled by a car while the brakes are applied and the car comes to a stop.
Centripetal force	The resultant force acting at right angles to the velocity of an object that gives rise to circular motion.
Conservation of momentum	The total momentum of moving objects before a collision is the same as the total momentum afterwards.
Crumple zone	A vehicle safety device in which part of the vehicle is designed to crumple in a crash, reducing the force of impact.
Deceleration	When an object is slowing down. It is a negative acceleration.
Displacement	The distance travelled in a particular direction. It is a vector quantity.
Distance	How far something has travelled. It is a scalar quantity.
Distance-time graph	A graph of the distance travelled against time for a moving object. The slope (gradient) gives the speed of the object.
Elastic collision	A collision in which momentum and energy are both conserved.
Free-body diagram	A diagram of an object showing all the forces acting upon it and the size and direction of those forces.
Friction	A force between two surfaces that resists motion and is always opposite to the direction of those forces.
Gravitational field strength	The gravitational force acting on an object per unit mass.
Inelastic collision	A collision in which momentum is conserved but kinetic energy is not because some of the energy is transformed into other forms such as thermal energy and sound.
Inertial mass	A measure of how difficult it is to change the velocity of an object. It is a ratio of resultant force/acceleration.
Mass	A measure of the amount of material that there is in an object. It is measured in kilograms (kg). It is a scalar quantity.
Momentum	A quantity calculated by multiplying the mass of an object by its velocity. It is a vector quantity as it has both size and direction and is measured in kg m/s.
Reaction	One of a pair of forces. The action force acts in the opposite direction.
Resultant force	The total force that results from two or more forces acting upon a single object. It is found by adding together the forces, taking account of their directions.
Scalar	A quantity that has only size (magnitude). It does not have a direction, for example distance, speed, energy and mass.
Seat belt	Vehicle safety device in which a material strip holds a person in place within a vehicle. It is designed to stretch in an impact, reducing the force of impact.
Speed	A measure of the distance an object travels in a given time. It is a scalar quantity.
Stopping distance	The sum of the thinking distance and the braking distance.
Terminal velocity	A constant, maximum velocity reached by objects falling. This happens when the weight downwards is equal to the air resistance upwards.
Thinking distance	Distance travelled by a car as the driver reacts to apply the brakes.
Vector	A quantity that has both magnitude (size) and direction. Force, velocity and momentum are examples.
Velocity	The speed of an object in a particular direction. It is a vector quantity.

Weight	The force pulling an object downwards. It depends on the mass of the object and the gravitational field strength. It is a vector.

Topic 3 Conservation of Energy - Keywords

Absorb	Energy taken into an object.
Biofuel	A fuel made from plants or animal wastes.
Chemical energy	A form of potential energy, stored in in matter and released by a chemical reaction (for example, combustion).
Closed system	When energy (or substances) cannot enter or leave.
Conduction	The way that energy is transferred through solids by heating. Vibrations are passed on from particle to particle.
Conserved	A quantity that is kept the same throughout. For example, conservation of energy means that the total energy before a transfer is equal to the total energy after that transfer.
Convection	The movement of particles in a fluid (gas or liquid) depending on their temperature. Hotter, less dense regions, rise and cooler, more dense regions, sink.
Efficiency	The proportion of input energy that is transferred to a useful form.
Elastic potential energy	A form of energy stored by things that have been stretched or squashed and can spring back.
Electrical energy	Energy transferred by a flow of charged particles.
Emit	Energy given out from an object.
Energy transfer	Energy being moved from one place to another, possibly with a change of form at the same time.
Equilibrium	When a situation is not changing because all the things affecting it balance out.
Fossil fuel	A fuel formed from the dead remains of organisms over millions of years, i.e. coal, oil and natural gas.
Global warming	The increase in the Earth's average temperature likely to be caused by the increased amounts of carbon dioxide in the atmosphere.
Gravitational potential energy	The energy stored in things that can fall.
Greenhouse effect	When gases in the atmosphere trap heat energy and keep the Earth warm.
Greenhouse gases	Gases that help to trap heat energy in the atmosphere. They include carbon dioxide, methane and water vapour.
Hydroelectricity	Electricity generated by moving water, usually from falling from a reservoir, to turn turbines and generators.
Insulator (thermal)	A material that does not allow energy to be transferred through it easily by heating.
Insulation	The method of reducing energy transfer using insulating materials.
Joule	The unit of energy (J).
Kinetic energy	Movement energy.
Law of conservation of energy	States that energy cannot be created or destroyed, although energy may transform from one form into another.
Light energy	The energy of visible light.
Lubrication	To reduce friction (and so energy wasted as heat) by putting a substance, usually a liquid, between 2 surfaces.

Non-renewable	Any energy resource that will run out because you cannot renew your supply of it, e.g. oil.
Nuclear energy	The energy stored in the nuclei of atoms.
Nuclear fuel	A radioactive metal such as uranium. These can be used in power stations to generate electricity.
Potential energy	Energy that is stored. Elastic, nuclear, gravitational and chemical are all examples.
Power	The rate of transferring energy. It is measured in watts (W).
Radiate	Energy given out from a source.
Radiation	A way of transferring energy. Often used to signify the transfer of energy by heating, which is better referred to as infrared radiation.
Renewable	An energy resource that will never run out, e.g. solar power.
Sankey diagram	A diagram showing energy transfers, where the width of each arrow is proportional to the amount of energy it represents.
Solar cell	A flat plate that uses energy transferred by the light to produce electricity.
Sound energy	The energy transferred by sound waves.
Temperature	A measure of how hot something is. Measured in $^{\circ}$C or K.
Thermal energy	Also called heat energy, the energy transferred by heating. Measured in J.
Thermal conductivity	A measure of how easily energy can pass through a material by heating. A material with a low thermal conductivity is a good insulating material.
Tidal energy	Generating electricity using the movement of the tides.
Vacuum	A place where there is no matter at all.
Wind turbine	A kind of windmill that generates electricity using energy transferred by the wind.

Topic 4 Waves - Keywords

Absorb	The energy of the wave is taken in by the object and so does not get through.
Angle of incidence (i)	The angle between the beam of incoming light and the normal line. It is measured in °.
Amplitude	Maximum displacement of a wave measured in from the mean position.
Compressions	Regions where particles are pushed together and create a region of higher pressure in a sound wave.
Density	The mass of a substance per unit volume. (Found for a substance by dividing its mass by its volume).
Displacement	Distance moved in a specific direction. It is a vector quantity. It is measured in metres.
Diffraction	The spreading of a wave at an opening.
Frequency	The number of vibrations per second or the number of complete waves passing a point per second. It is measured in Hertz.
Hertz (Hz)	The unit for frequency, 1 hertz is 1 wave per second.
Infrasound	Sound with a frequency less than 20Hz.
Longitudinal waves	Waves with vibrations parallel to the direction in which they travel.
Normal line	Line at right angles (90°) to the surface (i.e. of a mirror or glass block) where a ray of light hits it.
P wave	Primary (longitudinal) seismic wave.
Peak	Uppermost point of a wave.
Period	The time it takes for 1 complete wave to pass a point. It is measured in seconds.
Pitch	Whether a sound is low or high.
Rarefactions	Regions where particles are pulled apart and create a region of low pressure in a sound wave.
Reflection	When a wave is bounced of a surface. The law of reflection is obeyed i=r.
Refraction	The bending of a wave (change of direction) caused by the change in its speed.
S wave	Secondary (transverse) seismic wave.
Scalar	A quantity that has only size (magnitude). Speed is an example and so is time.
Seismic waves	Shock waves from earthquakes.
Speed	How fast something (for example a wave) is going. It is a scalar quantity. It is measured in m/s.
Transmit	The energy of the wave continue through the object.
Transverse waves	Waves with vibrations at right angles to the direction in which the waves is travelling.
Ultrasound	Sounds with frequencies greater than 20,000Hz.
Vacuum	Empty space that has no particles.
Vector	A quantity that has both size (magnitude) and direction. Velocity is an example.
Velocity	The speed in a particular direction. It is a vector quantity. It is measured in m/s.
Wavefront	The surface over which a wave has a maximum (peaks) or minimum value (troughs).
Wavelength	Distance between neighbouring wave peaks (or troughs).

Keywords topic 4 (part 2) Waves

absorb	When a wave disappears as the energy it is carrying transfers to the medium through which it is travelling.
amplify	To make bigger.
auditory nerve	The nerve that carries impulses from an ear to the brain.
cochlea	The part of the ear that changes vibrations into electrical impulses.

ear canal	The tube in the head that leads to the eardrum.
eardrum	A thin membrane inside the ear that vibrates when sound reaches it.
impulse	An electrical signal that travels in the nervous system.
infrasound	Sound waves with a frequency below 20 Hz, which is too low for the human ear to detect.
interface	The boundary between two materials.
neurone	A cell that transmits electrical impulses in the nervous system.
P waves	Longitudinal seismic waves that travel through the Earth.
S waves	Transverse seismic waves that travel through the Earth.
seismic waves	Vibrations in the rocks of the Earth caused by earthquakes or explosions. There are transverse and longitudinal seismic waves.
seismometer	An instrument that detects seismic waves.
shadow zone	A part of the Earth's surface that P waves or S waves from an earthquake do not reach because of the way they have been reflected or refracted within the Earth.
sonar	A way of finding the distance to an underwater object (such as the sea bed) by timing how long it takes for a pulse of ultrasound to be reflected.
sound waves	Vibrations in the particles of a solid, liquid or gas, which are detected by our ears and 'heard' as sounds. Sound waves are longitudinal waves.
transmit	When a wave passes through a material and is not absorbed or reflected.
ultrasound	Sound waves with a frequency above 20 000 Hz, which is too high for the human ear to detect.
ultrasound scan	A way of making an image of part of the body (usually a fetus) using ultrasound waves reflected from parts

Topic 5 Light and the electromagnetic spectrum - Keywords

Absorb	The energy of the wave is taken in by the object and so does not get through.
Angle of incidence (i)	The angle between the beam of incoming light and the normal line. It is measured in °.
Electromagnetic radiation	A form of energy transfer, including radio waves, microwaves, infrared, visible light, ultraviolet, x-rays and gamma rays.
Electromagnetic spectrum	The entire frequency range of electromagnetic waves.
Electromagnetic waves	A group of waves that all travel at the same speed in a vacuum, and all are transverse.
Frequency	The number of vibrations per second or the number of complete waves passing a point per second. It is measured in Hertz.
Gamma rays	High frequency, ionising electromagnetic radiation.
Hertz (Hz)	The unit for frequency, 1 hertz is 1 wave per second.
Infrared waves	Non-ionising waves with a wavelength longer than red light that are radiant heat.
Ion	An atom with an electrical charge (can be positive or negative)
Ionisation	A process in which radiation transfers some or all of its energy to liberate an electron from an atom.
Ionising radiation	Short wavelength, high frequency electromagnetic radiation or certain types of high-energy particles that can cause atoms to become electrically charged (to become ions).
Light waves	Electromagnetic waves that can be detected by the human eye.
Normal line	Line at right angles (90°) to the surface (i.e. of a mirror or glass block) where a ray of light hits it.
Microwaves	A type of electromagnetic wave that can cause internal heating.
Mutation	A change in the DNA of a gene. Such changes can trigger cancers.
Peak	Uppermost point of a wave.
Prism	A block of glass used to split white light into visible spectrum.
Radio waves	A non-ionising part of the electromagnetic spectrum with the longest wavelength range.
Reflection	When a wave is bounced of a surface. The law of reflection is obeyed i=r.
Refraction	The bending of a wave (change of direction) caused by the change in its speed.
Speed	How fast something (for example a wave) is going. It is a scalar quantity. It is measured in m/s.
Transmit	The energy of the wave continue through the object.
Transverse waves	Waves with vibrations at right angles to the direction in which the waves is travelling.
Vacuum	Empty space that has no particles.
Velocity	The speed in a particular direction. It is a vector quantity. It is measured in m/s.
Wavefront	The surface over which a wave has a maximum (peaks) or minimum value (troughs).
Wavelength	Distance between neighbouring wave peaks (or troughs).
X-rays	Electromagnetic waves with very short wavelength in the order of 0.000000001m.

Keywords for topic 5 (part 2) Light and the electromagnetic spectrum

absorb	To soak up or take in – for waves, it is when the wave disappears as the energy it is carrying is transferred to a material.
angle of incidence	The angle between an incoming light ray and the normal.
angle of reflection	The angle between the normal and a ray of light that has been reflected.
angle of refraction	The angle between the normal and a ray of light that has been refracted.
converging lens	A lens that brings together (converges) light rays
critical angle	The angle of incidence above which total internal reflection occurs inside a material such as glass or water.
diffuse reflection	Reflection from a rough surface, where the reflected light is scattered in all directions.
diminished	Smaller (image)

diverging lens	A lens that spreads out (diverges) light rays.
filter	Something that only transmits certain colours and absorbs the rest.
focal length	The distance from a lens to the focal point
focal point	The point at which parallel light rays converge after passing through a converging lens, or appear to come from after passing through a diverging lens.
greenhouse effect	The warming effect on the Earth's surface caused by greenhouse gases absorbing energy emitted from the warm surface of the Earth and reemitting it back to the surface.
greenhouse gas	A gas, such as carbon dioxide, water vapour or methane, in the Earth's atmosphere, which absorbs energy emitted from the Earth's surface and then reemits it back to the surface.
incident ray	A ray of light going towards an interface or object.
interface	The boundary between two materials.
inverted	Upside down (image)
Law of reflection	The law that says the angle of incidence and the angle of reflection are equal.
luminous	Giving off light. The Sun and light bulbs are luminous objects.
magnified	Larger (image)
normal	An imaginary line drawn at right angles to the surface of a mirror or lens where a ray of light hits it.
object	The thing looked at through a lens or other optical instrument.
power (energy transfers)	The amount of energy (in joules, J) transferred every second. It is measured in watts (W).
power (lenses)	A measure of how much the lens bends light rays passing through it. A more powerful lens bends rays more and has a shorter focal length.
ray diagram	A diagram that represents the path of light using arrows
real image	An image through which light rays pass, so that it can be seen on a screen placed at that point
reflection	When a wave bounces off a surface instead of passing through it or being absorbed.
reflected ray	A ray of light that has been reflected from a surface.
refracted ray	A ray of light that has changed direction because it has passed from one substance into another.
refraction	The change in direction when a wave goes from one medium to another.
specular reflection	When light is reflected evenly, so that all reflected light goes off in the same direction. Mirrors produce specular reflection.
total internal reflection	The reflection of a ray of light inside a medium such as glass or water when it reaches an interface. Total internal reflection only happens when the angle of incidence inside the material is greater than the critical angle
transmit	For waves, when the wave passes through something and is not absorbed or reflected.
virtual image	An image that light rays do not pass through; they only appear to come from the image.
visible spectrum	The different wavelengths (colours) that make up white light
watts (W)	The unit for measuring power. 1 watt = 1 joule of energy transferred every second
white light	Normal daylight, or the light from light bulbs, is white light.

Keywords for topic 6 Radioactivity

Alpha particle	Particle made of 2 protons and 2 neutrons, emitted as ionising radiation from some radioactive sources. It is equivalent to a helium nucleus emitted from an unstable atom.
Annihilation	Destruction caused by interaction of a particle with its anti-particle.
Antimatter	Matter made up of antiparticles, such as positrons.
Atom	The basic 'building block' of an element which cannot be **chemically** broken down.
Atomic number (also known as proton number)	This is the number of protons inside the nucleus of an atom. To be an atom, and so electrically neutral, an atom must have an equal number of electrons. It is the bottom number on the periodic table.
Background radiation	Radiation from natural radioactive sources around us and from outer space.
Becquerel (Bq)	The unit of activity: one Becquerel is equal to one nucleus decaying per second.
Beta minus decay	Emission of a high energy electron from an unstable **nucleus** when neutron becomes a proton (a down quark becomes an up quark).
Beta plus decay	Emission of a positron from an unstable nucleus when a proton becomes a neutron (an up quark becomes a down quark).
Beta particle	An electron or positron emitted from the inside of an unstable nucleus, from the nucleus.
Contaminate	When unwanted radioactive particles get onto (or into) an object.
Decay	When an unstable nucleus changes by giving out ionising radiation to become a smaller more stable nucleus.
Down quark	A fundamental particle with a charge of -1/3.
Electron	A negatively charged particle found in atoms.
Electron shell	A name given to the energy levels of an atom, the location of electrons around the nucleus. Also called the orbit.
Fundamental particle	A particle that cannot be broken down into smaller units. At present quarks, electrons and positrons are all thought to be examples of fundamental particles.
Gamma radiation	Ionising radiation in the form of pulses of electromagnetic radiation with very short wavelengths.
Half-life	The time taken for half of the undecayed nuclei to decay or the activity of a source to decay by half.
GM tube	Geiger-Muller Tube**.** A device that can detect ionising radiation and is used to measure the activity of a radioactive source.
Ion	An electrically charged particle or atom.

Ionisation	A process where an atom loses (or gains) electrons.
Ionisation energy	The energy required to remove an electron from an atom.
Ionising radiation	Radiation that can cause charged particles to be formed by knocking outer electrons out of the atom, making the atom into an ion. Causes tissue damage and may cause mutations.
Irradiate	When an object is exposed to radiation.
Isotopes	Atoms with the same number of protons but different numbers of neutrons.
Mass number (also known as the nucleon number)	A unit of mass for expressing the mass number of atoms. (Protons and Neutrons are said to have a mass of 1 whereas the mass of an electron is taken as 0). Is it the top number on the periodic table.
Mutation	A change in the DNA of a cell.
Neutrino	A particle with no charge and a very small mass emitted during beta-plus decay of unstable nuclei.
Neutron	Small particle which does not have a charge, found in the nucleus of an atom. (It is made up from 1 up quark and 2 down quarks).
Nuclear equation	Equation representing a nuclear reaction, i.e. a change in the nucleus due to radioactive decay, balancing the atomic number and mass number.
Nucleons	Protons and neutrons (both found in the nucleus of an atom)
Orbit	A name given to the energy levels of an atom, the location of electrons around the nucleus. Also called the shell.
Positron	The anti-particle of an electron; a particle with a similar mass to an electron but with an opposite charge (it has a positive charge).
Proton	Small positive particle found in the nucleus of an atom. (It is made up from 2 up quarks and 1 down quark).
Quark	A fundamental particle within particles such as protons and neutrons.
Radioactive	A substance that gives out ionising radiation such as alpha, beta particles or gamma rays.
Radioactive decay	When an unstable nucleus changes by giving out ionising radiation to become a smaller more stable nucleus.
Radon	A colourless, odourless and radioactive gas originating from rocks such as granite.
Stability curve	A curve on the N-Z graph (number of neutrons against number of protons) showing the positions of all stable nuclei.
Strong nuclear force	An attractive force between all neutrons and protons.
Thermionic emission	The process of emitting an electron from the surface of a heated metal, usually a hot filament.
Up quark	A fundamental particle with a charge of +2/3.

Keywords for topic 6 Radioactivity part 2

Annihilation	Destruction caused by interaction of a particle with its anti-particle.
Brachytherapy	An internal technique that uses radioactive sources to kill cancerous cells in the patient.
Chain reaction	A process in which an enormous amount of energy is produced when neutrons from previous fission reactions go on to produce further uncontrolled fission reactions.
Cold fusion	An invalidated theory proposing that nuclear fission had occurred at “room” temperature.
Contaminate	When unwanted radioactive particles get onto (or into) an object.
Control rods	Material used to absorb the neutrons in a nuclear reactor in order to produce a controlled chain reaction.
Coolant	Gas or liquid used to remove thermal energy from a nuclear reactor.
Critical mass	The minimum mass of fissile material that can sustain a chain reaction.
Cyclotron	A particle accelerator used to produce radioactive isotopes used in PET scanners.
Daughter nuclei	The nuclei produced in a fission reaction.
Decay	When an unstable nucleus changes by giving out ionising radiation to become a smaller more stable nucleus.
Fission	The splitting of a nucleus when it absorbs and neutron.
Fuel rods	Rods containing nuclear fuel for a fission reactor.
Fusion	A nuclear reaction in which lighter nuclei join together (fuse) and produce energy.
High level waste	Highly radioactive waste produces large amounts of ionising radiation. The radioactivity decreases over tens of years and it becomes intermediate level waste.
Gamma camera	A special camera used to produce a 3 dimensional image of the body using gamma rays emitted from inside the body.

Intermediate level waste	Materials which have become radioactive because they have been in a nuclear reactor. It remains radioactive for tens of thousands of years.
Irradiate	When an object is exposed to radiation.
Isotopes	Atoms with the same number of protons but different numbers of neutrons.
Low level waste	Slightly radioactive waste, usually clothing, cleaning materials and medical equipment.
Moderator	Material used to slow down the fast-moving neutrons in a nuclear reactor.
Nuclear equation	Equation representing a nuclear reaction, i.e. a change in the nucleus due to radioactive decay, balancing the atomic number and mass number.
Nuclear reactor	The part of a nuclear power station that contains the fuel rods, control rods, moderator and coolant.
Nucleons	Protons and neutrons (both found in the nucleus of an atom)
Palliative care	A medical intervention that does not cure a condition but may reduce pain or other symptoms and may extend life expectancy.
Particle accelerator	A machine used to accelerate charged particles to very high speeds.
PET scanner	A special scanner used to produce images of the metabolic functions of the body.
Positron	The anti-particle of an electron; a particle with a similar mass to an electron but with an opposite charge (it has a positive charge).
Radioactive decay	When an unstable nucleus changes by giving out ionising radiation to become a smaller more stable nucleus.
Radiopharmaceutical	A substance produced by tagging radioactive isotopes to natural chemicals such as glucose and water.
Radiotherapy	An external technique that uses gamma rays to kill cancerous cells in a patient.
Radioactive waste	Material left over after the fission of uranium that is radioactive.
Stability curve	A curve on the N-Z graph (number of neutrons against number of protons) showing the positions of all stable nuclei.
Sterilisation	A technique used to kill bacteria using intense gamma rays.
Strong nuclear force	An attractive force between all neutrons and protons.
Tracer	A radioactive material used to monitor the flow of a liquid.

Topic 7 Astronomy – Keywords

Absorb	When the wave is taken in.
Absorption spectrum	A spectrum of light that includes black lines. These are caused by some wavelengths being absorbed by the materials that the light passes through.
Artificial satellite	A satellite made by humans.
Asteroid	A small lump of rock orbiting the Sun.
Atmosphere	The layer of gases surrounding the planet.
Big Bang theory	The theory that says the universe began from a tiny point with huge energy, and has been expanding ever since.
Black hole	Core of a red supergiant that has collapsed. Black holes are formed if the remaining core has a mass more than 3 or 4 times the mass of the Sun.
Centripetal force	The resultant force acting at right angles to the velocity of an object that gives rise to circular motion.
Comet	A small lump of dirty ice orbiting the Sun.
Cosmic microwaves background radiation (CMB)	Microwave radiation received from all over the sky, originating at the Big Bang.
Cosmic rays	Charged particles with a high energy that come from stars, neutron stars, black holes and supernovae.
Doppler effect	The change in pitch of a sound coming from a moving source.
Dwarf planet	A rocky body orbiting the Sun that is not quite big enough to be called a planet.
Emission spectrum	A set of wavelengths of light or electromagnetic radiation showing which wavelengths have been given out by a substance.
Emit	To give out.
Equilibrium	When things are balanced and not changing they are in equilibrium.
Galaxy	A group of millions of stars held together by gravity.
Geocentric	Earth-centred.
Gravitational field	The space around any object with mass where its gravity attracts other masses.
Gravitational field strength	A measure of how strong the force of gravity is somewhere. The units are newtons per kilogram (N/kg)
Heliocentric	Sun-centred.
Luminous	Giving off light. The Sun is a luminous object.
Main sequence star	A star during the main part of its life cycle, where it is using hydrogen fuel.

Mass	A measure of the amount of material that there is in an object. It is measured in kilograms (kg). It is a scalar quantity.
Milky Way	The name of our galaxy.
Moon	A natural satellite of a planet.
Naked eye	Observation made using just the eyes, without using a telescope or any other aid.
Nebula	A cloud of gas in space. Some objects that look like nebulae are actually clusters of stars or other galaxies.
Neutron star	Core of a red supergiant that has collapsed.
Orbit	The path taken by a planet around the Sun, or a satellite around a planet.
Planet	A large body in space that orbits a star.
Protostar	A cloud of gas drawn together by gravity that has not yet started to produce its own energy.
Red giant	A star that has used up all the hydrogen in its core and is now using helium as a fuel. It is bigger than a normal star.
Red Supergiant	A star that has used up all the hydrogen in its core and has a mass much higher than the Sun.
Red-shift	Waves emitted by something moving away from an observer have their wavelength increased and frequency decreased compared to waves from a stationary object.
Reflecting telescope	A telescope in which the focusing of the main image is done by a curved mirror.
Refracting telescope	A telescope consisting of a series of lenses.
Scalar	A quantity that has only size (magnitude). It does not have a direction, for example distance, speed, energy and mass.
Solar system	An area of space in which objects are influenced by the Sun's gravity.
Space probe	A space vehicle that can be put into orbit around a planet or moon, or parachuted down through the atmosphere.
Spectrometer	An instrument that can split up light to show the colours of the spectrum.
Speed	A measure of the distance an object travels in a given time. It is a scalar quantity.
Star	A large ball of gas that produces heat and light energy from fusion reactions.
Steady State Theory	The theory that the Universe is expanding but new matter is being continually created, so that the Universe will always appear the same.
Supernova	An explosion produced when the core of a red supergiant collapses.
Telescope	A device for producing magnified images of distant objects.
Thermal imaging	Photography that uses a detector of infrared radiation.
Transmit	When the wave passes through something.

Universe	All the stars, galaxies and space itself.
Vacuum	Empty space that has no particles.
Vector	A quantity that has both magnitude (size) and direction. Force, velocity and momentum are examples.
Velocity	The speed of an object, in a particular direction. It is a vector quantity.
Weight	The force pulling an object downwards. It depends on the mass of the object and the gravitational field strength. It is a vector.
White dwarf	A very dense star that is not very bright.

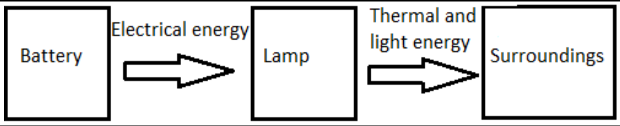
Paper 2 (Paper code: 1PH0/2F and 1PH0/2H)
Written examination: 1 hour and 45 minutes ***50% of the qualification*** ***100 marks***
Content overview • Topic 1 – Key concepts of physics • Topic 8 – Energy - Forces doing work • Topic 9 – Forces and their effects • Topic 10 – Electricity and circuits • Topic 11 – Static electricity • Topic 12 – Magnetism and the motor effect • Topic 13 – Electromagnetic induction • Topic 14 – Particle model • Topic 15 – Forces and matter

Physics Key Concepts

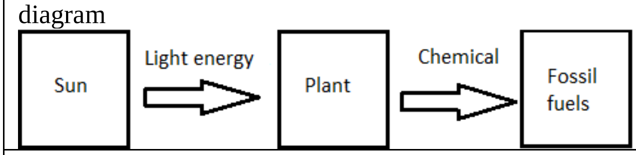
What is the standard unit and symbol for A) distance B) mass C) time D) temperature	 A) metre, m B) kilogram, kg C) second, s D) kelvin, K
What is the derived unit and symbol for A) Frequency B) Force C) Energy D) Power E) Pressure F) Electric charge G) Electric potential difference H) Electric resistance I) Magnetic flux density	 A) hertz, Hz B) newton, N C) joule, J D) watt, W E) pascal, Pa F) coulomb, C G) volt, V H) ohm, Ω I) tesla, T
Write the decimal of A) giga (G) B) mega (M) C) kilo (k) D) centi (c) E) milli (m) F) micro (μ) G) nano (n)	 A) 1,000,000,000 (10^9) B) 1,000,000 (10^6) C) 1000 (10^3) D) 0.01 (10-^{2}) E) 0.001 (10^{-3}) F) 0.000001 (10^{-6}) G) 0.000000001 (10^{-9})
How do you convert minutes into hours	Divide minutes value by 60
How do you convert minutes into seconds	Multiply minutes value by 60
Convert the following into standard form:	
In calculation questions what must you remember to do?	Substitute in values in standard units, show working out clearly and show the units on the answer. Triangles are a tool to help us re-arrange equations.

Topic 8 Energy – Forces doing work

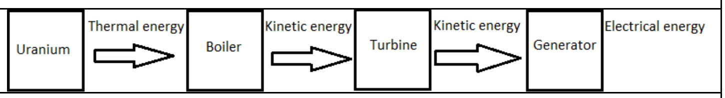
<table>
<tr><td>Describe the energy changes when a motor lifts a load</td><td>The motor uses electrical energy and transfers this into thermal, sound and kinetic energy. The kinetic energy is transferred into GPE as the load is lifted.</td></tr>
<tr><td>Describe the energy changes when a person uses a bow and arrow</td><td>A person uses stored chemical energy and is transferred into kinetic energy as the person pulls the bow back. This is transferred into stored elastic energy. When released, the stored elastic energy is transferred into kinetic energy and GPE of the arrow, until the arrow falls to the floor where it is transferred into sound and thermal energy.</td></tr>
<tr><td>Draw an energy transfer diagram for a torch</td><td>



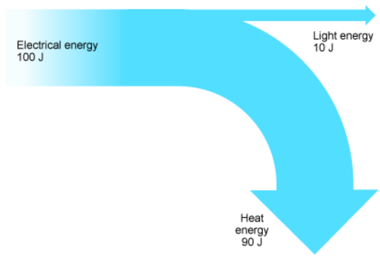
</td></tr>
<tr><td>Describe what is happening in this energy transfer diagram



</td><td>A plant is absorbing light energy from the sun and transferring it into chemical energy through the process of photosynthesis.
Over millions of years the plant has been transformed into a fossil fuel which is a stored chemical energy.</td></tr>
<tr><td>Draw an energy transfer diagram for a nuclear power station</td><td>

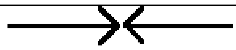
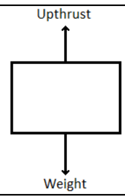
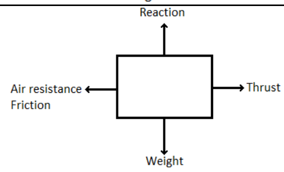
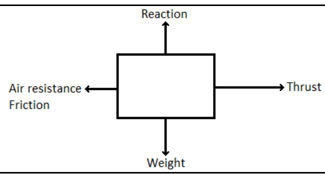


</td></tr>
<tr><td>Identify the different ways that the energy of a system can be changed</td><td>1) through work done by forces
2) in electrical equipment
3) in heating</td></tr>
<tr><td>Recall the equation for work done</td><td>Work done (J) = Force (N) x Distance moved in direction of resultant force (m)</td></tr>
<tr><td>What is the unit for work done?</td><td>Joules</td></tr>
<tr><td>Explain, using examples, how in all system changes energy is dissipated so that it is stored in less useful ways</td><td>All energy transfers eventually dissipate heat and sound energy to the surroundings which is wasteful.
For example, a torch transferring light and heat energy to the surroundings</td></tr>
<tr><td>How are all mechanical processes wasteful?</td><td>Mechanical processes become wasteful as they cause a rise in temperature so dissipating thermal energy to the surroundings</td></tr>
<tr><td>What is a definition of power?</td><td>The amount of energy transferred every second (Joule per second (J/S))</td></tr>
<tr><td>Recall the power equation</td><td>Power (W) = energy transferred (J) / time (s)</td></tr>
<tr><td>What is the unit for power?</td><td>Watt (W)</td></tr>
<tr><td>What can be measured in joules per second?</td><td>Power because 1 J/s = 1W</td></tr>
<tr><td>How can you combine work done = force x distance and power = work done / time</td><td>Power = $\frac{\text{(force x distance)}}{\text{time}}$</td></tr>
<tr><td>What is the law of conservation of energy?</td><td>Energy can never be created or destroyed, only transferred from one store (or form) to another.</td></tr>
<tr><td>What is the net change to the total energy in a closed system?</td><td>Zero</td></tr>
<tr><td>Draw a Sankey diagram to show that 100J of electrical energy is transferred into 10J of light energy and ?J of thermal (or heat) energy.</td><td>



</td></tr>
</table>

An objected is lifted upwards, what is the energy transfer that takes place?	Kinetic energy is transferred to gravitational energy.
A moving object crashes into a wall. What types of energy does its kinetic energy get transferred into?	Heat and sound
An object is accelerated by a force, what type of energy does it gain?	Kinetic energy
A moving vehicle applies its brakes, what type of energy does its kinetic energy get transferred into and where is most of this energy stored?	Heat, stored in the brakes
What happens to electrical energy when using a kettle to boil water?	Some is transferred usefully to heat energy in the water and some is wasted heating the surroundings.
When a mechanical process wastefully transfers energy to heat, what happens to the heat?	Heat is dissipated, heating the surroundings.
A stiff bicycle chain wastefully dissipates some energy as heat and sound. Describe how this unwanted energy transfer can be reduced.	Lubricate the chain to reduce friction.
A boiler's hot water tank wastefully dissipates some of its heat energy to its surroundings. Describe how this unwanted energy transfer can be reduced.	Insulate the tank to slow down the rate at which heat is lost to the surroundings.
State the equation for energy efficiency.	$\text{efficiency} = \frac{\text{(useful energy transferred by the device)}}{\text{(total energy supplied to the device)}}$
State the equation for calculating a change in gravitational potential energy.	change in gravitational potential energy (J) = mass (kg) × gravitational field strength (N/kg) × change in vertical height (m) $\Delta GPE = m \times g \times \Delta h$
State the equation for calculating the kinetic energy of an object.	kinetic energy (J) $= \frac{1}{2}$ × mass (kg) × speed^2 ($(m/s)^2$) $KE = \frac{1}{2} \times m \times v^2$

Name example forces that cause objects to interact at a distance (without contact)	gravity, magnetism, static electricity
Name contact forces	Normal contact force, thrust, up thrust, air resistance, friction, water resistance
Why are displacement, velocity, acceleration, forces and momentum all vector quantities and not scalar quantities?	Because they have size (magnitude) and direction. (scalar quantities only have size)
Describe a vector diagram to show how the Earth and moon interact	 Lines point towards each other (opposite directions), equal in length (size or magnitude the same)
Describe a vector diagram to show how 2 objects with the same charge interact	 Lines point away from each other (opposite directions), equal in length (size or magnitude the same)
Describe a vector diagram to show how a book resting on a table interacts with the table	 Lines point away from each other in vertical plane (opposite directions), equal in length (size or magnitude the same)
What is a free-body diagram used to show?	The size and direction of the different forces acting on a single object.
Draw a free body force diagram for a duck sitting on the surface of the water	
Draw a free body force diagram for a person walking at constant speed	
Draw a free body force diagram for a car accelerating	
What are action and reaction forces?	When 2 bodies interact (for example, your foot and a football) they exert forces on each other that are equal in size and opposite in direction.
What is the extra, left over, force called in an unbalanced situation?	Resultant force or net force
What are forces measured in?	Newtons (N).
How do you calculate the resultant force?	You subtract the total of the forces in one direction from the total force in the opposite direction.
What do resultant forces change?	The speed, direction and/or the shape of an object.
Describe how to calculate the resultant force using a vector diagram	1) Draw arrows to scale to represent the forces acting on an object 2) Draw lines with the existing force arrows to make a parallelogram 3) Draw a line diagonal of the parallelogram, this is the resultant force 4) Measure the length of the resultant force line and use the scale to calculate the size
Describe how to resolve a force acting down a slope	1) Draw an arrow to scale to represent the force you are trying to resolve 2) Draw 2 lines at right angles in the direction of the slope 3) Draw 2 more lines to enclose the force into a rectangle 4) Measure the length of the 2 edges of the rectangle (the 2 components of the force) use the scale to calculate their sizes
Give examples where forces can cause rotation	Spanner undoing a bolt, scissors cutting, door opening, arm wrestling, a crane's counterweight etc – there are so many!
State the equation that allows us to calculate the turning force (or moment)	Moment = Force x Distance normal to the direction of the force.
State the standard units for turning forces	Newton metres (Nm)
State the principle of moments	For equilibrium, the total clockwise turning force is equal to the total anticlockwise turning force.
How do levers transmit the rotational effect of forces?	A small effort is applied a long distance from the pivot (or fulcrum) to create a large turning effect. This moment is then balanced by raising the heavy load which is on the opposite side of the fulcrum but close to this pivot point. A

	small force x long distance normal to the direction of the force = larger force x shorter distance normal to the direction of the force. Levers are force magnifiers.
How do gears transmit the rotational effect of forces?	They use a ratio of interlocking teeth between 2 gears to pass on the rotation from 1 gear to another.
How can the effects of friction be reduced when forces are turning objects?	Lubrication
Why would we want to reduce the effects of friction when forces are turning objects?	Friction causes unwanted energy transfer through heating.

Topic 10 Electricity and circuits – Core knowledge questions

Where do you find a proton in an atom?	In the nucleus
Where do you find a neutron in an atom?	In the nucleus
Where do you find an electron in an atom?	In the energy levels/orbits or shells
What charge does an electron have?	Negative (-1)
What mass does an electron have?	Its atomic mass is so small we take it as 0
What charge does a proton have?	Positive (+1)
What mass does a proton have?	An atomic mass of 1
What charge does a neutron have?	It has no charge
What mass does a neutron have?	An atomic mass of 1
What name is given to the negatively charged subatomic particles that cause an electric current?	Electrons
What are the two terminals of an electric cell labelled as?	Positive (+) and negative (–)
What is the circuit symbol for a lamp?	A circle with a cross in it
What is the circuit symbol for a cell?	Two vertical lines, one longer than the other
How can you tell which is the negative terminal of a cell from the circuit symbol?	It is the shorter line.
If you connect some cells together in series, what is formed?	A battery
What is the name of a circuit with one path around it and no branches?	A series circuit
Give a disadvantage of connecting lamps in series.	If one goes out, they all go out/cannot switch one off independently.
What is the name given to a circuit with components in different branches?	A parallel circuit
Which component is used to measure potential difference?	A voltmeter connected in parallel (across the component you are measuring)
Define potential difference (also called voltage)	The energy transferred per unit of charge.
Which equation relates the energy transferred in a circuit to the potential difference.	Energy transferred = charge x potential difference ($E = Q \times V$)
What is another term for potential difference?	Voltage
In a circuit, energy is transferred to a charge. Where is this energy transferred from?	Cell/battery/power supply
State the unit and the symbol for potential difference.	Volt, V
How many volts is one joule per coulomb?	1V
What is the rule for voltage in series?	The voltages across each of the components add up to give the total voltage.
What is the rule for voltage in parallel?	The voltage across each branch is the same.
What component is used to measure current?	Ammeter connected in series
What word describes materials that electricity cannot pass through?	Insulators

What components word describes materials that electricity will pass through?	Conductors
In an electric circuit with a battery, which of these materials will conduct: copper, wood, salty water?	Copper and salty water
Which of these materials are insulators: plastic, metal, air?	Plastic and air
What is the difference between conventional current and the flow of electrons?	Electrons flow from the negative terminal of a cell to the positive terminal, conventional current flows the other way.
What unit is current measured in?	Amps/amperes (symbol A)
What two conditions are needed to give a current in a circuit?	A closed circuit and potential difference
What is the current rule for series circuits?	The current is the same everywhere.
What is the current rule for parallel circuits?	The current is shared between the branches – it is conserved at a junction.
A series circuit has two lamps. When the current through one lamp is 2 A, what is the current through the other lamp?	2A
A parallel circuit has two lamps in parallel. When the current through each lamp is 2 A, what is the current from the battery?	4A
Define electric current	The rate of flow of charge. In a metal, the charged particles that flow are electrons.
State the unit and the symbol for charge.	Coulomb, C
What is the equation relating the total charge that flows to current and time.	Charge = current x time ($Q = I \times t$)
Why are current and potential difference related?	They are directly proportional for a constant resistance. As the potential difference increases the current increases in step with each other. This is because, if you increase the energy of the electrons as you increase the voltage and so the electrons travel faster – there is a greater number of electrons passing the same point in the same amount of time.
State the unit and the symbol for electrical resistance.	Ohm, Ω
Which equation is used to work out electrical resistance? (also called ohms law)	Resistance = potential difference divided by current ($R = V / I$)
What is the symbol for a resistor?	A rectangle
What component can be used to change the resistance in a circuit, for example to change the volume in a loudspeaker?	A variable resistor
What is the symbol for a variable resistor?	A rectangle with an arrow through it
Why does changing the resistance in a circuit change the current?	As resistance increases, current decreases. This is because, resistances opposes the flow of electrons. The greater the resistance the better it is at slowing down the electrons and so less electrons flow per second

Why does current have a heating effect?	As the free electrons flow through the ions of the lattice they collide with those ions. These collisions result in a transfer of energy (kinetic energy of the electron to thermal energy in the wire) and the wire gets hotter
Which variables affect resistance of a wire and how do they affect it?	Length (longer wires = more resistance), thickness (thicker wires = less resistance), material (different materials have different resistances, copper has a lower resistance than nichrome) and temperature (hotter = more resistance)
A circuit contains a resistor. If another resistor is added in series with the first, does the total resistance in the circuit increase, decrease or stay the same?	Increase
A circuit contains a resistor. If another resistor is added in parallel with the first, does the total resistance in the circuit increase, decrease or stay the same?	Decrease
When resistors are connected in series, how can you calculate the total resistance?	Add the resistances together
When the potential difference across a fixed resistor is doubled, what happens to the current?	The current doubles (assuming the temperature is constant)
How does the current vary with voltage for a fixed resistor (or fixed piece of wire)?	They are directly proportional for a constant resistance. As the potential difference increases the current increases in step with each other.
What happens to the resistance of a light-dependent resistor (LDR) when light intensity increases?	It decreases
What happens to the resistance of a thermistor when the temperature increases? (it decreases)	It decreases
Which component could be used to change the current in a circuit when the temperature changes?	A thermistor
Which component could be used to change the current in a circuit when the light intensity changes?	A light-dependent resistor
What is a diode and what does it do in a circuit?	A component that only allows a current to flow one way around a circuit. They can be used to protect other components in a circuit.
How does the current vary with voltage for a diode?	When they are connected the correct way round as current increases voltage increases but it is not directly proportional (not a straight line on the graph).
What happens to the resistance of a filament lamp when the potential difference is increased?	It increases

How does the current vary with voltage for a filament lamp as it warms up?	As a bulb heats up the resistance increases and so, as current increases voltage increases but it is not directly proportional (not a straight line on the graph). The gradient of the graph increases as current increases. This is because as the bulb gets hotter its resistance increases, until it reaches its maximum temperature.
What does the graph of current against potential difference look like for a fixed resistor?	A straight line through the origin/directly proportional relationship
When an electric current passes through a high-resistance wire, what happens to the wire?	It becomes hot
How can resistance in the wires in circuits be reduced?	Cool the wire / use low-resistance material for the wire / make the wire thicker / make the wires as short as possible
Give an example of an appliance that uses the heating effect of a current.	Kettle, iron, toaster etc..
Give an example of a disadvantage that can result from overheating by an electric current.	Wasted energy, fire, damage to the appliance/wires etc..
If the new connecting wires in a house have a lower resistance than the old ones, what effect will this have on daily electricity use?	It will be less
When electrons move through a lattice of positive ions, what happens to cause electrical resistance?	Collisions
Power is the transfer of what each second?	Energy
Name the unit and give the symbol for power.	Watt, W
Which is more powerful: kettle A, which boils a mug of water in 1 minute, or kettle B, which boils a mug of water in 2 minutes, or do they both have the same power?	A
Define power.	It is the rate of energy transfer.
Which equation links power to energy transferred, *E*.	Power = energy transferred divided by time ($P = \frac{E}{t}$)
Which uses more power: A a 12 V 20 W lamp, or B a 240 V 9 W lamp or do they both use the same power?	A
Which equation links power to current and potential difference.	Power = current x potential difference ($P = I \times V$)
Which equation links together both power equations to for an equation for electrical energy transferred?	Energy = Current x potential difference x time (E = I x V x t)
Which equation links power to electrical resistance.	Power = current squared x resistance ($P = I^2 \times R$)
What is the mains voltage in the UK?	230 V
What is the frequency of the a.c. mains voltage in the UK?	50 Hz
What type of energy store does a battery have?	Chemical

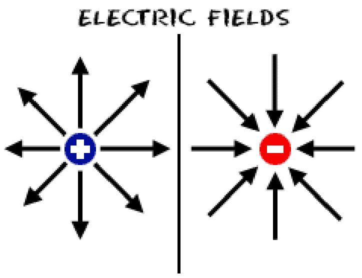
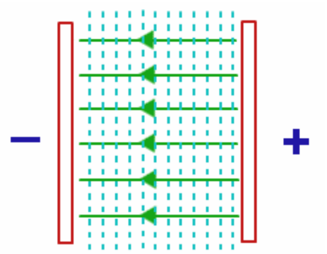
At some time after energy is transferred to an electric toothbrush, in what energy store does the energy end up?	In the thermal store of the surroundings
What do the letters d.c. mean?	Direct current
Describe the way the electrons move in d.c.	In one continuous direction. Electrons flow around the circuit in one direction
What do the letters a.c. mean?	Alternating current
Describe the way the electrons move in a.c.	Keep reversing direction. Electrons vibrate passing kinetic energy on
Describe the shape of a d.c trace on the oscilloscope	A straight horizontal line
Describe the shape of a d.c trace on the oscilloscope	A sine wave with peaks and troughs above and below the x axis
Describe the earth wire and state its function	Green and yellow wire, used to prevent electrocution by connecting the metal parts of the appliance to the ground. It has a low resistance and can create a short circuit if needed. Voltage is 0V when the circuit is working correctly
Describe the live wire and state its function	Brown wire, used to connect the appliance to the power supply. In the UK the voltage is 230V across this wire
Describe the neutral wire and state its function	Blue wire, used to complete the circuit to the power supply. The voltage across it is 0V
Explain how a fuse works	The fuse is a deliberate weak link in the circuit made using a special piece of thin wire in a glass tube. If the current is higher, than the fuse is made to allow, the heating effect of the current will melt the wire and the wire will break. This breaks the circuit and stops current flowing to the appliance. Fuses prevent appliances from overheating and causing fires
What is a RCCB?	A residual current circuit breaker. This is a re-settable switch than can be used instead of a fuse. They work quicker than a melting fuse to break the circuit if they detect a dangerous change in the current

Core Knowledge question topic 11 Static Electricity

What charge does an electron have?	Negative (-1)
What charge does a proton have?	Positive (+1)
How can an insulator be charged?	By rubbing the insulator so that force of friction causes electrons to be transferred.
If a plastic rod is rubbed with a cloth and charges are transferred to the cloth. What charge will the rod have and what charge will the cloth have?	The only charges that can be transferred are electrons. The electrons are transferred to the cloth to make it negative and the rod will be left positively charged.
When two negatively charged objects are brought near to each other what happens?	They repel each other.
When two positively charged objects are brought near to each other what happens?	They repel each other.
When two oppositely charged objects (one positive and one negative) are brought near to each other what happens?	They attract each other.
Explain why hair combed with a plastic comb, might stick up in all directions.	As the hair is combed, electrons are transferred by friction. Each hair has the same charge and so, each hair is repelled from the nearby hairs.
How does earthing a charged object (with a conductor) remove the excess charge and make the object neutral?	If the object is negative, the excess electrons will be able to travel through the conductor to earth. If the object is positive, electrons will be able to travel through the conductor from the earth to the object until the overall charge is zero.
Explain why dry leaves jump and stick to amber when it has been rubbed and held near.	When the amber is rubbed, electrons are transferred to it and it becomes negatively charged. As the charged amber gets near to the dry leaves, it repels the electrons and attracts the protons at the surface of the leaf and so the leaf jumps to the amber and is held to it with an electrostatic force. The leaves are charged by induction.

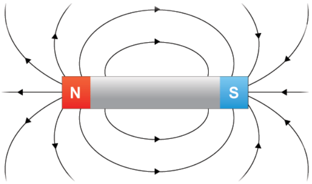
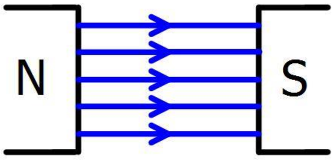
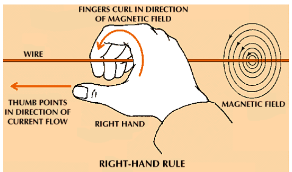
Explain why pieces of paper jump and stick to plastic comb when it has been rubbed and held near.	When the comb is rubbed, electrons are transferred and it becomes charged. As the charged comb gets near to the pieces of paper, the paper is charged by induction.
Explain why a balloon sticks to wall when it has been rubbed and held near.	When the balloon is rubbed, electrons are transferred and it becomes charged. As the charged balloon gets near to the wall, the surface of the wall is charged by induction.
Explain why water bends and when aa acetate rod has been rubbed and held near.	When the acetate rod is rubbed, electrons are transferred from it and it becomes positively charged. As the charged acetate gets near to the water stream, it attracts the electrons and repels the protons at the surface of the water and so the water bends to the acetate, pulled towards it with an electrostatic force. The water is charged by induction.
When an object is charged by induction, do any charges get transferred?	No. The surface charges just rearrange within the same atoms.
Explain why you might feel a shock after trampolining wearing socks.	As your socked feet rub against the elastic, of the trampoline. you gain a charge. As you climb down and touch the metal frame, or another person, the excess charge flows to earth and you feel the shock as it does.
Explain why lightning occurs.	Charge builds up in the clouds due to friction between particles of ice or water moved by air currents. This excess charge can jump between the clouds and the ground. The rapid heating of the air by this electric current, causes the sound and energy is released, as the air recombines with electrons, in the form of light.

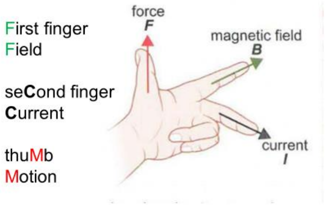
Explain how static electricity is useful in paint spraying.	The nozzle is charged and so, the droplets of paint also gain the same charge as they move through it. Because all the droplets have the same charge, they repel each other and the paint spreads out into a fine mist. The object that is being painted is given the opposite charge to that given to the paint. This means that the paint is attracted to the object and prevents paint from being wasted.
Compare the use of insecticide sprayers with paint sprayers.	Insecticide spraying works in the same way except the crops are not given an opposite charge. The nozzle is charged and so, the droplets of paint also gain the same charge as they move through it. Because all the droplets have the same charge, they repel each other and the insecticide spreads out into a fine mist. The insecticide is attracted to all parts of the crops by induction.
How might an aircraft get charged as it flies?	The air rubs against the aircraft causing a transfer of electrons.
Explain why aircraft need a bonding line when refuelling.	As the fuel flows through the fuel pipe it is charged up. The excess charges could lead to a spark as they try to reach Earth (in a similar way to lightning). This spark could cause an explosion of the fuel. To prevent the charge building up, the fuel tank is connected to earth by a conductor called the bonding line.
When refuelling a car, how is excess charge in the tanks, pipes, hoses, car and person filling up, prevented from building up and causing a spark?	In filling stations the tanks, pipes and hoses are earthed. The car is earthed through its tyres (because they are made of carbon) and the person filling up is earthed when they touch the metal car or the fuel pump.
What is an electric current?	The rate of flow of charge (negative charge or electrons).
What is the difference between a conductor and an insulator?	A conductor has electrons that are free to move (free electrons) and so it allows a flow of electrons – an electric current – through it. An insulator does not have electrons that are free to move (free electrons) and so cannot allow the flow of an electric current through it.

What unit do we measure charge in?	Coulombs (C).
What is an electric field?	The region where any electric charge will experience a force.
Describe the direction and shape of the electric field around a point charge.	The field radiates out in all directions from the point charge. The direction is away, or out of, a positive charge and into, or towards, a negative charge. 
Describe the direction and shape of the electric field between parallel plates.	There is a uniform electric field in the direction of positive to negative. 
How is the strength of an electric field shown using field lines?	The stronger the electric field, the closer the field lines will be.

How does the idea of electric charge explain static attraction and repulsion?	Charges will be forced to follow the lines of force by being pushed or pulled.

Topic 12 Magnetism and the motor effect – Core questions

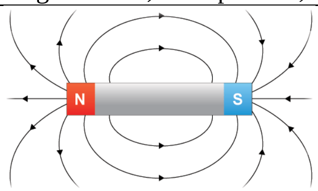
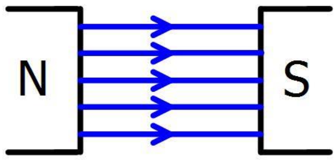
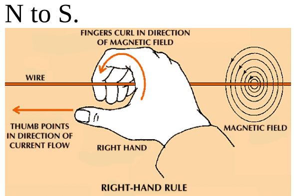
What happens when like and unlike magnetic poles get near to one another?	Like poles repel and unlike pole attract
What is a magnetic field?	The region where magnetic materials (and current carrying wires) experience a force.
Name the 4 materials that can become induced magnets in a magnetic field.	Iron, steel, nickel and colbalt.
What is the difference between a permanent magnet and an induced magnet?	Permanent magnets are always magnetic. They produce their own magnetic field. Induced magnets are only magnetic themselves when they are in the magnetic field of another magnet.
Name a use for permanent magnets	Electric motors. Also generators, loudspeakers, door latches etc.
Describe the shape and direction of the magnetic field around a bar magnet	
Describe the shape and direction of the magnetic field in a uniform magnetic field	
How is the strength of a magnetic field related to the magnetic field lines?	The stronger the magnetic field, the closer the field lines are.
Describe how you could use a plotting compass to show the shape and direction of a magnetic field around a bar magnet.	1. Place the magnet on some paper 2. Draw around it and label N and S 3. Place the plotting compass at a corner 4. Draw a dot at the point and tail of the arrow 5. Remove the compass and draw an arrow 6. Place the compass with its tail at the point of the last arrow you drew 7. Repeat stages 4 to 7 until you leave the paper or return to the magnet Start again at any point around the magnet and repeat all around the magnet.
Why is a compass needle weighted?	A magnet suspended on a string will tilt relative to the horizontal by different amounts in different places.
How does the behaviour of a compass needle provide evidence that the core of the Earth is magnetic?	Because the compass needle is a magnet and it is attracted and repelled by the poles of the Earth. The North pole of Earth attracts the North point of the compass needle because it is acting like the south pole of a bar magnet.
How can you prove that a current carrying wire creates a magnetic field?	Hold a compass near and the needle will move or use iron fillings to show the magnetic field lines.
What method can you use to work out the direction of the magnetic field around a long straight conductor?	The right hand grip rule. Thumb + to – for the electric current and fingers for the field N to S. 
What are the two variables that affect the strength of the magnetic field in a long straight conductor?	Size of the current (larger current will create stronger magnetic field) and distance from the wire (further away from the conductor the magnetic field will be weaker).
What is a solenoid?	A coil of wire.

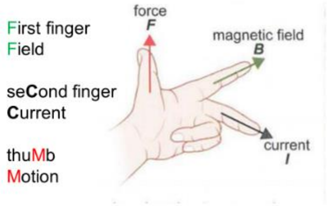
In a solenoid, where is the magnetic field strongest and why?	In the centre because the field is uniform there, the magnetic field from each individual coil adds up. (Around the outside some of the magnetic fields cancel out and so the overall field is weaker).
Explain why a current carrying conductor placed near a magnet will move.	**The magnetic field from the current interacts with the magnetic field from the magnet and forces the conductor.**
What is true about the force on the wire and the force on the magnet for the current carrying conductor between the poles of a magnet?	**They are equal in size (magnitude) and opposite in direction.**
What causes magnetic forces?	**The interaction between magnetic fields.**
When is the force on a current carrying wire, in a magnetic field, strongest?	**When the direction of the current is at right angles to the direction of the magnetic field.**
What is Fleming's left hand rule?	
Which factors affect the magnetic force?	**Size of the current (larger current = bigger force), strength of the magnetic field (greater magnetic flux density = bigger force) and length of wire in the magnetic field (longer wire, more turns on coil = bigger force).**
Which equation links the factors affecting the magnetic force?	**Force (N) = Magnetic flux density (T) x current (A) x length of wire (m).** $F = B \times I \times l$
1 N/Am is equivalent to what?	**1 Tesla (1T)**
Why does the coil in a simple d.c. motor start to turn?	**The current flows one way down one side of the coil and the opposite way down the other side of the coil, each side creating a magnetic field. The magnetic field from each side of the coil, interacts with the magnetic field from the permanent magnets forcing one side of the coil upwards and the other side of the coil downwards.**
How does the split ring commutator keep the coil spinning in a simple d.c. motor?	**It switches the current to keep it flowing in the correct direction so that the forces on the coil keep it spinning in one direction.**

Core questions topic 13 Electromagnetic induction (part 1 for triples)

How can an electric current be induced?	By moving the either the wire or the magnetic field, relative to one another or by changing the magnetic field.
How can a larger current be induced?	By moving the magnet or wire faster, by using a bigger coil of wire (to have more length in the magnetic field) or by using a stronger magnet.
What is the difference between direct current (DC) and alternating current (AC)?	d.c. is always in one direction. For example the current from a battery or solar cell. a.c. changes polarity because it is constantly changing direction. For example in the generator at a power station.
What does a transformer do?	A transformer changes the voltage of an a.c. supply.
How does a transformer work?	An alternating current flows into the primary coil. This makes a magnetic field in the core. The magnetic field changes direction many times a second. The changing magnetic field induces a current in the secondary coil. The induced current is alternating too.
Why can't transformers work on d.c. supplies?	A direct current flowing into the primary coil would make a constant magnetic field in the coil. This would cause a spike of current in the secondary coil, when it is first switched on because it would be like pushing the magnet into the secondary coil. There would also be a spike in current (in the opposite direction) when you turn it off (because it would like pulling the magnet out of the coil) but once on, it would be like the magnet is stationary in the secondary coil and so there would be no movement of the coil or magnetic field and no current would be induced in the secondary coil.
What is a step up transformer?	To increase the voltage you need less coils of wire on the primary coil of the iron core and more on the secondary coil. This is a step up transformer, it will increase the voltage and to maintain the same power, decrease the current.
What is a step down transformer?	To decrease the voltage you need less coils of wire on the secondary coil of the iron core and more on the primary coil. This is a step down transformer, it will decrease the voltage and to maintain the same power, increase the current.
Why is electrical energy transmitted at high voltages?	It improves efficiency by reducing heat loss in the transmission lines by allowing a lower current to be used for the same power output.
Where would step up and step down transformers be used in the national grid?	Step up transformers are used at the power station whereas step down transformers are used before electricity enters factories and again before it enters homes, offices and shops.
What is power and what units is it measured in?	It is the rate of transferring energy. It is measured in Watts (W). 1W = 1 J/s.
What are the standard units for current?	amperes (A).
What are the standard units for voltage or potential difference?	volts (V).
What are the hazards of transmitting electricity?	High voltages could cause electrocution.
What is efficiency?	A measure of how much of the energy is transferred into a useful energy type.

Core questions full version for topics 12 and 13 triple science

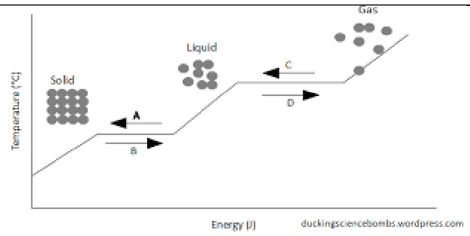
What happens when like and unlike magnetic poles get near to one another?	Like poles repel and unlike pole attract
What is a magnetic field?	The region where magnetic materials (and current carrying wires) experience a force.
Name the 4 materials that can become induced magnets in a magnetic field.	Iron, steel, nickel and colbalt.
What is the difference between a permanent magnet and an induced magnet?	Permanent magnets are always magnetic. They produce their own magnetic field. Induced magnets are only magnetic themselves when they are in the magnetic field of another magnet.
Name a use for permanent magnets	Electric motors. Also generators, loudspeakers, door latches etc.
Describe the shape and direction of the magnetic field around a bar magnet	
Describe the shape and direction of the magnetic field in a uniform magnetic field	
How is the strength of a magnetic field related to the magnetic field lines?	The stronger the magnetic field, the closer the field lines are.
Describe how you could use a plotting compass to show the shape and direction of a magnetic field around a bar magnet.	1. Place the magnet on some paper 2. Draw around it and label N and S 3. Place the plotting compass at a corner 4. Draw a dot at the point and tail of the arrow 5. Remove the compass and draw an arrow 6. Place the compass with its tail at the point of the last arrow you drew 7. Repeat stages 4 to 7 until you leave the paper or return to the magnet Start again at any point around the magnet and repeat all around the magnet.
Why is a compass needle weighted?	A magnet suspended on a string will tilt relative to the horizontal by different amounts in different places.
How does the behaviour of a compass needle provide evidence that the core of the Earth is magnetic?	Because the compass needle is a magnet and it is attracted and repelled by the poles of the Earth. The North pole of Earth attracts the North point of the compass needle because it is acting like the south pole of a bar magnet.
How can you prove that a current carrying wire creates a magnetic field?	Hold a compass near and the needle will move or use iron fillings to show the magnetic field lines.
What method can you use to work out the direction of the magnetic field around a long straight conductor?	The right hand grip rule. Thumb + to – for the electric current and fingers for the field N to S. 
What are the two variables that affect the strength of the magnetic field in a long straight conductor?	Size of the current (larger current will create stronger magnetic field) and distance from the wire (further away from the conductor the magnetic field will be weaker).

What is a solenoid?	A coil of wire.
In a solenoid, where is the magnetic field strongest and why?	In the centre because the field is uniform there, the magnetic field from each individual coil adds up. (Around the outside some of the magnetic fields cancel out and so the overall field is weaker).
Explain why a current carrying conductor placed near a magnet will move.	**The magnetic field from the current interacts with the magnetic field from the magnet and forces the conductor.**
What is true about the force on the wire and the force on the magnet for the current carrying conductor between the poles of a magnet?	**They are equal in size (magnitude) and opposite in direction.**
What causes magnetic forces?	**The interaction between magnetic fields.**
When is the force on a current carrying wire, in a magnetic field, strongest?	**When the direction of the current is at right angles to the direction of the magnetic field.**
What is Fleming's left hand rule?	
Which factors affect the magnetic force?	**Size of the current (larger current = bigger force), strength of the magnetic field (greater magnetic flux density = bigger force) and length of wire in the magnetic field (longer wire, more turns on coil = bigger force).**
Which equation links the factors affecting the magnetic force?	**Force (N) = Magnetic flux density (T) x current (A) x length of wire (m).** $F = B \times I \times l$
1 N/Am is equivalent to what?	**1 Tesla (1T)**
Why does the coil in a simple d.c. motor start to turn?	**The current flows one way down one side of the coil and the opposite way down the other side of the coil, each side creating a magnetic field. The magnetic field from each side of the coil, interacts with the magnetic field from the permanent magnets forcing one side of the coil upwards and the other side of the coil downwards.**
How does the split ring commutator keep the coil spinning in a simple d.c. motor?	**It switches the current to keep it flowing in the correct direction so that the forces on the coil keep it spinning in one direction.**
How can an electric current be induced?	By moving the either the wire or the magnetic field, relative to one another or by changing the magnetic field.
How can a larger current be induced?	By moving the magnet or wire faster, by using a bigger coil of wire (to have more length in the magnetic field) or by using a stronger magnet.
Explain how an electric current can be produced on a small scale in the laboratory	A simple generator consists of a coil of wire, with the ends connected to slip rings, that is rotated inside a magnetic field. As the coil turns a current is induced. Carbon brushes are used to connect the slip rings to an external circuit.
Explain how an electric current can be produced by an alternator in a car	A rotating electromagnet is surrounded by coils. The electromagnet is turned by the car's engine and this induces a current in the coil. The coil is connected to an external circuit. The induced current is a.c.
Explain how an electric current can be produced on a large scale (for example, at a power station)	A large rotating electromagnet that is surrounded by coils. The electromagnet is turned by the steam driven turbines and this induces a current in the coil. The coil is connected to an external circuit. The induced current is a.c.

What is the difference between direct current (DC) and alternating current (AC)?	d.c. is always in one direction. For example the current from a battery or solar cell. a.c. changes polarity because it is constantly changing direction. For example in the generator at a power station.
Explain how electromagnetic induction is used in dynamos	A coil of wire is turned (for example by being connected to the moving wheel of a bike) inside a magnetic field, inducing a current. The coil is connected to a commutator which switches the connections every half turn. This causes the induced current in the external circuit to be in one direction (d.c.)
What type of current is generated with a dynamo?	Direct current (d.c.)
What type of current is generated with an alternator?	Alternating current (a.c.)
What is the difference between an alternator and a dynamo in design?	An alternator has slip rings and a dynamo has a commutator (or split ring commutator)
Explain how a loudspeaker works	They convert variations in electrical current into sound waves using a coil in a magnetic field. As the varying current flows through the coil, the force exerted on the coil causes it to move back and forth. The coil is connected to a diaphragm which also moves and produced sound waves.
Explain how a microphone works	They convert pressure variations in sound waves into variations in electrical current. As the sound waves cause the diaphragm to vibrate back and forth, it moves a coil of wire backwards and forwards within a magnetic field. This induces a varying electrical signal.
What does a transformer do?	A transformer changes the voltage of an a.c. supply.
How does a transformer work?	An alternating current flows into the primary coil. This makes a magnetic field in the core. The magnetic field changes direction many times a second. The changing magnetic field induces a current in the secondary coil. The induced current is alternating too.
Why can’t transformers work on d.c. supplies?	A direct current flowing into the primary coil would make a constant magnetic field in the coil. This would cause a spike of current in the secondary coil, when it is first switched on because it would be like pushing the magnet into the secondary coil. There would also be a spike in current (in the opposite direction) when you turn it off (because it would like pulling the magnet out of the coil) but once on, it would be like the magnet is stationary in the secondary coil and so there would be no movement of the coil or magnetic field and no current would be induced in the secondary coil.
What is a step up transformer?	To increase the voltage you need less coils of wire on the primary coil of the iron core and more on the secondary coil. This is a step up transformer, it will increase the voltage and to maintain the same power, decrease the current.
What is a step down transformer?	To decrease the voltage you need less coils of wire on the secondary coil of the iron core and more on the primary coil. This is a step down transformer, it will decrease the voltage and to maintain the same power, increase the current.
How does the power compare in the primary and secondary coils of a transformer?	It is the same.
Why is electrical energy transmitted at high voltages?	It improves efficiency by reducing heat loss in the transmission lines by allowing a lower current to be used for the same power output.

Where would step up and step down transformers be used in the national grid?	Step up transformers are used at the power station whereas step down transformers are used before electricity enters factories and again before it enters homes, offices and shops.
What is power and what units is it measured in?	It is the rate of transferring energy. It is measured in Watts (W). 1W = 1 J/s.
What are the standard units for current?	amperes (A).
What are the standard units for voltage or potential difference?	volts (V).
What are the hazards of transmitting electricity?	High voltages could cause electrocution.
What is efficiency?	A measure of how much of the energy is transferred into a useful energy type.
State what each part of the turns ratio equation stands for and any units involved	N_p = Number of turns on the primary coil of the transformer (no unit) N_s = Number of turns on the secondary coil of the transformer (no unit) V_p = Voltage (or potential difference) across the primary coil (in volts) V_s = Voltage (or potential difference) across the secondary coil (in volts)
State the 3 different power equations and the relevant units	Power (W) = energy transferred (J) / time (s) Power (W) = current (A) x voltage (V) Power (W) = current squared (A) x resistance (Ω)

Core questions - Topic 14 Particle Model

Describe solids in terms of the movement and arrangement of particles	Particles vibrate but cannot move, keep their shape, cannot be compressed.
Describe liquids in terms of the movement and arrangement of particles	Particles moving faster, can move around each other. Take shape of container, will flow, cannot be compressed.
Describe gases in terms of the movement and arrangement of particles	Particles far apart, move freely, expand to fill container, can compress.
Why is changing state a physical change? (2 reasons)	No new substance is made and it will recover its original properties if the change is reversed.
What pattern, in the force of attraction between particles, is seen, as you go from solids to liquids to gases?	Forces of attraction get weaker.
What pattern, in density, is **usually** seen, as you go from solids to liquids to gases?	Density increases.
Explain why a solid is denser than a gas.	In solids, the particles are closer together and so there is more mass per volume.
What is the equation linking density, mass and volume?	density = mass ÷ volume (p=m/V)
What is the standard unit for density?	Kg/m^3
What equipment could you use to find the volume of an irregular shaped object	Displacement can or a measuring cylinder if the object is small enough. (If the object floats it will need to be weighted down with an object of known volume).
If a 5g solid copper is melted, what will the mass of liquid copper be? Why?	5g. Because mass is conserved.
What is the difference between temperature & heat?	Temperature is a measure of how hot something is whereas, heat is a measure of the thermal energy contained in an object.
In which changes of state is thermal energy absorbed?	Melting, evaporating and subliming.
In which changes of state is thermal energy emitted?	Freezing and condensing.
 Label A-D	A - freezing, B - melting, C - condensing, D - evaporating
Describe why adding energy isn't leading to a temperature increase in the plateaus on a temperature/time graph.	The temperature stays the same during a change of state, even though heat energy is still being absorbed. The extra energy is making the particles break away.
How is energy stored by the particles in any substance?	As kinetic energy of the particles.

How is the energy stored by a substance related to the temperature of that substance?	The more energy stored by the particles, the faster they are moving and the higher the temperature.
Define specific heat capacity	The specific heat capacity of a substance is the energy needed to increase the temperature of 1 kg of the substance by 1 ºC.
Which equation, on your formula sheet, includes the specific heat capacity?	change in thermal energy = mass × specific heat capacity × change in temperature $\Delta Q = m \times c \times \Delta\theta$
Which unit is specific heat capacity measured in?	J/kg ˚ C
Define specific latent heat	The specific latent heat of a substance is the energy needed to melt or boil 1 kg of the substance.
Why is there a specific latent heat of melting and a specific latent heat of evaporation?	It takes more energy to evaporate 1kg of a substance than to melt 1kg of the same substance. It takes the same amount of energy to freeze-melt or evaporate/condense.
Which equation, on your formula sheet, includes the specific latent heat?	Thermal energy for a change of state = mass × specific latent heat. $Q = m \times L$
Which unit is specific latent heat measured in?	J/kg
What piece of equipment can be used in place of a voltmeter, ammeter and stopwatch to measure the energy transferred by an electric immersion heater?	Joulemeter.
When experimentally measuring the specific heat capacity of a liquid, where does the main error come from?	Heating the surroundings and the cup that holds the liquid. Not all the energy transferred by the heater goes into the liquid. This can be reduced by insulating the cup well and using a lid.
Explain how using bubble wrap would reduce unwanted energy transfer.	Bubble wrap has a low thermal conductivity. It reduces the heat loss by conduction. The material also reduces air circulating, reducing heat loss by convection.
Describe the term absolute zero	Absolute zero is the point at which the gas particles stop moving. The particles will exert no pressure at this temperature.
What is absolute zero in °C	−273 °C.
Convert 25 °C to kelvin	25 + 273 = 298 K
Convert -93 k to degrees Celsius	-93 – 273 = -366 °C
What is the relationship between kinetic energy of the particles in a gas and its temperature in Kelvin?	As a gas is heated up and temperature increases, the particles gain more energy. With more kinetic energy the particles move faster. Temperature (**in K**) and kinetic energy are directly proportional.

How do particles cause gas pressure?	Gas pressure is caused by the collisions between the particles and the container it is in. This means that there is a net force exerted at right angles to the area.
Why would heating a gas in a container increase pressure, with a fixed volume? (aka pressure law)	When the temperature is increased, the gas particles move faster because they have more kinetic energy. The collisions become harder and more frequent and so there is more force on the same area.
Name the 3 factors that affect gas pressure in a closed container	The number of gas molecules, the volume of the container and the temperature.
What is the relationship between volume of a gas and its pressure, for a fixed mass and temperature of gas? (aka Boyles law)	As the volume of a gas decreases, the pressure would increase. Volume and pressure are inversely proportional to each other.
Use the particle model to explain how decreasing the volume of a container of gas would affect the pressure.	Because there has been a decrease in volume the particles will collide more frequently with the walls of the container. More collisions mean more force on the same area, so the pressure will increase.
What does each part of this equation mean? $p_1V_1 = p_2V_2$	P_1 is the initial pressure V_1 is the initial volume P_2 is the final pressure V_2 is the final volume
What must the units for volume and pressure be when using the Boyles law equation?	It doesn't matter but the same unit must be used on both sides of the equation.
Why are the gases that are used in medicine stored in special bottles?	To save storage space. By compressing the gas more gas can be squashed into a smaller volume. This is done by increasing the pressure above atmospheric pressure of 100 000 Pa.
Define work done	**Work is the transfer of energy by a force.**
How does using a bicycle pump increase the temperature of the gas inside?	**The bicycle pump forces the gas into the tyre, this transfers energy into it (work). The energy makes the gas particles move faster and this can be detected as an increase in temperature.**

Core questions topic 15 Forces and matter

What is the minimum number of forces that need to be applied to an object to stretch, bend or compress it?	Two
What is the difference between elastic and inelastic distortion?	A distortion is a change of shape when there is a force applied. When the object is elastic, t it returns to its original shape when the force is removed but an inelastic object does not return to its original shape.
Describe the relationship between the **length** of a spring and the force applied to it **before** it reaches its elastic limit	The force and length have a linear relationship. The graph would be a straight line.
Describe the relationship between the **extension** of a spring and the force applied to it **before** it reaches its elastic limit	The force and extension have a linear relationship. They are directly proportional to each other. This means the graph will not only be a straight line, it will pass through (0,0) because as the force doubles, the extension will double as well.
Describe the relationship between the extension of a spring and the force applied to it **after** it reaches its elastic limit	The force and extension would have a non-linear relationship. The graph would be a curved line.
How would you measure the extension of a spring?	Measure the length with no force applied. Measure the length with the force applied. Find extension from stretched length – original length.
How would you calculate the spring constant if you know the force and the extension?	Spring constant (N/m) = Force (N) / extension (m)
How would you calculate the spring constant from a graph of extension against force?	From the gradient of the graph (extension along the x axis and force on the y axis).
In what circumstances can you use the equation $F = k \times x$ when stretching materials?	Only for elastic materials before the elastic limit, where the relationship between force and extension is linear.
Do stiffer springs have a higher or lower spring constant?	Higher because you would need to apply more force to get the same extension.
Which equation can be used to calculate the amount of energy transferred in stretching a spring?	Energy transferred = ½ x spring constant x extension^2
Which equation can be used to calculate the work done when a spring is stretched?	The same equation (Energy transferred = ½ x spring constant x extension^2) because work done and energy transferred are the same thing.
What is the magnitude of atmospheric pressure at sea level?	100 000 Pa
Explain why the atmosphere exerts a pressure on you	The atmosphere is made up from gas particles. These particles collide with you, causing a force at right angles to your surface area – a pressure.
Explain why atmospheric pressure varies on you at different heights above the earth's surface	As you go higher, you have less air above you and so atmospheric pressure decreases. The deeper you are in a fluid, the more weight of fluid there is above you. When you are at sea level, you are at the bottom of the atmosphere and atmospheric pressure is at its maximum.
Explain what happens to the air pressure if you go down a deep mine.	It increases because as you descend, there is more atmosphere above you.

When you hold out your hand in air, why don't you feel the force exerted down onto it by atmospheric pressure?	There is also the same force (same atmospheric pressure) acting upwards on the other side of your hand. The forces are balanced and there is no resultant force.
Explain why a sealed balloon would inflate more as it moves higher in the atmosphere (assume temperature does not change).	When the balloon was filled and sealed, the pressure inside and outside is balanced. As the balloon rises, the atmospheric pressure will decrease outside the balloon but the pressure inside the balloon would remain the same. Therefore, the pressure inside the balloon will push it outwards.
Explain what causes the pressure on a deep-sea diver	The ocean is made up from liquid particles. These particles collide with you, causing a force at right angles to your surface area – a pressure. It is important to remember that the atmosphere is also exerting its maximum pressure from above the ocean too.
How can pressure be calculated?	Pressure (Pascals, Pa) = Force normal to the surface (newtons, N)/ area of the surface (metres squared, m^2)
Footballers wear boots with studs on the bottom. Explain why football boots help the player grip the pitch.	The area of the studs is much smaller than the area of the boots, so the pressure under the studs is greater (same force at normal because it is the weight of the player). The greater pressure causes the player to sink into the muddy pitch and provides better grip.
Which word can be used to describe both liquids and gases?	Fluid
In which direction do the forces acts in fluids?	Forces acts normal to the surface (at 90˚or at right angles) in all directions.
Explain how pressure varies with depth in a liquid	The deeper you go, the greater the pressure.
Explain how pressure varies with density of a liquid	The greater the density of the liquid, the greater the pressure. This is because denser liquids have more particles packed into the same volume and so more force (weight of the particles) on the same area.
Which equation links the pressure due to a column of liquid to the depth and density of that liquid?	Pressure (Pascal, Pa) = Height of the column (metres, m) x Density of the liquid (kilogram per cubic metre, kg/m^3) x gravitational field strength (newtons per kilogram, N/kg)
If you dive 10m underwater, what is the effect on the pressure on you?	The pressure would double that at the surface. This is because water is over 800 times more dense than air at sea level and the total pressure on you will be from both the water and the air above the water.
Which force is due to the difference between the pressure above and below an object in a fluid?	Upthrust (measured in newtons, N)
What does the weight of fluid displaced by an object equal?	Upthrust (measured in newtons, N)
Describe the forces acting on a floating object	The weight of the object is balanced by the upthrust.
Why do heavier objects float deeper into a liquid than lighter objects?	They need a greater pressure beneath them to balance their weight and so need to sink to a lower depth (where the pressure is greater) before the forces of weight and upthrust balance.
Explain why some objects do not float.	The upthrust is less than the weight of the object and so there is a resultant force downwards.
Explain why a hot air balloon can float in air	The pressure on top of the balloon is less than the pressure underneath it. This pressure difference causes an upthrust. Because the air in the balloon is heated, it is less dense than than the gas in the surrounding atmosphere and the weight of the atmosphere displaced by the balloon is equal to the total weight of the balloon. The upthrust balances the weight.

Keywords for topic 8

Closed system	When energy (or substances) cannot enter or leave.
Conserved	A quantity that is kept the same throughout. For example, conservation of energy means that the total energy before a transfer is equal to the total energy after that transfer.
Dissipated	Spread out
Efficiency	The proportion of input energy that is transferred to a useful form.
Energy	Something that is needed to make things happen or change.
Equilibrium	When a situation is not changing because all the things affecting it balance out.
Joule	The unit of energy (J).
Power	The amount (rate) of energy transferred per second. The units are watts (W).
Sankey diagram	A diagram showing energy transfers, where the width of each arrow is proportional to the amount of energy it represents.
watts (W)	The unit for measuring power. 1 watt = 1 joule of energy transferred every second.
Work done	A measure of the energy transferred when a force acts through a distance.

Keywords for topic 9

action−reaction forces	Pairs of forces on interacting objects. Action–reaction forces are always the same size, in opposite directions, and acting on different objects. They are not the same as balanced forces, which act on a single object.
component (forces)	One of two forces at right angles to each other, resolved from a single force.
contact forces	Forces where there needs to be contact between objects before the force can have an effect (e.g. friction or upthrust).
electric field/ electrostatic field	The space around an object with a charge of static electricity, where it can affect other objects.
force field	The space around something where a non-contact force affects things. Examples include magnetic fields and gravitational fields.
free body force diagram	A diagram of an object showing all the forces acting on it and the size and direction of those forces.
friction	A force between two surfaces that resists motion.
gears	A system of toothed wheels. The teeth interlock so that turning one wheel turns the one in contact with it. If gears of different sizes are used, the speed of rotation or the force transmitted can be changed.
gravitational field	The space around any object with mass where its gravity attracts other masses.
in equilibrium	When things are balanced and not changing they are 'in equilibrium'.
interact	Affect one another.
lever	A simple machine that consists of a long bar and a pivot. It can increase the size of a force or increase the distance the force moves.
magnet	An object that has its own magnetic field around it.
magnetic field	The area around a magnet where it can affect magnetic materials.
magnetic material	A material such as iron that is attracted to a magnet.
magnetism	The force caused by magnets or magnetic materials.
magnitude	The size of something, such as the size of a force or the measurement of a distance.
moment	The turning effect of a force. It is calculated by multiplying the force by the distance between the force and the pivot, measured at right angles to the force (this is called the normal distance).
non-contact force	A force that can affect something from a distance (e.g. gravity).
net force	Another term for resultant force.
newton metre (N m)	The unit for the moment of a force.

normal	If something is normal to something else, it is at right angles to it.
normal contact force	A force that acts at right angles to a surface as a reaction to a force on that surface.
resolving (forces)	Representing a single force as two forces at right angles to each other.
resultant force	The total force that results from two or more forces acting upon a single object. It is found by adding together the forces, taking into account their directions. Another term for net force.
scalar quantity	A quantity that has a magnitude (size) but not a direction. Examples include mass, distance, energy and speed.
scale diagram	A way of working out the resultant forces or component forces by drawing a diagram where the lengths of arrows represent thee sizes of the forces.
static electricity	Electric charges on insulating materials.
upthrust	A force that pushes things up in liquids and gases.
vector	A quantity that has both size and direction.
vector diagram	A diagram on which vectors are displayed (e.g. a scale diagram, a free body force diagram).

Keywords Topic 10 Electricity and circuits

alternating current (a.c.)	Current whose direction changes many times each second.
ammeter	A meter used to measure current.
ampere (A)	The unit for current. Can be shortened to amp.
atom	The smallest neutral part of an element that can take part in chemical reactions.
battery	More than one cell joined together.
cell (physics)	A chemical store of energy that can be transferred by electricity.
charge	Electric charge is a basic property of matter that causes forces between charged particles or objects. It can be positive or negative. The charge on something is the sum of the charges of all the positively and negatively charged particles they contain.
circuit breaker	An electrical component that switches off the current in a circuit if there is a fault and the current rises to dangerous levels. It can be switched back on when the fault is fixed.
conserved	Kept the same throughout.
coulomb (C)	The unit for measuring charge.
diode	A component that lets electric current flow through it in one direction only.
direct current (d.c.)	A current that flows in one direction only, such as the current produced by a battery.
direct proportion	A relationship in which when one variable is multiplied by any number the other variable is multiplied by the same number, e.g. doubling one variable doubles the other. A direct proportion is seen as a straight line through the origin when the two variables are plotted on a scatter graph.
dissipated	Spread out.
earth wire	A low-resistance path for electric current to flow to earth for safety if there is a fault in an appliance.
electron	A tiny particle with a negative charge and negligible mass.
fuse	A safety device containing a length of wire that is designed to melt if the current in a circuit gets too hot.
hertz	The unit for frequency, 1 hertz is one wave per second.

light-dependent resistor (LDR)	A resistor whose resistance gets lower when light shines on it.
light-emitting diode (LED)	A diode that emits light when current flows through it.
live wire	The wire connected to the a.cc. supply from the power station. The voltage oscillates between the maximum V in one direction and the maximum V in the opposite direction.
mains electricity	Electricity supplied from power stations using the national grid.
national grid	The system of wires and transformers that distributes electricity around the country.
neutral wire	A neutral wire is held at or near earth potential (0 V). It completes the circuit to the power station and carries current.
neutron	A particle found in the nucleus of an atom, having zero charge and a mass of 1 (relative to a proton).
nucleus	The central part of an atom.
ohm (Ω)	The unit for measuring electrical resistance.
parallel circuit	A circuit in which there is more than one path for the current to follow.
potential difference	The energy transferred to or from a coulomb of electric charge when it flows between two points. Sometimes called voltage.
power	The amount (rate) of energy transferred per second. The units are watts (W).
power rating	The energy transferred per second by an appliance.
proton	A particle found in the nucleus of an atom, having a positive charge and the same mass as a neutron.
rate	How quickly something happens.
resistance	A measurement of how difficult it is for electricity to flow through something.
series circuit	A type of circuit with only one loop of wire.
shell (electron shell)	A distinct region around a nucleus that can be occupied by electrons and is usually drawn as a circle.

thermal energy store	The hotter something is, the more energy it has in its thermal energy store. It is sometimes called ‘heat’.
thermistor	A component whose resistance changes as its temperature changes. The thermistors you will meet increase in resistance as the temperature increases.
volt (V)	The unit for potential difference (or voltage).
voltage	See potential difference.
voltmeter	Meter used to measure potential difference (or voltage).
watt (W)	The unit for measuring power. 1 watt = 1 joule of energy transferred every second.
work	Work is done when a force moves an object through a distance. So work is done when a charged particle is moved between two points in an electric field. The unit for work is the joule (J).

Topic 11 Static Electricity Keywords

Atom	The basic 'building block' of an element which cannot be chemically broken down.
Charge	A conserved property of some particles (e.g. protons, electrons etc) which causes them to exert forces on each other.
Coulomb (C)	The unit for charge.
Discharge	To remove an electric charge by conduction.
Earthing	A method for ensuring the safe discharge of charges to (or from) the Earth.
Electric Current	The rate of flow of charge (negative charge - electrons).
Electric field	A region where electric charges experience a force.
Electrical conductivity	How well a substance conducts an electrical current.
Electrical conductor	A material that allows an electric current to flow through it.
Electrons	Tiny negatively charged particles within an atom that orbit the nucleus – responsible for current in electrical circuits.
Electrostatic attraction	A force between two electrical charges that have opposite signs that pulls them together.
Electrostatic charge	An overall electric charge caused by an object gaining or losing electrons.
Electrostatic repulsion	A force between two electrical charges that have the same sign that pushes them apart.
Electrostatic forces	The very strong forces between positive and negative ions in an ionic substance.
Electrostatic induction	The redistribution of electrical charge in an object. (also see induction below)
Field lines	Lines which show where a force is stronger or weaker.
Friction	Energy losses caused by two or more objects rubbing against each other.
Induction	When an object is charged by another charged object placed close to it.
Insulators	Materials that are poor electrical conductors, such as glass. They do not allow an electric current to flow through them.
Ion	An electrically charged particle.

Neutrons	Small particles that do not have a charge found in the nucleus of an atom.
Nucleus	The central core of an atom, which contains protons and neutrons and has a positive charge.
Point charge	A charge with a very small volume; a uniform sphere whose charge acts as though it is concentrated at the centre.
Protons	Small positive particles found in the nucleus of an atom.
Static electricity	Electric charges on insulating materials which do not move.
Uniform	The same in all places.

Magnetism and the motor effect (Topic 12) Keywords

Electromagnet	A magnet made using a coil of wire with electricity flowing through it.
Field lines	Lines which show where the forces is stronger or weaker.
Induced magnet	A piece of material that becomes a magnet because it is in the magnetic field of another magnet.
Magnet	An object that has its own magnetic field around it.
Magnetic field	The area around a magnet where it can affect magnetic materials or induce a current.
Magnetic flux density	A way of describing the strength of a magnetic field. It is measured in tesla (T).
Magnetic materials	Materials that are attracted to magnets, e.g. iron.
Magnetism	The force caused by magnets on magnetic materials.
Permanent magnet	A magnet that is always magnetic such as a bar magnet.
Plotting compass	A small compass used to find the shape of a magnetic field.
Solenoid	A coil of wire with electricity flowing in it.
Temporary magnet	A magnet that is not always magnetic, such as an electromagnet or an induced magnet.
Tesla (T)	The unit for magnetic flux density, also given as newtons per ampere metre (N/Am).
Uniform	The same in all places.

Keywords topic 13 Electromagnetic induction (part 1 for triples)

Alternating current (a.c.)	Current which changes direction many times a second.
Direct current (d.c.)	A current that flows in one direction only, such as the current produced by a battery.
Efficiency	The proportion of input energy that is transferred to a useful form. A more efficient system, wastes less energy.
Electric current	The rate of flow of charge (electrons). It is measured in amperes (A).
Electrical power	Power transferred by electricity.
Electromagnet	A magnet made using a coil of wire with electricity flowing through it.
Electromagnetic induction	A process that creates a current in a wire when the wire is moved relative to a magnetic field, or when the magnetic field around it changes.
Induce	To create.
National grid	The system of wires and transformers that distributes electricity around the country.
Potential difference	The energy per unit charge or the difference in the energy carried by electrons before and after they have flowed through. It is also called voltage. It is measured in volts (V).
Power	The amount of energy (in joules, J) transferred every second. It is measured in watts (W).
Primary coil	The coil on the transformer to which the electricity supply is connected.
Secondary coil	The coil on a transformer where the changed voltage is obtained.
Step-down transformer	A transformer that reduces the voltage.
Step-up transformer	A transformer that increases the voltage.
Transformer	A device that can change the voltage of an electrical supply.
Transmission lines	The wires (overhead or underground) that take electricity from power stations to towns and cities.
Voltage	The energy per unit charge or the difference in the energy carried by electrons before and after they have flowed through. It is also called potential difference. It is measured in volts (V).

Completing Topics 12 and 13 – Keywords

Alternating current (a.c.)	Current which changes direction many times a second.
Alternator	A generator that produces alternating current
Carbon brush	A block of carbon that makes electrical contact between a circuit and a moving object such as a slip ring or commutator.
Commutator	A device attached to the rotating coil of a generator that makes electrical contact with an external circuit. A commutator switches over the connections every half turn of the coil so the output is a form of direct current.
Coulomb (C)	The unit of electric charge. One coulomb is the charge that passes a point in a circuit when there is a current of 1 ampere for 1 second.
Core	The innermost part of something e.g. the central part of the Earth.
Diaphragm	A thin sheet of flexible material
Direct current (d.c.)	A current that flows in one direction only, such as the current produced by a battery.
Dynamo	A generator that uses a commutator to change its output from alternating current to direct current
Efficiency	The proportion of input energy that is transferred to a useful form. A more efficient system, wastes less energy.
Electric current	The rate of flow of charge (electrons). It is measured in amperes (A).
Electrical power	Power transferred by electricity.
Electromagnet	A magnet made using a coil of wire with electricity flowing through it.
Electromagnetic induction	A process that creates a current in a wire when the wire is moved relative to a magnetic field, or when the magnetic field around it changes.
Field lines	Lines which show where the forces is stronger or weaker.
Fleming's left hand rule	A way of remembering the direction of the force when a current flows in a magnetic field. The thumb shows the direction of the force, the first finger shows the direction of the magnetic field (N to S) and the second finger shows the current (+ to −).
Generator	A machine that produces electricity by rotating coils of wire in a magnetic field (or by rotating magnets near a coil of wire)
Induce	To create. For example, a wire in a changing magnetic field has a current induced in it
Induced magnet	A piece of material that becomes a magnet because it is in the magnetic field of another magnet.
Loudspeaker	A machine for converting changes in electrical current or voltage into sound waves
Magnet	An object that has its own magnetic field around it.
Magnetic field	The area around a magnet where it can affect magnetic materials or induce a current.
Magnetic flux density	A way of describing the strength of a magnetic field. It is measured in tesla (T).
Magnetic materials	Materials that are attracted to magnets, e.g. iron.
Magnetism	The force caused by magnets on magnetic materials.
Microphone	A machine for converting sound waves into changes in electrical current or voltage
Motor effect	The force experienced by a wire carrying a current that is placed in a magnetic field

National grid	The system of wires and transformers that distributes electricity around the country.
Permanent magnet	A magnet that is always magnetic such as a bar magnet.
Plotting compass	A small compass used to find the shape of a magnetic field.
Potential difference	The energy per unit charge or the difference in the energy carried by electrons before and after they have flowed through. It is also called voltage. It is measured in volts (V).
Power	The amount of energy (in joules, J) transferred every second. It is measured in watts (W).
Primary coil	The coil on the transformer to which the electricity supply is connected.
Secondary coil	The coil on a transformer where the changed voltage is obtained.
Slip ring	Metal rings connected to the rotation coil in a generator. They make electrical contact with an external circuit.
Solenoid	A coil of wire with electricity flowing in it.
Split-ring commutator	A device attached to the rotating coil of a motor that makes electrical contact with an external circuit. A commutator switches over the connections every half turn of the coil.
Step-down transformer	A transformer that reduces the voltage.
Step-up transformer	A transformer that increases the voltage.
Temporary magnet	A magnet that is not always magnetic, such as an electromagnet or an induced magnet.
Tesla (T)	The unit for magnetic flux density, also given as newtons per ampere metre (N/Am).
Transformer	A device that can change the voltage of an electrical supply.
Transmission lines	The wires (overhead or underground) that take electricity from power stations to towns and cities.
Uniform	The same in all places.
Voltage	The energy per unit charge or the difference in the energy carried by electrons before and after they have flowed through. It is also called potential difference. It is measured in volts (V).

Topic 14 Particle model – Keywords

Absolute zero	The temperature at which all particles stop moving and so the pressure of a gas drops to zero. It is - 273 °C or 0 K.
Atmospheres (atm)	A unit of pressure. 1 atm is the pressure exerted by the atmosphere of Earth at sea level and is equal to 100 kPa.
Boyles law	The pressure exerted by a fixed mass of gas, at a constant temperature, is inversely proportional to its volume.
Change of state	The changing of matter from one state to another e.g. from solid to liquid
Compress	To force particles closer together to make an object shorter or smaller, or to decrease the volume of a substance
Conserved	A quantity that remains the same throughout e.g. momentum (because momentum is conserved).
Density	The mass of a substance per unit volume. It has units such as g/cm^3.
Directly proportional	A relationship between 2 variables where one variable doubles when the other doubles. The graph is a straight line through (0,0).
Energy	Something that is needed to make things happen or change.
Gas pressure	The force on a surface caused by the collisions of gas particles with the surface. Gas pressure acts at right angles to a surface.
Heat	See Thermal energy!
Insulator	A thermal insulator acts as a barrier to the transfer of thermal energy and so, can be used as a material in reducing unwanted energy transfer.
Inversely proportional	A relationship between 2 variables where one variable halves when the other doubles. The graph is a straight line through (0,0).

Joule (J)	The standard unit for measuring energy.
Kelvin(K)	The standard unit for temperature. On the Kelvin temperature scale, one kelvin is the same temperature interval as 1 °C.
Kelvin temperature scale	A temperature scale that measures temperatures relative to absolute zero.
Kinetic energy	A term used to describe energy when it is stored in moving things. It is measured in J.
Kinetic theory	The model that explains the properties of different states of matter in terms of the movement of particles.
Particle theory	The theory that all matter is made up of particles (atoms).
Pascal (Pa)	A unit of pressure.1 Pa; 1 N/m^2.
Physical change	A change in which no new substances are formed, such as changes of state.
Pressure	The force on a certain area. It is measured in pascals or N/m^2.
Pressure law	The pressure exerted by a fixed mass of gas, at a constant volume, is directly proportional to its temperature in Kelvin (K).
Specific heat capacity	The energy needed to raise the temperature of 1 kg of a substance by 1 °C.
Specific latent heat	The energy taken in or released when 1 kg of a substance changes state.
State of matter	One of three different forms that a substance can have: solid, liquid or gas.
Sublimation	When a solid changes state from a solid to a gas (without becoming a liquid).
Temperature	A measure of how hot something is. It can be measured in °C for convenience but the standard unit is K.

Thermal conductivity	A measure of how easily thermal energy can travel through a material by heating. A material with a low thermal conductivity is a good insulating material.
Thermal energy	A term used to describe energy when it is stored in hot objects. It is measured in J. The hotter something is, the more thermal energy it has. It is sometimes called 'heat energy'.
Vacuum	A place where there is no matter at all.
Work	The energy transferred when a force moves an object. It is calculated using the size of the force and the distance moved by the force. The unit for work is joule the (J)
Work done	A measure of the energy transferred when a force acts through a distance.

Keywords for topic 15 Force and matter

Atmospheric pressure	The pressure exerted by the weight of the air around us.
Compress	To squash something together to make it shorter or smaller.
Density	A measure of a substance's mass per unit volume. A common unit for density is kg/m^3.
Directly proportional	A relationship between 2 variables where one variable doubles when the other doubles. The graph is a straight line through (0,0).
Displace	To push out of the way.
Elastic	A material that changes shape when there is a force on it but it returns to its original shape when the force is removed.
Elastic potential energy	The name given to the type of energy stored in a stretched or squashed material before it returns to its original shape.
Extension	The amount by which a material has stretched. It is worked out from the stretched length minus the original length.
Fluid	A gas or liquid.
Gradient	A measurement that describes the steepness of a line on a graph. It is calculated by taking the vertical distance between 2 points and dividing it be the horizontal distance between the same 2 points.
Inelastic	A material that changes shape when there is a force on it but it does not return to its original shape when the force is removed.
Linear relationship	The graph between the 2 variables is a straight line with a constant gradient.
Non-linear relationship	The graph between the 2 variables is a curved line with a changing gradient.
Normal	At right angles to a surface.
Pascal (pa)	A unit for pressure. 1 Pa = 1 newton per square metre (N/m^2).
Pressure	The amount of force pushing on a certain area. It is a way of saying how spread out a force is.
Spring constant	A measure of how stiff a spring is. It is the force needed (in N) to stretch the spring by 1m.
Upthrust	A force that pushes things up in liquids and gases.
Work done	A measure of the energy transferred when a force is acting through a distance.

Topics common to Paper 1 and Paper 2

Topic 1 – Key concepts of physics

Students should:		Maths skills
1.1	Recall and use the SI unit for physical quantities, as listed in *Appendix 3*	
1.2	Recall and use multiples and sub-multiples of units, including giga (G), mega (M), kilo (k), centi (c), milli (m), micro (μ) and nano (n)	3c
1.3	Be able to convert between different units, including hours to seconds	1c
1.4	Use significant figures and standard form where appropriate	1b

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).

Topics for Paper 1

Topic 2 – Motion and forces

Students should:		Maths skills
2.1	Explain that a scalar quantity has magnitude (size) but no specific direction	
2.2	Explain that a vector quantity has both magnitude (size) and a specific direction	5b
2.3	Explain the difference between vector and scalar quantities	5b
2.4	Recall vector and scalar quantities, including: a displacement/distance b velocity/speed c acceleration d force e weight/mass f momentum g energy	
2.5	Recall that velocity is speed in a stated direction	5b
2.6	Recall and use the equations: a (average) speed (metre per second, m/s) = distance (metre, m) ÷ time (s) b distance travelled (metre, m) = average speed (metre per second, m/s) × time (s)	1a, 1c, 1d 2a 3a, 3c, 3d
2.7	Analyse distance/time graphs including determination of speed from the gradient	2a 4a, 4b, 4d, 4e
2.8	Recall and use the equation: acceleration (metre per second squared, m/s^2) = change in velocity (metre per second, m/s) ÷ time taken (second, s) $a = \frac{(v - u)}{t}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d

2.9	Use the equation: (final velocity)^2 ((metre/second)^2, (m/s)^2) – (initial velocity)^2 ((metre/second)^2, (m/s)^2) = 2 × acceleration (metre per second squared, m/s^2) × distance (metre, m) $v^2 - u^2 = 2 \times a \times x$	1a, 1c, 1d 2a 3a, 3c, 3d

Students should:		Maths skills
2.10	Analyse velocity/time graphs to: a compare acceleration from gradients qualitatively b calculate the acceleration from the gradient (for uniform acceleration only) c determine the distance travelled using the area between the graph line and the time axis (for uniform acceleration only)	1a, 1c, 1d 2a 4a, 4b, 4c, 4d, 4e, 4f 5c
2.11	Describe a range of laboratory methods for determining the speeds of objects such as the use of light gates	1a, 1d 2a, 2b, 2c, 2f, 2h 3a, 3c, 3d 4a, 4c
2.12	Recall some typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems	
2.13	Recall that the acceleration, g, in free fall is 10 m/s^2 and be able to estimate the magnitudes of everyday accelerations	1d 2h
2.14	Recall Newton's first law and use it in the following situations: a where the resultant force on a body is zero, i.e. the body is moving at a constant velocity or is at rest b where the resultant force is not zero, i.e. the speed and/or direction of the body change(s)	1a, 1d 2a 3a, 3c, 3d
2.15	Recall and use Newton's second law as: force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s^2) $F = m \times a$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d

2.16	Define weight, recall and use the equation: weight (newton, N) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) $W = m \times g$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.17	Describe how weight is measured	
2.18	Describe the relationship between the weight of a body and the gravitational field strength	1c
2.19	*Core Practical: Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*	1a, 1c,1d 2a, 2b, 2f 3a, 3b, 3c, 3d 4a, 4b, 4c, 4d

Students should:		Maths skills
2.20	**Explain that an object moving in a circular orbit at constant speed has a changing velocity (qualitative only)**	5b
2.21	**Explain that for motion in a circle there must be a resultant force known as a centripetal force that acts towards the centre of the circle**	5b
2.22	**Explain that inertial mass is a measure of how difficult it is to change the velocity of an object (including from rest) and know that it is defined as the ratio of force over acceleration**	1c,
2.23	Recall and apply Newton's third law **both** to equilibrium situations **and to collision interactions and relate it to the conservation of momentum in collisions**	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.24	**Define momentum, recall and use the equation:** **momentum (kilogram metre per second, kg m/s) = mass (kilogram, kg) × velocity (metre per second, m/s)** $\boldsymbol{p = m \times v}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.25	**Describe examples of momentum in collisions**	1a, 1c, 1d 2a 3a, 3b, 3c, 3d

2.26	**Use Newton's second law as:** **force (newton, N) = change in momentum (kilogram metre per second, kg m/s) ÷ time (second, s)** $F = \frac{(mv - mu)}{t}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.27	Explain methods of measuring human reaction times and recall typical results	2a, 2b, 2c, 2g
2.28	Recall that the stopping distance of a vehicle is made up of the sum of the thinking distance and the braking distance	1a
2.29	Explain that the stopping distance of a vehicle is affected by a range of factors including: a the mass of the vehicle b the speed of the vehicle c the driver's reaction time d the state of the vehicle's brakes e the state of the road f the amount of friction between the tyre and the road surface	1c, 1d 2b, 2c, 2h 3b, 3c

Students should:		Maths skills
2.30	Describe the factors affecting a driver's reaction time including drugs and distractions	1d 2b, 2h 3c
2.31	Explain the dangers caused by large decelerations **and estimate the forces involved in typical situations on a public road**	1c, 1d, 2c, 2h, 3b, 3c
2.32P	Estimate how the distance required for a road vehicle to stop in an emergency varies over a range of typical speeds	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.33P	Carry out calculations on work done to show the dependence of braking distance for a vehicle on initial velocity squared (work done to bring a vehicle to rest equals its initial kinetic energy)	1c, 1d 2b, 2h 3b, 3c

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Relate changes and differences in motion to appropriate distance-time, and velocity-time graphs, and interpret lines and slopes (4a, 4b, 4c, 4d).
- **Interpret enclosed areas in velocity-time graphs (4a, 4b, 4c, 4d, 4f).**
- Apply formulae relating distance, time and speed, for uniform motion, and for motion with uniform acceleration, and calculate average speed for non-uniform motion (1a, 1c, 3c).
- Estimate how the distances required for road vehicles to stop in an emergency, varies over a range of typical speeds (1c, 1d, 2c, 2h, 3b, 3c).
- Apply formulae relating force, mass and relevant physical constants, including gravitational field strength, to explore how changes in these are inter-related (1c, 3b, 3c).
- Apply formulae relating force, mass, velocity and acceleration to explain how the changes involved are inter-related (3b, 3c, 3d).
- Estimate, for everyday road transport, the speed, accelerations and forces involved in large accelerations (1d, 2b, 2h, 3c).

Suggested practicals

- Investigate the acceleration, g, in free fall and the magnitudes of everyday accelerations.
- Investigate conservation of momentum during collisions.
- Investigate inelastic collisions with the two objects remaining together after the collision and also ‘near’ elastic collisions.
- Investigate the relationship between mass and weight.
- Investigate how crumple zones can be used to reduce the forces in collisions.

Topic 3 – Conservation of energy

Students should:		Maths skills
3.1	Recall and use the equation to calculate the change in gravitational PE when an object is raised above the ground: change in gravitational potential energy (joule, J) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) × change in vertical height (metre, m) $\Delta GPE = m \times g \times \Delta h$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d

3.2	Recall and use the equation to calculate the amounts of energy associated with a moving object: kinetic energy (joule, J) = $\frac{1}{2}$ × mass (kilogram, kg) × (speed)^2 ((metre/second)^2, (m/s)^2) $KE = \frac{1}{2} \times m \times v^2$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
3.3	Draw and interpret diagrams to represent energy transfers	1c 2c
3.4	Explain what is meant by conservation of energy	
3.5	Analyse the changes involved in the way energy is stored when a system changes, including: a an object projected upwards or up a slope b a moving object hitting an obstacle c an object being accelerated by a constant force d a vehicle slowing down e bringing water to a boil in an electric kettle	
3.6	Explain that where there are energy transfers in a closed system there is no net change to the total energy in that system	
3.7	Explain that mechanical processes become wasteful when they cause a rise in temperature so dissipating energy in heating the surroundings	
3.8	Explain, using examples, how in all system changes energy is dissipated so that it is stored in less useful ways	
3.9	Explain ways of reducing unwanted energy transfer including through lubrication, thermal insulation	
3.10	Describe the effects of the thickness and thermal conductivity of the walls of a building on its rate of cooling qualitatively	
3.11	Recall and use the equation: efficiency = $\frac{\text{(useful energy transferred by the device)}}{\text{(total energy supplied to the device)}}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d

Students should:	Maths skills
3.12 **Explain how efficiency can be increased**	

3.13	Describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydroelectricity, the tides and the Sun), and compare the ways in which both renewable and non-renewable sources are used	2c, 2g
3.14	Explain patterns and trends in the use of energy resources	2c, 2g

Uses of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Calculate relevant values of stored energy and energy transfers; convert between newton-metres and joules (1c, 3c).
- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).

Suggested practicals

- Investigate conservation of energy.

Topic 4 – Waves

Students should:		Maths skills
4.1	Recall that waves transfer energy and information without transferring matter	
4.2	Describe evidence that with water and sound waves it is the wave and not the water or air itself that travels	
4.3	Define and use the terms frequency and wavelength as applied to waves	
4.4	Use the terms amplitude, period, wave velocity and wavefront as applied to waves	
4.5	Describe the difference between longitudinal and transverse waves by referring to sound, electromagnetic, seismic and water waves	
4.6	Recall and use both the equations below for all waves: wave speed (metre/second, m/s) = frequency (hertz, Hz) × wavelength (metre, m) $v = f \times \lambda$ wave speed (metre/second, m/s) = distance (metre, m) ÷ time (second, s) $v = \frac{x}{t}$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
4.7	Describe how to measure the velocity of sound in air and ripples on water surfaces	2g
4.8P	**Calculate depth or distance from time and wave velocity**	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
4.9P	Describe the effects of a reflection b refraction c transmission d absorption of waves at material interfaces	5b

4.10	Explain how waves will be refracted at a boundary in terms of the change of direction **and speed**	1c 3c 5b
4.11	**Recall that different substances may absorb, transmit, refract or reflect waves in ways that vary with wavelength**	

Students should:		Maths skills
4.12P	**Describe the processes which convert wave disturbances between sound waves and vibrations in solids, and** **a explain why such processes only work over a limited frequency range b use this to explain the way the human ear works**	
4.13P	**Recall that sound with frequencies greater than** **20 000 hertz, Hz, is known as ultrasound**	
4.14P	**Recall that sound with frequencies less than 20 hertz,** **Hz, is known as infrasound**	
4.15P	**Explain uses of ultrasound and infrasound, including a sonar b foetal scanning c exploration of the Earth's core**	1a, 1b, 1c, 2a 3a, 3b, 3c, 3d 5b
4.16P	Describe how changes, if any, in velocity, frequency and wavelength, in the transmission of sound waves from one medium to another are inter-related	1a, 1c, 1d 2a 3a, 3c, 3d
4.17	*Core Practical: Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*	2g

Use of mathematics

- Apply formulae relating velocity, frequency and wavelength (1c, 3c).
- Show how changes, if any, in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related (1c, 3c).

Suggested practicals

- Investigate models to show refraction, such as toy cars travelling into a region of sand.

- Investigate refraction in rectangular glass blocks.

Topic 5 – Light and the electromagnetic spectrum

Students should:		Maths skills
5.1P	Explain, with the aid of ray diagrams, reflection, refraction and total internal reflection (TIR), including the law of reflection and critical angle	5a, 5b
5.2P	Explain the difference between specular and diffuse reflection	5b
5.3P	Explain how colour of light is related to a differential absorption at surfaces b transmission of light through filters	
5.4P	Relate the power of a lens to its focal length and shape	5b
5.5P	Use ray diagrams to show the similarities and differences in the refraction of light by converging and diverging lenses	5b
5.6P	Explain the effects of different types of lens in producing real and virtual images	5b
5.7	Recall that all electromagnetic waves are transverse, that they travel at the same speed in a vacuum	
5.8	Explain, with examples, that all electromagnetic waves transfer energy from source to observer	
5.9	*Core Practical: Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter*	
5.10	Recall the main groupings of the continuous electromagnetic spectrum including (in order) radio waves, microwaves, infrared, visible (including the colours of the visible spectrum), ultraviolet, x-rays and gamma rays	
5.11	Describe the electromagnetic spectrum as continuous from radio waves to gamma rays and that the radiations within it can be grouped in order of decreasing wavelength and increasing frequency	1a, 1c 3c
5.12	Recall that our eyes can only detect a limited range of frequencies of electromagnetic radiation	
5.13	**Recall that different substances may absorb, transmit, refract or reflect electromagnetic waves in ways that vary with wavelength**	

5.14	**Explain the effects of differences in the velocities of electromagnetic waves in different substances**	1a, 1c 3c
5.15P	Explain that all bodies emit radiation, that the intensity and wavelength distribution of any emission depends on their temperature	5c
5.16P	**Explain that for a body to be at a constant temperature it needs to radiate the same average power that it absorbs**	
Students should:		**Maths skills**
5.17P	**Explain what happens to a body if the average power it radiates is less or more than the average power that it absorbs**	
5.18P	**Explain how the temperature of the Earth is affected by factors controlling the balance between incoming radiation and radiation emitted**	
5.19P	*Core Practical: Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*	1a, 1c, 1d 2a, 2c, 2f 3a, 3c, 3d 4a, 4c
5.20	Recall that the potential danger associated with an electromagnetic wave increases with increasing frequency	
5.21	Describe the harmful effects on people of excessive exposure to electromagnetic radiation, including: a microwaves: internal heating of body cells b infrared: skin burns c ultraviolet: damage to surface cells and eyes, leading to skin cancer and eye conditions d x-rays and gamma rays: mutation or damage to cells in the body	

5.22 Describe some uses of electromagnetic radiation a radio waves: including broadcasting, communications and satellite transmissions b microwaves: including cooking, communications and satellite transmissions c infrared: including cooking, thermal imaging, short range communications, optical fibres, television remote controls and security systems d visible light: including vision, photography and illumination e ultraviolet: including security marking, fluorescent lamps, detecting forged bank notes and disinfecting water f x-rays: including observing the internal structure of objects, airport security scanners and medical x-rays g gamma rays: including sterilising food and medical equipment, and the detection of cancer and its treatment	
5.23 **Recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits**	
5.24 Recall that changes in atoms and nuclei can a generate radiations over a wide frequency range b be caused by absorption of a range of radiations	

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Apply the relationships between frequency and wavelength across the electromagnetic spectrum (1a, 1c, 3c).
- Construct two-dimensional ray diagrams to illustrate reflection and refraction (qualitative – equations not needed) (5a, 5b).

Suggested practicals

- Investigate total internal reflection using a semi-circular block (glass or plastic).
- Construct devices using two converging lenses of differing focal lengths.
- Construct a simple spectrometer, from a CD or DVD, and use it to analyse common light sources.
- Investigate the areas beyond the visible spectrum, such as the work of Herschel and Ritter in discovering IR and UV respectively.

Topic 6 – Radioactivity

Students should:		Maths skills
6.1	Describe an atom as a positively charged nucleus, consisting of protons and neutrons, surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with almost all of the mass in the nucleus	5b
6.2	Recall the typical size (order of magnitude) of atoms and small molecules	
6.3	Describe the structure of nuclei of isotopes using the terms atomic (proton) number and mass (nucleon) number and using symbols in the format using symbols in the format $^{13}_{6}C$	1a 3a
6.4	Recall that the nucleus of each element has a characteristic positive charge, but that isotopes of an element differ in mass by having different numbers of neutrons	2g 5b
6.5	Recall the relative masses and relative electric charges of protons, neutrons, electrons and positrons	
6.6	Recall that in an atom the number of protons equals the number of electrons and is therefore neutral	
6.7	Recall that in each atom its electrons orbit the nucleus at different set distances from the nucleus	5b
6.8	Explain that electrons change orbit when there is absorption or emission of electromagnetic radiation	5b
6.9	Explain how atoms may form positive ions by losing outer electrons	5b
6.10	Recall that alpha, β– (beta minus), β+ (positron), gamma rays and neutron radiation are emitted from unstable nuclei in a random process	
6.11	Recall that alpha, β– (beta minus), β+ (positron) and gamma rays are ionising radiations	
6.12	Explain what is meant by background radiation	
6.13	Describe the origins of background radiation from Earth and space	

6.14	Describe methods for measuring and detecting radioactivity limited to photographic film and a Geiger–Müller tube	
6.15	Recall that an alpha particle is equivalent to a helium nucleus, a beta particle is an electron emitted from the nucleus and a gamma ray is electromagnetic radiation	
6.16	Compare alpha, beta and gamma radiations in terms of their abilities to penetrate and ionise	

Students should:		**Maths skills**
6.17	Describe how and why the atomic model has changed over time including reference to the plum pudding model and Rutherford alpha particle scattering leading to the Bohr model	5b
6.18	Describe the process of β– decay (a neutron becomes a proton plus an electron)	1b, 1c, 3c
6.19	Describe the process of β+ decay (a proton becomes a neutron plus a positron)	1b, 1c, 3c
6.20	Explain the effects on the atomic (proton) number and mass (nucleon) number of radioactive decays (α, β, γ and neutron emission)	1b, 1c, 3c
6.21	Recall that nuclei that have undergone radioactive decay often undergo nuclear rearrangement with a loss of energy as gamma radiation	
6.22	Use given data to balance nuclear equations in terms of mass and charge	1b, 1c, 3c
6.23	Describe how the activity of a radioactive source decreases over a period of time	2g 4c
6.24	Recall that the unit of activity of a radioactive isotope is the Becquerel, Bq	
6.25	Explain that the half-life of a radioactive isotope is the time taken for half the undecayed nuclei to decay or the activity of a source to decay by half	1c, 1d 2a
6.26	Explain that it cannot be predicted when a particular nucleus will decay but half-life enables the activity of a very large number of nuclei to be predicted during the decay process	1c, 3d

6.27	Use the concept of half-life to carry out simple calculations on the decay of a radioactive isotope, including graphical representations	1a, 1b, 1c, 1d 2a, 2g 3a, 3b, 3c, 3d
6.28P	Describe uses of radioactivity, including: a household fire (smoke) alarms b irradiating food c sterilisation of equipment d tracing and gauging thicknesses e diagnosis and treatment of cancer	
6.29	Describe the dangers of ionising radiation in terms of tissue damage and possible mutations and relate this to the precautions needed	
6.30P	Explain how the dangers of ionising radiation depend on halflife and relate this to the precautions needed	

Students should:		Maths skills
6.31	Explain the precautions taken to ensure the safety of people exposed to radiation, including limiting the dose for patients and the risks to medical personnel	
6.32	Describe the differences between contamination and irradiation effects and compare the hazards associated with these two	
6.33P	Compare and contrast the treatment of tumours using radiation applied internally or externally	5b
6.34P	Explain some of the uses of radioactive substances in diagnosis of medical conditions, including PET scanners and tracers	
6.35P	Explain why isotopes used in PET scanners have to be produced nearby	
6.36P	Evaluate the advantages and disadvantages of nuclear power for generating electricity, including the lack of carbon dioxide emissions, risks, public perception, waste disposal and safety issues	
6.37P	Recall that nuclear reactions, including fission, fusion and radioactive decay, can be a source of energy	

6.38P	Explain how the fission of U-235 produces two daughter nuclei and the emission of two or more neutrons, accompanied by a release of energy	1b, 1c, 3c
6.39P	Explain the principle of a controlled nuclear chain reaction	
6.40P	Explain how the chain reaction is controlled in a nuclear reactor, including the action of moderators and control rods	5b
6.41P	Describe how thermal (heat) energy from the chain reaction is used in the generation of electricity in a nuclear power station	
6.42P	Recall that the products of nuclear fission are radioactive	
6.43P	Describe nuclear fusion as the creation of larger nuclei resulting in a loss of mass from smaller nuclei, accompanied by a release of energy, and recognise fusion as the energy source for stars	1b, 1c, 3c
6.44P	Explain the difference between nuclear fusion and nuclear fission	
6.45P	Explain why nuclear fusion does not happen at low temperatures and pressures, due to electrostatic repulsion of protons	
6.46P	Relate the conditions for fusion to the difficulty of making a practical and economic form of power station	

Uses of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Balance equations representing alpha-, beta- or gamma-radiations in terms of the masses and charges of the atoms involved (1b, 1c, 3c).
- **Calculate the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives (1c, 3d).**

Suggested practicals

- Investigate models which simulate radioactive decay.

Topic 7 – Astronomy

Students should:		Maths skills
7.1P	Explain how and why both the weight of any body and the value of g differ between the surface of the Earth and the surface of other bodies in space, including the Moon	
7.2P	Recall that our Solar System consists of the Sun (our star), eight planets and their natural satellites (such as our Moon); dwarf planets; asteroids and comets	5b
7.3P	Recall the names and order, in terms of distance from the Sun, of the eight planets	
7.4P	Describe how ideas about the structure of the Solar System have changed over time	5b
7.5P	Describe the orbits of moons, planets, comets and artificial satellites	5b
7.6P	Explain for circular orbits how the force of gravity can lead to changing velocity of a planet but unchanged speed	5b
7.7P	Explain how, for a stable orbit, the radius must change if orbital speed changes (qualitative only)	
7.8P	Compare the Steady State and Big Bang theories	5b
7.9P	Describe evidence supporting the Big Bang theory, limited to red-shift and the cosmic microwave background (CMB) radiation	
7.10P	Recall that as there is more evidence supporting the Big Bang theory than the Steady State theory, it is the currently accepted model for the origin of the Universe	
7.11P	Describe that if a wave source is moving relative to an observer there will be a change in the observed frequency and wavelength	5b
7.12P	Describe the red-shift in light received from galaxies at different distances away from the Earth	2g 5b
7.13P	Explain why the red-shift of galaxies provides evidence for the Universe expanding	5b
7.14P	Explain how both the Big Bang and Steady State theories of the origin of the Universe both account for red-shift of galaxies	

7.15P	Explain how the discovery of the CMB radiation led to the Big Bang theory becoming the currently accepted model	

Students should:		Maths skills
7.16P	Describe the evolution of stars of similar mass to the Sun through the following stages: a nebula b star (main sequence) c red giant d white dwarf	2g
7.17P	Explain how the balance between thermal expansion and gravity affects the life cycle of stars	
7.18P	Describe the evolution of stars with a mass larger than the Sun	2g
7.19P	Describe how methods of observing the Universe have changed over time including why some telescopes are located outside the Earth's atmosphere	

Topics for Paper 2

Topic 8 – Energy – forces doing work

Students should:		Maths skills
8.1	Describe the changes involved in the way energy is stored when systems change	
8.2	Draw and interpret diagrams to represent energy transfers	1c, 2c
8.3	Explain that where there are energy transfers in a closed system there is no net change to the total energy in that system	
8.4	Identify the different ways that the energy of a system can be changed a through work done by forces b in electrical equipment c in heating	
8.5	Describe how to measure the work done by a force and understand that energy transferred (joule, J) is equal to work done (joule, J)	
8.6	Recall and use the equation: work done (joule, J) = force (newton, N) × distance moved in the direction of the force (metre, m) $E = F \times d$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d 4f
8.7	Describe and calculate the changes in energy involved when a system is changed by work done by forces	
8.8	Recall and use the equation to calculate the change in gravitational PE when an object is raised above the ground: change in gravitational potential energy (joule, J) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) × change in vertical height (metre, m) $\Delta GPE = m \times g \times \Delta h$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d

8.9	Recall and use the equation to calculate the amounts of energy associated with a moving object: kinetic energy (joule, J) = $\frac{1}{2}$ × mass (kilogram, kg) × (speed)^2 ((metre/second)^2, (m/s)^2) $KE = \frac{1}{2} \times m \times v^2$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
8.10	Explain, using examples, how in all system changes energy is dissipated so that it is stored in less useful ways	
Students should:		**Maths skills**
8.11	Explain that mechanical processes become wasteful when they cause a rise in temperature so dissipating energy in heating the surroundings	
8.12	Define power as the rate at which energy is transferred and use examples to explain this definition	1c
8.13	Recall and use the equation: power (watt, W) = work done (joule, J) ÷ time taken (second, s) $P = \frac{E}{t}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
8.14	Recall that one watt is equal to one joule per second, J/s	1c
8.15	Recall and use the equation: efficiency = $\frac{\text{(useful energy transferred by the device)}}{\text{(total energy supplied to the device)}}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d

Use of mathematics

- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).
- Calculate relevant values of stored energy and energy transfers; convert between newton-metres and joules (1c, 3c).
- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).

Suggested practicals

- Investigate power by moving up the stairs, step-ups onto a low platform or lifting objects of different weights.

Topic 9 – Forces and their effects

Students should:		Maths skills
9.1	Describe, with examples, how objects can interact a at a distance without contact, linking these to the gravitational, electrostatic and magnetic fields involved b by contact, including normal contact force and friction c producing pairs of forces which can be represented as vectors	
9.2	Explain the difference between vector and scalar quantities using examples	
9.3	**Use vector diagrams to illustrate resolution of forces, a net force, and equilibrium situations (scale drawings only)**	4a, 5a, 5b
9.4	**Draw and use free body force diagrams**	4a, 5a, 5b
9.5	**Explain examples of the forces acting on an isolated solid object or a system where several forces lead to a resultant force on an object and the special case of balanced forces when the resultant force is zero**	5a
9.6P	Describe situations where forces can cause rotation	
9.7P	Recall and use the equation: moment of a force (newton metre, N m) = force (newton, N) × distance normal to the direction of the force (metre, m)	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
9.8P	Recall and use the principle of moments in situations where rotational forces are in equilibrium: the sum of clockwise moments = the sum of anti-clockwise moments for rotational forces in equilibrium	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
9.9P	Explain how levers and gears transmit the rotational effects of forces	5b

9.10	Explain ways of reducing unwanted energy transfer through lubrication	

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- **Use vector diagrams to illustrate resolution of forces, a net force, and equilibrium situations (scale drawings only) (4a, 5a, 5b).**

Suggested practicals

- Investigate levers and gears.

Topic 10 – Electricity and circuits

Students should:		Maths skills
10.1	Describe the structure of the atom, limited to the position, mass and charge of protons, neutrons and electrons	5b
10.2	Draw and use electric circuit diagrams representing them with the conventions of positive and negative terminals, and the symbols that represent cells, including batteries, switches, voltmeters, ammeters, resistors, variable resistors, lamps, motors, diodes, thermistors, LDRs and LEDs	5b
10.3	Describe the differences between series and parallel circuits	
10.4	Recall that a voltmeter is connected in parallel with a component to measure the potential difference (voltage), in volt, across it	
10.5	Explain that potential difference (voltage) is the energy transferred per unit charge passed and hence that the volt is a joule per coulomb	1a, 1c 3c
10.6	Recall and use the equation: energy transferred (joule, J) = charge moved (coulomb, C) × potential difference (volt, V) $E = Q \times V$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
10.7	Recall that an ammeter is connected in series with a component to measure the current, in amp, in the component	
10.8	Explain that an electric current as the rate of flow of charge and the current in metals is a flow of electrons	

10.9 Recall and use the equation: charge (coulomb, C) = current (ampere, A) × time (second, s) $Q = I \times t$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
10.10 Describe that when a closed circuit includes a source of potential difference there will be a current in the circuit	
10.11 Recall that current is conserved at a junction in a circuit	
10.12 Explain how changing the resistance in a circuit changes the current and how this can be achieved using a variable resistor	
10.13 Recall and use the equation: potential difference (volt, V) = current (ampere, A) × resistance (ohm, Ω) $V = I \times R$	1a, 1d 2a 3a, 3c, 3d
10.14 Explain why, if two resistors are in series, the net resistance is increased, whereas with two in parallel the net resistance is decreased	

Students should:	Maths skills
10.15 Calculate the currents, potential differences and resistances in series circuits	1a, 1d 2a 3a, 3c, 3d
10.16 Explain the design and construction of series circuits for testing and measuring	
10.17 *Core Practical: Construct electrical circuits to:* a *investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp* b *test series and parallel circuits using resistors and filament lamps*	1a, 1c, 1d 2a, 2b, 2f 3a, 3b, 3c, 3d 4a, 4b, 4c, 4d, 4e
10.18 Explain how current varies with potential difference for the following devices and how this relates to resistance a filament lamps b diodes c fixed resistors	2g 4a, 4b, 4c, 4d, 4e

10.19 Describe how the resistance of a light-dependent resistor (LDR) varies with light intensity	4c, 4d
10.20 Describe how the resistance of a thermistor varies with change of temperature (negative temperature coefficient thermistors only)	4c, 4d
10.21 Explain how the design and use of circuits can be used to explore the variation of resistance in the following devices a filament lamps b diodes c thermistors d LDRs	5b
10.22 Recall that, when there is an electric current in a resistor, there is an energy transfer which heats the resistor	
10.23 Explain that electrical energy is dissipated as thermal energy in the surroundings when an electrical current does work against electrical resistance	
10.24 Explain the energy transfer (in 10.22 above) as the result of collisions between electrons and the ions in the lattice	
10.25 Explain ways of reducing unwanted energy transfer through low resistance wires	
10.26 Describe the advantages and disadvantages of the heating effect of an electric current	

Students should:	Maths skills
10.27 Use the equation: energy transferred (joule, J) = current (ampere, A) × potential difference (volt, V) × time (second, s) $E = I \times V \times t$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
10.28 Describe power as the energy transferred per second and recall that it is measured in watt	1c
10.29 Recall and use the equation: power (watt, W) = energy transferred (joule, J) ÷ time taken (second, s) $P = \frac{E}{t}$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d

t	
10.30 Explain how the power transfer in any circuit device is related to the potential difference across it and the current in it	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
10.31 Recall and use the equations: electrical power (watt, W) = current (ampere, A) × potential difference (volt, V) $P = I \times V$ electrical power (watt, W) = current squared (ampere^2, A^2) × resistance (ohm, Ω) $P = I^2 \times R$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
10.32 Describe how, in different domestic devices, energy is transferred from batteries and the a.c. mains to the energy of motors and heating devices	
10.33 Explain the difference between direct and alternating voltage	4c
10.34 Describe direct current (d.c.) as movement of charge in one direction only and recall that cells and batteries supply direct current (d.c.)	
10.35 Describe that in alternating current (a.c.) the movement of charge changes direction	
10.36 Recall that in the UK the domestic supply is a.c., at a frequency of 50 Hz and a voltage of about 230 V	
10.37 Explain the difference in function between the live and the neutral mains input wires	
10.38 Explain the function of an earth wire and of fuses or circuit breakers in ensuring safety	
10.39 Explain why switches and fuses should be connected in the live wire of a domestic circuit	

Students should:	**Maths skills**

10.40 Recall the potential differences between the live, neutral and earth mains wires	
10.41 Explain the dangers of providing any connection between the live wire and earth	
10.42 Describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use	1c 2c

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Apply the equations relating p.d., current, quantity of charge, resistance, power, energy, and time, and solve problems for circuits which include resistors in series, using the concept of equivalent resistance (1c, 3b, 3c, 3d).
- Use graphs to explore whether circuit elements are linear or non-linear and relate the curves produced to their function and properties (4c, 4d).
- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).

Suggested practicals

- Investigate the power consumption of low-voltage electrical items.

Topic 11 – Static electricity

Students should:		Maths skills
11.1P	Explain how an insulator can be charged by friction, through the transfer of electrons	
11.2P	Explain how the material gaining electrons becomes negatively charged and the material losing electrons is left with an equal positive charge	
11.3P	Recall that like charges repel and unlike charges attract	

11.4P	Explain common electrostatic phenomena in terms of movement of electrons, including a shocks from everyday objects b lightning c attraction by induction such as a charged balloon attracted to a wall and a charged comb picking up small pieces of paper	
11.5P	Explain how earthing removes excess charge by movement of electrons	
11.6P	Explain some of the uses of electrostatic charges in everyday situations, including insecticide sprayers	
11.7P	Describe some of the dangers of sparking in everyday situations, including fuelling cars, and explain the use of earthing to prevent dangerous build-up of charge	
11.8P	Define an electric field as the region where an electric charge experiences a force	
11.9P	Describe the shape and direction of the electric field around a point charge and between parallel plates and relate the strength of the field to the concentration of lines	5b
11.10P	Explain how the concept of an electric field helps to explain the phenomena of static electricity	

Suggested practicals

- Investigate the forces of attraction and repulsion between charged objects.

Topic 12 – Magnetism and the motor effect

Students should:		Maths skills
12.1	Recall that unlike magnetic poles attract and like magnetic poles repel	
12.2	Describe the uses of permanent and temporary magnetic materials including cobalt, steel, iron and nickel	
12.3	Explain the difference between permanent and induced magnets	
12.4	Describe the shape and direction of the magnetic field around bar magnets and for a uniform field, and relate the strength of the field to the concentration of lines	5b

12.5 Describe the use of plotting compasses to show the shape and direction of the field of a magnet and the Earth's magnetic field	5b
12.6 Explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic	5b
12.7 Describe how to show that a current can create a magnetic effect around a long straight conductor, describing the shape of the magnetic field produced and relating the direction of the magnetic field to the direction of the current	5b
12.8 Recall that the strength of the field depends on the size of the current and the distance from the long straight conductor	
12.9 Explain how inside a solenoid (an example of an electromagnet) the fields from individual coils a add together to form a very strong almost uniform field along the centre of the solenoid b cancel to give a weaker field outside the solenoid	5b
12.10 **Recall that a current carrying conductor placed near a magnet experiences a force and that an equal and opposite force acts on the magnet**	5b
12.11 **Explain that magnetic forces are due to interactions between magnetic fields**	
12.12 **Recall and use Fleming's left-hand rule to represent the relative directions of the force, the current and the magnetic field for cases where they are mutually perpendicular**	5b
Students should:	**Maths skills**
12.13 **Use the equation:** **force on a conductor at right angles to a magnetic field carrying a current (newton, N) = magnetic flux density (tesla, T or newton per ampere metre, N/A m) × current (ampere, A) × length (metre, m)** $F = B \times I \times l$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
12.14P **Explain how the force on a conductor in a magnetic field is used to cause rotation in electric motors**	5b

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).

Suggested practicals

- Construct an electric motor.

Topic 13 – Electromagnetic induction

Students should:		Maths skills
13.1P	**Explain how to produce an electric current by the relative movement of a magnet and a conductor a on a small scale in the laboratory b in the large-scale generation of electrical energy**	
13.2	**Recall the factors that affect the size and direction of an induced potential difference, and describe how the magnetic field produced opposes the original change**	5b
13.3P	**Explain how electromagnetic induction is used in alternators to generate current which alternates in direction (a.c.) and in dynamos to generate direct current (d.c.)**	5b
13.4P	**Explain the action of the microphone in converting the pressure variations in sound waves into variations in current in electrical circuits, and the reverse effect as used in loudspeakers and headphones**	5b
13.5	**Explain how an alternating current in one circuit can induce a current in another circuit in a transformer**	
13.6	**Recall that a transformer can change the size of an alternating voltage**	
13.7P	**Use the turns ratio equation for transformers to calculate either the missing voltage or the missing number of turns:** $\frac{\textit{potential difference across primary coil}}{\textit{potential difference across secondary coil}} = \frac{\textit{number of turns in primary coil}}{\textit{number of turns in secondary coil}}$ $\frac{V_p}{V_s} = \frac{N_p}{N_s}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d 5b
13.8	Explain why, in the national grid, electrical energy is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic uses as it improves the efficiency by reducing heat loss in transmission lines	

13.9 Explain where and why step-up and step-down transformers are used in the transmission of electricity in the national grid	

Students should:	Maths skills
13.10 Use the power equation (for transformers with100% efficiency): potential difference across primary coil (volt, V) × current in primary coil (ampere, A) = potential difference across secondary coil (volt, V) × current in secondary coil (ampere, A) $V_P \times I_P = V_S \times I_S$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
13.11P **Explain the advantages of power transmission in highvoltage cables, using the equations in 10.29, 10.31, 13.7P and 13.10**	1a, 1c, 1d 2a 3a, 3b, 3c, 3d 5b

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- **Apply the equations linking the p.d.s and numbers of turns in the two coils of a transformer, to the currents and the power transfer involved, and relate these to the advantages of power transmission at high voltages (1c, 3b, 3c).**
- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).

Suggested practicals

- Investigate factors affecting the generation of electric current by induction.

Topic 14 – Particle model

Students should:	Maths skills
14.1 Use a simple kinetic theory model to explain the different states of matter (solids, liquids and gases) in terms of the movement and arrangement of particles	

14.2 Recall and use the equation: density (kilogram per cubic metre, kg/m^3) = mass (kilogram, kg) ÷ volume (cubic metre, m^3) $\rho = \frac{m}{V}$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d 5c
14.3 *Core Practical: Investigate the densities of solid and liquids*	1a, 1b, 1c, 1d 2a, 2c, 2f 3a, 3b, 3c, 3d 4a, 4c 5c
14.4 Explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules	5b
14.5 Describe that when substances melt, freeze, evaporate, boil, condense or sublimate mass is conserved and that these physical changes differ from some chemical changes because the material recovers its original properties if the change is reversed	
14.6 Explain how heating a system will change the energy stored within the system and raise its temperature or produce changes of state	
14.7 Define the terms specific heat capacity and specific latent heat and explain the differences between them	
14.8 Use the equation: change in thermal energy (joule, J) = mass (kilogram, kg) × specific heat capacity (joule per kilogram degree Celsius, J/kg °C) × change in temperature (degree Celsius, °C) $\Delta Q = m \times c \times \Delta\theta$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
14.9 Use the equation: thermal energy for a change of state (joule , J) = mass (kilogram, kg) × specific latent heat (joule per kilogram, J/kg) $Q = m \times L$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
14.10 Explain ways of reducing unwanted energy transfer through thermal insulation	
Students should:	**Maths skills**

14.11 *Core Practical: Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice*	1a, 1b, 1c, 1d 2a, 2b, 2f 3a, 3b, 3c, 3d 4a, 4c, 4e
14.12 Explain the pressure of a gas in terms of the motion of its particles	5b
14.13 Explain the effect of changing the temperature of a gas on the velocity of its particles and hence on the pressure produced by a fixed mass of gas at constant volume (qualitative only)	5b
14.14 Describe the term absolute zero, −273 °C, in terms of the lack of movement of particles	
14.15 Convert between the kelvin and Celsius scales	1a 2a
14.16P Explain that gases can be compressed or expanded by pressure changes	
14.17P Explain that the pressure of a gas produces a net force at right angles to any surface	
14.18P Explain the effect of changing the volume of a gas on the rate at which its particles collide with the walls of its container and hence on the pressure produced by a fixed mass of gas at constant temperature	5b
14.19P Use the equation: $P_1 \times V_1 = P_2 \times V_2$ to calculate pressure or volume for gases of fixed mass at constant temperature	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
14.20P **Explain why doing work on a gas can increase its temperature, including a bicycle pump**	

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).

- Calculate relevant values of stored energy and energy transfers; convert between newtonmetres and joules (1c, 3c).
- Apply the relationship between density, mass and volume to changes where mass is conserved (1a, 1b, 1c, 3c).
- Apply the relationship between change in internal energy of a material and its mass, specific heat capacity and temperature change to calculate the energy change involved; apply the relationship between specific latent heat and mass to calculate the energy change involved in a change of state (1a, 3c, 3d).

Suggested practicals

- Investigate the temperature and volume relationship for a gas.
- Investigate the volume and pressure relationship for a gas.
- Investigate latent heat of vaporisation.

Topic 15 – Forces and matter

Students should:		Maths skills
15.1	Explain, using springs and other elastic objects, that stretching, bending or compressing an object requires more than one force	
15.2	Describe the difference between elastic and inelastic distortion	
15.3	Recall and use the equation for linear elastic distortion including calculating the spring constant: force exerted on a spring (newton, N) = spring constant (newton per metre, N/m) × extension (metre, m) $F = k \times x$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
15.4	Use the equation to calculate the work done in stretching a spring: energy transferred in stretching (joules, J) = 0.5 × spring constant (newton per metre, N/m) × (extension (metre, m))^2 $E = \frac{1}{2} \times k \times x^2$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d 4c, 4e, 4f
15.5	Describe the difference between linear and non-linear relationships between force and extension	4c, 4e
15.6	*Core Practical: Investigate the extension and work done when applying forces to a spring*	1a, 1c, 1d 2a, 2b, 2c, 2f 3a, 3b, 3c, 3d 4a, 4b, 4c, 4d
15.7P	Explain why atmospheric pressure varies with height above the Earth's surface with reference to a simple model of the Earth's atmosphere	
15.8P	Describe the pressure in a fluid as being due to the fluid and atmospheric pressure	
15.9P	Recall that the pressure in fluids causes a force normal to any surface	
15.10P	Explain how pressure is related to force and area, using appropriate examples	1c

15.11P	Recall and use the equation: pressure (pascal, Pa) = force normal to surface (newton, N) ÷ area of surface (square metre, m^2) $P = \frac{F}{A}$	1a, 1b, 1c, 1d 2a 3a, 3c, 3d 5b, 5c
15.12P	Describe how pressure in fluids increases with depth and density	1c

Students should:		Maths skills
15.13P	**Explain why the pressure in liquids varies with density and depth**	1c
15.14P	**Use the equation to calculate the magnitude of the pressure in liquids and calculate the differences in pressure at different depths in a liquid:** **pressure due to a column of liquid (pascal, Pa) = height of column (metre, m) × density of liquid (kilogram per cubic metre, kg/m^3) × gravitational field strength (newton per kilogram, N/kg)** $P = h \times \rho \times g$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
15.15P	**Explain why an object in a fluid is subject to an upwards force (upthrust) and relate this to examples including objects that are fully immersed in a fluid (liquid or gas) or partially immersed in a liquid**	5b
15.16P	**Recall that the upthrust is equal to the weight of fluid displaced**	
15.17P	**Explain how the factors (upthrust, weight, density of fluid) influence whether an object will float or sink**	5b

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- **Calculate the differences in pressure at different depths in a liquid (1c, 3c).**

- Calculate relevant values of stored energy and energy transfers; convert between newtonmetres and joules (1c, 3c).
- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).

Suggested practicals

- Investigate the upthrust on objects in different liquids.
- Investigate the stretching of rubber bands.