OCR A Comb Sci Phys

Topic P1: Matter

P1.1 The particle model

P1.1a — describe how and why the atomic model has changed over time

1. What did Thomson's model suggest an atom looked like?
2. What did the Geiger–Marsden experiment show about the structure of the atom?
3. How did Rutherford's model differ from Thomson's model?
4. What did Bohr add to Rutherford's model?
5. Why did the atomic model change as new experimental evidence was obtained?
6. How did different scientists working together contribute to the development of the atomic model?

P1.1b — describe the atom as a positively charged nucleus 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

1. What is the charge of the nucleus of an atom?
2. What particles are found in the nucleus?
3. What is the charge of an electron?
4. How does the radius of the nucleus compare with the radius of the atom?
5. Where is almost all of an atom's mass concentrated?
6. Why is an atom electrically neutral overall?

P1.1c — recall the typical size (order of magnitude) of atoms and small molecules

1. What is the typical size of an atom?
2. What is the order of magnitude of the radius of an atom?
3. Write the typical size of an atom in standard form.

4. How does the size of an atom compare with 1 metre?
5. What unit is commonly used to describe the size of atoms?
6. Why are atoms too small to be seen directly with an ordinary light microscope?

P1.1d — define density

1. What is density?
2. What is the SI unit of density?
3. What measurements are needed to calculate the density of a solid?
4. How can the volume of a regular solid be determined?
5. How can the volume of an irregular solid be measured using a Eureka can?
6. A solid has a mass of 240 g and a volume of 80 cm^3. Calculate its density.

P1.1e — explain the differences in density between the different states of matter in terms of the arrangements of the atoms and molecules

1. How are particles arranged in a solid?
2. How are particles arranged in a liquid?
3. How are particles arranged in a gas?
4. Why are solids usually denser than gases?
5. Why are particles in a gas much further apart than particles in a solid?
6. How does the arrangement of particles affect the density of a substance?

P1.1f — apply the relationship between density, mass and volume to changes where mass is conserved

1. What is the equation linking density, mass and volume?
2. How can the equation for density be rearranged to calculate mass?
3. How can the equation for density be rearranged to calculate volume?
4. A substance has a density of 2 g/cm^3 and a volume of 50 cm^3. Calculate its mass.
5. A substance has a mass of 300 g and a density of 3 g/cm^3. Calculate its volume.
6. If the mass of a substance is conserved when its volume changes, what happens to its density if its volume decreases?

Topic P1: Matter

P1.2 Changes of state

P1.2a — describe how mass is conserved when substances melt, freeze, evaporate, condense or sublimate

1. What happens to the mass of a substance when it melts?
2. What happens to the mass of a substance when it freezes?
3. What happens to the mass of a substance when it evaporates?
4. What happens to the mass of a substance when it condenses?
5. What happens to the mass of a substance when it sublimates?
6. Why is mass conserved during a change of state?

P1.2b — describe that physical changes differ from chemical changes because the material recovers its original properties if the change is reversed

1. What is a physical change?
2. What is a chemical change?
3. Why is melting ice a physical change?
4. Why is burning a substance a chemical change?
5. What happens to the original properties of a material when a physical change is reversed?
6. What happens to the original properties of a material when a chemical change cannot be reversed?

P1.2c — describe how heating a system will change the energy stored within the system and raise its temperature or produce changes of state

1. What happens to the energy stored in a system when it is heated?
2. What happens to the temperature of a substance when heating increases its internal energy without changing its state?
3. What happens to the temperature of a substance while it is changing state?
4. What happens to the energy supplied to a substance during a change of state?
5. Why can heating a substance cause it to change state?
6. What happens to the internal energy of a substance when it is heated from a solid to a liquid?

P1.2d — define the term specific heat capacity and distinguish between it and the term specific latent heat

1. What is specific heat capacity?

2. What does a material's specific heat capacity tell us about the energy needed to raise its temperature?
3. What is specific latent heat?
4. What is specific latent heat of fusion?
5. What is specific latent heat of vaporisation?
6. What is the difference between specific heat capacity and specific latent heat?

P1.2e — 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

1. What equation links energy change, mass, specific heat capacity and temperature change?
2. What is the unit of specific heat capacity?
3. What happens to the energy needed to heat a substance if its mass is doubled?
4. Calculate the energy needed to heat 2 kg of water by 10°C. The specific heat capacity of water is 4200 J/kg°C.
5. A 0.5 kg metal is heated by 20°C and gains 5000 J of energy. Calculate its specific heat capacity.
6. A 3 kg substance has a specific heat capacity of 1000 J/kg°C. How much energy is needed to increase its temperature by 5°C?

P1.2f — apply the relationship between specific latent heat and mass to calculate the energy change involved in a change of state

1. What equation links energy change, mass and specific latent heat?
2. What is the unit of specific latent heat?
3. What happens to the energy needed for a change of state if the mass of the substance is doubled?
4. Calculate the energy needed to melt 0.5 kg of a substance with a specific latent heat of fusion of 200 000 J/kg.
5. A substance requires 600 000 J to change state and has a mass of 2 kg. Calculate its specific latent heat.
6. What type of energy transfer occurs when a substance changes state without changing temperature?

P1.2g — explain how the motion of the molecules in a gas is related both to its temperature and its pressure

1. What happens to the average speed of gas molecules when the temperature increases?

2. Why do gas molecules move faster when the temperature increases?
3. What happens to the frequency of collisions between gas molecules and the walls when the molecules move faster?
4. What happens to the pressure of a gas when its molecules collide with the walls more frequently?
5. Why does cooling a gas reduce its pressure in a closed system at constant volume?
6. Why does heating a gas increase its pressure in a closed system at constant volume?

P1.2h — explain the relationship between the temperature of a gas and its pressure at constant volume (qualitative only)

1. What happens to the pressure of a gas when its temperature increases at constant volume?
2. What happens to the pressure of a gas when its temperature decreases at constant volume?
3. Why does heating a gas increase its pressure when its volume is kept constant?
4. Why does cooling a gas decrease its pressure when its volume is kept constant?
5. A sealed container of gas is heated while its volume remains constant. What happens to the pressure?
6. A sealed container of gas is cooled while its volume remains constant. What happens to the pressure?

Topic P2: Forces

P2.1 Motion

P2.1a — describe how to measure distance and time in a range of scenarios

1. What instrument can be used to measure distance?
2. What instrument can be used to measure time?
3. What unit is commonly used to measure distance in physics?
4. What unit is commonly used to measure time in physics?
5. How could you measure the distance travelled by a learner walking along a straight path?
6. How could you measure the time taken for a learner to travel a measured distance?

P2.1b — describe how to measure distance and time and use these to calculate speed from graphs

1. What two measurements are needed to calculate speed?
2. How can the distance travelled by a moving object be measured?
3. How can the time taken for an object to travel a distance be measured?
4. What does the gradient of a distance-time graph represent?
5. A learner travels 20 m in 5 s. Calculate their speed.
6. A distance-time graph shows an object travelling 60 m in 10 s. Calculate its speed.

P2.1c — make calculations using ratios and proportional reasoning to convert units and to compute rates

1. How many metres are there in 1 kilometre?
2. How many seconds are there in 1 minute?
3. Convert 2.5 km into metres.
4. Convert 180 seconds into minutes.
5. Convert 72 km/h into m/s.
6. An object travels 150 m in 12 s. Calculate its speed in m/s.

P2.1d — explain the vector-scalar distinction as it applies to displacement and distance, velocity and speed

1. What is a scalar quantity?
2. What is a vector quantity?
3. What is the difference between distance and displacement?
4. What is the difference between speed and velocity?
5. Which of distance and displacement is a vector?
6. Which of speed and velocity is a vector?

P2.1e — relate changes and differences in motion to appropriate distance-time, and velocity-time graphs; interpret lines and slopes

1. What does a horizontal line on a distance-time graph show?
2. What does a straight sloping line on a distance-time graph show?
3. What does a steeper gradient on a distance-time graph mean?
4. What does a horizontal line on a velocity-time graph show?
5. What does a positive gradient on a velocity-time graph represent?
6. What does a negative gradient on a velocity-time graph represent?

P2.1f — interpret enclosed areas in velocity-time graphs

1. What does the area under a velocity-time graph represent?
2. What quantity is found by calculating the area under a velocity-time graph?
3. How can the distance travelled be calculated from a rectangular section of a velocity-time graph?
4. A vehicle travels at 10 m/s for 5 s. Calculate the area under its velocity-time graph.
5. What does a larger area under a velocity-time graph indicate?
6. How can the total distance travelled be found when a velocity-time graph contains several sections?

P2.1g — calculate average speed for non-uniform motion

1. What is meant by non-uniform motion?
2. What equation is used to calculate average speed?
3. A cyclist travels 200 m in 20 s, then 300 m in 30 s. What total distance does the cyclist travel?
4. A cyclist travels 200 m in 20 s, then 300 m in 30 s. What is the total time taken?
5. A cyclist travels 500 m in 50 s. Calculate their average speed.
6. Why is average speed needed when an object does not travel at a constant speed?

P2.1h — apply formulae relating distance, time and speed, for uniform motion, and for motion with uniform acceleration

1. What equation links distance, speed and time?
2. What equation links acceleration, change in velocity and time?
3. A car travels at a constant speed of 15 m/s for 8 s. Calculate the distance travelled.
4. A runner travels 100 m at a constant speed of 5 m/s. Calculate the time taken.
5. A car's velocity increases from 10 m/s to 30 m/s in 5 s. Calculate its acceleration.
6. What does uniform acceleration mean?

P2.2 Newton’s laws

P2.2a — recall examples of ways in which objects interact

1. What type of interaction occurs between two electrically charged objects?
2. What type of interaction occurs between two objects with mass?
3. What type of interaction occurs between two magnetic poles?

4. What is a normal contact force?
5. What is friction?
6. What is the difference between a contact interaction and a non-contact interaction?

P2.2b — describe how such examples involve interactions between pairs of objects which produce a force on each object

1. What is meant by an interaction between two objects?
2. When two objects interact, how many forces are produced by the interaction?
3. What happens to the forces acting on the two objects in an interaction?
4. What force does Earth exert on an object near its surface?
5. What force does a surface exert on an object resting on it?
6. Why must forces always be considered as interactions between pairs of objects?

P2.2c — represent forces as vectors

1. What is a force vector?
2. What does the length of a force arrow represent on a force diagram?
3. What does the direction of a force arrow represent?
4. What information must be included in a free-body force diagram?
5. How can a free-body diagram show that two forces acting on an object are equal?
6. What is the resultant force when two equal forces act in opposite directions?

P2.2d — apply Newton's first law to explain the motion of an object moving with uniform velocity and also an object where the speed and/or direction change

1. What does Newton's First Law state about the resultant force on an object moving with constant velocity?
2. What happens to the velocity of an object when the resultant force acting on it is zero?
3. What happens to the motion of an object when there is a non-zero resultant force?
4. Why can an object moving at constant speed still have a changing velocity?
5. A car travels in a straight line at constant velocity. What is the resultant force acting on it?
6. A car's speed increases from 10 m/s to 20 m/s. What does this tell you about the resultant force acting on the car?

P2.2e — use vector diagrams to illustrate resolution of forces, a net force (resultant force), and equilibrium situations

1. What is meant by resolving a force?
2. What is a resultant force?
3. What is meant by equilibrium?
4. How can two perpendicular forces be combined using a vector diagram?
5. What condition must be satisfied for an object to be in equilibrium?
6. On a force diagram, how can you determine whether the resultant force is zero?

P2.2f — describe examples of the forces acting on an isolated solid object or system

1. What forces act on a falling skydiver before they reach terminal velocity?
2. What happens to the air resistance acting on a skydiver as their speed increases?
3. What is terminal velocity?
4. What is the resultant force on an object travelling at terminal velocity?
5. Why does a skydiver stop accelerating when terminal velocity is reached?
6. How are the forces on a vehicle similar to those on a skydiver when the vehicle travels at constant speed?

P2.2g — describe, using free body diagrams, examples where two or more forces lead to a resultant force on an object

1. What is the resultant force when two forces act in the same direction?
2. What is the resultant force when two forces act in opposite directions?
3. A 10 N force acts to the right and a 6 N force acts to the left. What is the resultant force?
4. In which direction does the resultant force act in the situation in question 3?
5. How does a non-zero resultant force affect the velocity of an object?
6. How can a free-body diagram be used to determine the resultant force on an object?

P2.2h — describe using free body force diagrams the special case of balanced forces when the resultant force is zero

1. What are balanced forces?
2. What is the resultant force when forces are balanced?
3. What happens to the velocity of an object when the forces acting on it are balanced?

4. Can an object be moving when the forces acting on it are balanced?
5. What would a free-body diagram look like for an object at rest with balanced forces?
6. What would a free-body diagram look like for an object moving at constant velocity with balanced forces?

P2.2i — apply Newton's Second Law in calculations relating forces, masses and accelerations

1. What equation links resultant force, mass and acceleration?
2. What is the unit of force?
3. What is the unit of acceleration?
4. Calculate the resultant force on a 5 kg object accelerating at 3 m/s^2.
5. A 20 N resultant force acts on a 4 kg object. Calculate its acceleration.
6. A 30 N resultant force produces an acceleration of 6 m/s^2. Calculate the mass of the object.

P2.2j — explain that inertia is a measure of how difficult it is to change the velocity of an object and that the inertial mass is defined as the ratio of force over acceleration

1. What is inertia?
2. What does a large inertia mean for an object's motion?
3. Which property of an object determines its inertia?
4. What is inertial mass?
5. What equation defines inertial mass in terms of force and acceleration?
6. How does the inertial mass of an object affect the acceleration produced by a given force?

P2.2k — define momentum and describe examples of momentum in collisions

1. What is momentum?
2. What equation links momentum, mass and velocity?
3. What is the unit of momentum?
4. Calculate the momentum of a 4 kg object travelling at 5 m/s.
5. What happens to the total momentum of a closed system during a collision?
6. A 2 kg trolley travelling at 3 m/s collides with a stationary 1 kg trolley. What is the total momentum of the system before the collision?

P2.2l — use the relationship between work done, force, and distance moved along the line of action of the force and describe the energy transfer involved

1. What is the equation linking work done, force and distance moved?
2. What is the unit of work done?
3. When is work done on an object by a force?
4. A force of 20 N moves an object 5 m in the direction of the force. Calculate the work done.
5. What energy transfer occurs when a force does work on an object?
6. Why must the distance used in the work-done equation be measured along the line of action of the force?

P2.2m — calculate relevant values of stored energy and energy transfers; convert between newton-metres and joules

1. How many joules are equal to one newton-metre?
2. What is the gravitational potential energy equation?
3. Calculate the gravitational potential energy gained by a 2 kg object lifted through 5 m. Take gravitational field strength as 10 N/kg.
4. What happens to the gravitational potential energy of an object when it is raised?
5. What happens to the gravitational potential energy of an object when it falls?
6. Why is work done against gravity equal to the increase in gravitational potential energy?

P2.2n — explain, with reference to examples, the definition of power as the rate at which energy is transferred

1. What is power?
2. What is the equation linking power, energy transferred and time?
3. What is the unit of power?
4. A machine transfers 600 J of energy in 20 s. Calculate its power.
5. Which transfers energy faster: a 1000 W machine or a 500 W machine?
6. Why does a more powerful machine transfer the same amount of energy in less time?

P2.2o — recall and apply Newton's Third Law

1. What does Newton's Third Law state?
2. What two properties do a Newton's Third Law pair of forces have?
3. Where do the two forces in a Newton's Third Law pair act?

4. What is the Newton's Third Law force when Earth attracts an object downwards?
5. When a swimmer pushes water backwards, what is the Newton's Third Law force?
6. Why do the two forces in a Newton's Third Law pair not cancel each other out?

P2.2p — explain why an object moving in a circle with a constant speed has a changing velocity

1. What is velocity?
2. What changes when an object moving in a circle changes direction?
3. Why does a change in direction mean that velocity changes?
4. Can an object moving at constant speed have a changing velocity?
5. What is the direction of the velocity of an object at any point on a circular path?
6. Why does an object moving at constant speed around a circle have a resultant force acting on it?

P2.3 Forces in action

P2.3a — explain, that to stretch, bend or compress an object, more than one force has to be applied

1. Why must more than one force be applied to stretch an object?
2. Why must more than one force be applied to compress an object?
3. How can a pair of forces cause an object to bend?
4. What happens to an object when two equal and opposite forces act to stretch it?
5. Give one real-life example of forces stretching an object.
6. Give one real-life example of forces bending or compressing an object.

P2.3b — describe the difference between elastic and plastic deformation (distortions) caused by stretching forces

1. What is elastic deformation?
2. What is plastic deformation?
3. What happens to an object after an elastic deformation when the force is removed?
4. What happens to an object after a plastic deformation when the force is removed?
5. What does it mean if a spring has been stretched beyond its elastic limit?

6. How could you experimentally determine whether a material has undergone elastic or plastic deformation?

P2.3c — describe the relationship between force and extension for a spring and other simple systems

1. What is meant by the extension of a spring?
2. How is the extension of a spring calculated from its original and stretched lengths?
3. What happens to the extension of a spring when the applied force increases?
4. What does the gradient of a force-extension graph represent when the relationship is linear?
5. What would a force-extension graph look like for a spring obeying Hooke's Law?
6. How can a graph be used to determine whether a spring obeys a proportional relationship between force and extension?

P2.3d — describe the difference between linear and non-linear relationships between force and extension

1. What is a linear relationship between force and extension?
2. What would the graph look like for a linear force-extension relationship?
3. What is a non-linear relationship between force and extension?
4. What would the graph look like for a non-linear force-extension relationship?
5. How can you identify the limit of proportionality from a force-extension graph?
6. What happens to the relationship between force and extension when a spring is stretched beyond its limit of proportionality?

P2.3e — calculate a spring constant in linear cases

1. What equation links force, spring constant and extension?
2. What is the unit of spring constant?
3. What does a large spring constant indicate about a spring?
4. A spring extends by 0.04 m when a force of 8 N is applied. Calculate its spring constant.
5. A spring has a spring constant of 250 N/m and is extended by 0.08 m. Calculate the applied force.
6. A spring has a spring constant of 100 N/m and a force of 15 N is applied. Calculate its extension.

P2.3f — calculate the work done in stretching

1. What does the area under a force-extension graph represent?
2. What equation can be used to calculate the work done when a spring is stretched and the force-extension graph is a straight line?
3. What happens to the work done when the extension of a spring is increased?
4. A spring is stretched by 0.20 m by a force that increases uniformly from 0 N to 10 N. Calculate the work done.
5. A force-extension graph has a triangular area with a base of 0.30 m and a height of 20 N. Calculate the work done.
6. Where is the energy transferred to when work is done stretching an elastic object?

P2.3g — describe that all matter has a gravitational field that causes attraction, and the field strength is much greater for massive objects

1. What is a gravitational field?
2. What does a gravitational field do to an object with mass?
3. Why do two objects with mass attract each other?
4. Do all objects with mass produce a gravitational field?
5. How does the gravitational field strength of a massive object compare with that of a less massive object?
6. Why is Earth's gravitational field much stronger than the gravitational field of a small object such as a tennis ball?

P2.3h — define weight, describe how it is measured and describe the relationship between the weight of an object and the gravitational field strength, g

1. What is weight?
2. What instrument is used to measure weight?
3. What is the unit of weight?
4. What equation links weight, mass and gravitational field strength?
5. What is the value of gravitational field strength, g, at the Earth's surface?
6. An object has a mass of 6 kg. Calculate its weight at the Earth's surface.

P2.3i — recall the acceleration in free fall

1. What is meant by free fall?
2. What is the acceleration of an object in free fall near the Earth's surface?
3. What unit is used for acceleration in free fall?
4. What causes an object to accelerate when it is in free fall?
5. What happens to the velocity of an object during free fall when air resistance is negligible?

6. What would happen to the acceleration of a falling object if air resistance were ignored?

Topic P3: Electricity and magnetism

P3.1 Static electricity and current

P3.1a — describe that charge is a property of all matter and that there are positive and negative charges

1. What are the two types of electric charge?
2. What is the net charge of an object containing equal numbers of positive and negative charges?
3. What happens to the net charge of an object when it gains more electrons than it has positive charges?
4. What happens to the net charge of an object when it loses electrons?
5. Why do most objects have zero net charge?
6. What happens between two objects carrying charges of the same sign?

P3.1b — describe the production of static electricity, and sparking, by rubbing surfaces, and evidence that charged objects exert forces of attraction or repulsion on one another when not in contact

1. How can static electricity be produced by rubbing two surfaces together?
2. Why does static charge build up on an insulator?
3. What happens when two objects with the same type of charge are brought close together?
4. What happens when two objects with opposite charges are brought close together?
5. How can a charged object produce a spark?
6. Why can a charged balloon be attracted to a wall even though the wall is initially uncharged?

P3.1c — explain how transfer of electrons between objects can explain the phenomena of static electricity

1. Which particles are transferred when an object becomes statically charged?
2. What happens to the charge of an object when it gains electrons?
3. What happens to the charge of an object when it loses electrons?

4. Why does rubbing two different insulating materials together cause one to become positively charged and the other negatively charged?
5. Why does a charged rod attract small pieces of paper?
6. How can a gold-leaf electroscope be used to detect the presence of electric charge?

P3.1d — recall that current is a rate of flow of charge (electrons) and the conditions needed for charge to flow

1. What is electric current?
2. What particles flow through a metal wire to produce an electric current?
3. What two conditions are required for charge to flow continuously in a circuit?
4. What is meant by a closed circuit?
5. What provides the potential difference needed to drive charge around a circuit?
6. What happens to the current if a circuit containing a cell is opened?

P3.1e — recall that current has the same value at any point in a single closed loop

1. What happens to the current at different points in a single closed loop?
2. What is the current through a lamp in a simple series circuit if the current leaving the cell is 0.5 A?
3. Why is the current the same at every point in a series circuit?
4. A series circuit has a current of 2 A before a lamp. What is the current after the lamp?
5. Where should an ammeter be connected to measure the current through a component?
6. What happens to the current at a junction in a circuit containing more than one branch?

P3.1f — recall and use the relationship between quantity of charge, current and time

1. What equation links charge, current and time?
2. What is the unit of electric charge?
3. What is the unit of electric current?
4. Calculate the charge flowing when a current of 3 A flows for 20 s.
5. A charge of 120 C flows through a circuit in 30 s. Calculate the current.
6. A current of 0.5 A flows for 2 minutes. Calculate the charge transferred.

P3.2 Simple circuits

P3.2a — describe the differences between series and parallel circuits

1. What is the difference between a series circuit and a parallel circuit?
2. How does current behave in a series circuit?
3. How does current behave at a junction in a parallel circuit?
4. How is potential difference shared between components in a series circuit?
5. What is the potential difference across components connected in parallel with each other?
6. Where should an ammeter and a voltmeter be connected in a circuit to measure current and potential difference?

P3.2b — represent d.c. circuits with the conventions of positive and negative terminals, and the symbols that represent common circuit elements

1. What do the positive and negative terminals of a d.c. power supply represent on a circuit diagram?
2. What circuit symbol represents a cell?
3. What circuit symbol represents a diode?
4. What circuit symbols represent an LDR and an NTC thermistor?
5. What circuit symbols represent an ammeter and a voltmeter?
6. What circuit symbols represent a fixed resistor, variable resistor, filament lamp and switch?

P3.2c — recall that current (I) depends on both resistance (R) and potential difference (V) and the units in which these are measured

1. What is potential difference?
2. What is the unit of potential difference?
3. What is the unit of resistance?
4. What is the unit of current?
5. What happens to the current through a resistor if the potential difference increases while resistance remains constant?
6. What happens to the current through a resistor if its resistance increases while potential difference remains constant?

P3.2d — recall and apply the relationship between I, R and V and that for some resistors the value of R remains constant but that in others it can change as the current changes

1. What equation links potential difference, current and resistance?

2. A resistor has a potential difference of 12 V across it and a resistance of 4 Ω. Calculate the current.
3. A current of 2 A flows through a 6 Ω resistor. Calculate the potential difference across it.
4. A 10 V potential difference produces a current of 0.5 A through a component. Calculate its resistance.
5. What happens to the resistance of an ohmic resistor when the current changes, provided its temperature remains constant?
6. Why can the resistance of some components change as the current changes?

P3.2e — explain that for some resistors the value of R remains constant but that in others it can change as the current changes

1. What is meant by a resistor having a constant resistance?
2. Which type of resistor has a constant resistance when physical conditions remain constant?
3. What happens to the resistance of a filament lamp as its temperature increases?
4. Why does the resistance of a filament lamp increase as the current increases?
5. How does the resistance of a diode depend on the direction and size of the applied potential difference?
6. What is meant by a non-linear circuit component?

P3.2f — explain the design and use of circuits to explore such effects

1. How could a circuit be designed to investigate the resistance of a wire?
2. Which instrument is used to measure the current through a component?
3. Which instrument is used to measure the potential difference across a component?
4. How could you investigate how the resistance of a wire changes with its length?
5. How could a circuit be used to investigate the effect of temperature on an NTC thermistor?
6. How could a circuit be used to investigate how light intensity affects an LDR?

P3.2g — use graphs to explore whether circuit elements are linear or non-linear

1. What type of graph can be used to investigate whether a circuit component is linear?
2. What would the I-V graph of a linear circuit component look like?

3. What does a constant gradient on an I-V graph indicate?
4. What does a curved I-V graph indicate about a circuit component?
5. How can an I-V graph be used to determine whether a component obeys Ohm's Law?
6. What is the relationship between current and potential difference for a component with constant resistance?

P3.2h — use graphs and relate the curves produced to the function and properties of circuit elements

1. What does the I-V characteristic graph of a filament lamp show?
2. Why does the I-V graph of a filament lamp become less steep as the potential difference increases?
3. What does the I-V characteristic graph of a diode show?
4. Why does a diode allow current to flow much more easily in one direction than the other?
5. How does the resistance of an NTC thermistor change as temperature increases?
6. How does the resistance of an LDR change as light intensity increases?

P3.2i — explain why, if two resistors are in series the net resistance is increased, whereas with two in parallel the net resistance is decreased

1. Why does adding a resistor in series increase the total resistance?
2. What happens to the total resistance when another resistor is added in series?
3. Why does adding a resistor in parallel decrease the total resistance?
4. How does adding another parallel path affect the total current supplied by the power source?
5. Which arrangement gives a greater total resistance: two identical resistors in series or two identical resistors in parallel?
6. Why does connecting resistors in parallel provide more paths for charge to flow?

P3.2j — calculate the currents, potential differences and resistances in d.c. series and parallel circuits

1. What is the total resistance of two 4 Ω resistors connected in series?
2. A 12 V supply is connected to two 3 Ω resistors in series. Calculate the total resistance and circuit current.
3. Two identical resistors are connected in parallel. How does the current divide between the two branches?

4. A 6 Ω and a 3 Ω resistor are connected in parallel. Calculate their equivalent resistance.
5. Two resistors of 2 Ω and 4 Ω are connected in series across a 12 V supply. Calculate the current and the potential difference across each resistor.
6. In a parallel circuit, the potential difference across each branch is 6 V. A 3 Ω resistor is connected in one branch. Calculate the current through that resistor.

P3.2k — explain the design and use of d.c. circuits for measurement and testing purposes

1. Why is an ammeter connected in series with the component being tested?
2. Why is a voltmeter connected in parallel with the component being tested?
3. Why should an ammeter have a very low resistance?
4. Why should a voltmeter have a very high resistance?
5. How could a d.c. circuit be designed to measure the resistance of a component?
6. Why should measurements of current and potential difference be taken for a range of values when investigating a component?

P3.2l — explain how the power transfer in any circuit device is related to the potential difference across it and the current, and to the energy changes over a given time

1. What equation links power, potential difference and current?
2. What is the unit of power?
3. What equation links energy transferred, power and time?
4. A lamp operates at 12 V with a current of 2 A. Calculate its power.
5. A 60 W lamp operates for 30 s. Calculate the energy transferred.
6. What happens to the energy transferred by a circuit device when it operates at a higher power for the same length of time?

P3.2m — apply the equations relating potential difference, 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

1. What equation links potential difference, current and resistance?
2. What equation links charge, current and time?
3. What equation links energy transferred, potential difference and charge?
4. What equation links power, potential difference and current?
5. Two 5 Ω resistors are connected in series to a 20 V supply. Calculate the total resistance and current.

6. A 4 Ω resistor carries a current of 3 A for 20 s. Calculate the potential difference across the resistor, the charge transferred and the energy transferred.

P3.3 Magnets and magnetic fields

P3.3a — describe the attraction and repulsion between unlike and like poles for permanent magnets

1. What are the two poles of a permanent magnet?
2. What happens when two unlike magnetic poles are brought together?
3. What happens when two like magnetic poles are brought together?
4. Which magnetic poles attract each other?
5. Which magnetic poles repel each other?
6. What would the magnetic field pattern between two unlike poles look like compared with the pattern between two like poles?

P3.3b — describe the difference between permanent and induced magnets

1. What is a permanent magnet?
2. What is an induced magnet?
3. What happens to an induced magnet when the magnetising field is removed?
4. What happens to a permanent magnet when the magnetising field is removed?
5. Why can an induced magnet be attracted to a permanent magnet?
6. Give one example of a material that can be permanently magnetised and one that can be temporarily magnetised.

P3.3c — describe the characteristics of the magnetic field of a magnet, showing how strength and direction change from one point to another

1. What is a magnetic field?
2. What does the direction of a magnetic field line show?
3. In which direction do magnetic field lines point outside a bar magnet?
4. Where is the magnetic field strongest around a bar magnet?
5. How does the spacing of magnetic field lines indicate the strength of the field?
6. How could plotting compasses be used to investigate the magnetic field around a bar magnet?

P3.3d — explain how the behaviour of a magnetic (dipping) compass is related to evidence that the core of the Earth must be magnetic

1. What causes a compass needle to point approximately north-south?
2. How does a compass behave when placed in the Earth's magnetic field?
3. What does the behaviour of a compass provide evidence for?
4. Why does a compass needle behave as a small magnet?
5. What does the Earth's magnetic field suggest about the Earth's core?
6. Why must the Earth have a magnetic field for a magnetic compass to behave as it does?

P3.3e — describe how to show that a current can create a magnetic effect and describe the directions of the magnetic field around a conducting wire

1. What happens to a compass placed near a current-carrying wire?
2. What does the deflection of a compass near a current-carrying wire demonstrate?
3. What shape is the magnetic field around a straight current-carrying wire?
4. How does the direction of the magnetic field around a wire relate to the direction of the current?
5. What happens to the direction of the magnetic field if the current in the wire is reversed?
6. How could plotting compasses be used to investigate the magnetic field around a current-carrying wire?

P3.3f — recall that the strength of the field depends on the current and the distance from the conductor

1. What happens to the magnetic field strength around a wire when the current increases?
2. What happens to the magnetic field strength as the distance from a current-carrying wire increases?
3. How could you investigate the effect of current on the magnetic field strength around a wire?
4. How could you investigate the effect of distance from a wire on magnetic field strength?
5. At which point is the magnetic field stronger: 1 cm or 5 cm from a current-carrying wire?
6. At which point is the magnetic field stronger: around a wire carrying 5 A or one carrying 1 A, at the same distance?

P3.3g — explain how solenoid arrangements can enhance the magnetic effect

1. What is a solenoid?
2. What happens to the magnetic field when a current flows through a solenoid?
3. How does increasing the number of turns on a solenoid affect its magnetic field?
4. How does inserting a magnetic material such as iron into a solenoid affect its magnetic field?
5. How can the magnetic field of a solenoid be investigated using plotting compasses?
6. Why does a solenoid produce a magnetic field similar to that of a bar magnet?

P3.3h — describe how a magnet and a current-carrying conductor exert a force on one another

1. What happens when a current-carrying conductor is placed in a magnetic field?
2. What causes the force on a current-carrying conductor in a magnetic field?
3. What happens to the force if the direction of the current is reversed?
4. What happens to the force if the direction of the magnetic field is reversed?
5. What happens to the force if both the current and magnetic field directions are reversed?
6. What does the jumping wire experiment demonstrate about the interaction between a magnet and a current-carrying conductor?

P3.3i — show that Fleming's left-hand rule represents the relative orientations of the force, the current and the magnetic field

1. What does Fleming's left-hand rule show?
2. Which finger represents the direction of the magnetic field in Fleming's left-hand rule?
3. Which finger represents the direction of the conventional current?
4. Which direction does the thumb represent?
5. How can Fleming's left-hand rule be used to determine the direction of the force on a current-carrying conductor?
6. What happens to the direction of the force if the direction of the current is reversed while the magnetic field remains unchanged?

P3.3j — apply the equation that links the force on a conductor to the magnetic flux density, the current and the length of conductor to calculate the forces involved

1. What equation links force, magnetic flux density, current and conductor length?
2. What is the unit of magnetic flux density?
3. A 0.20 m wire carries a current of 3 A in a magnetic field of flux density 0.5 T. Calculate the force on the wire.
4. A wire of length 0.4 m carries a current of 2 A and experiences a force of 1.6 N. Calculate the magnetic flux density.
5. A wire experiences a force of 0.9 N in a 0.3 T magnetic field. If its length is 0.5 m, calculate the current.
6. What happens to the force on a conductor if the current is doubled while the magnetic flux density and conductor length remain constant?

P3.3k — explain how the force exerted from a magnet and a current-carrying conductor is used to cause rotation in electric motors

1. What causes a current-carrying conductor in a magnetic field to experience a force?
2. Why do forces on opposite sides of a current-carrying coil cause it to rotate?
3. What happens to the direction of the force when the current in a side of the coil is reversed?
4. Why must the current in the coil be reversed during each half-turn of a simple electric motor?
5. What is the role of the magnetic field in an electric motor?
6. How is electrical energy transferred when an electric motor causes a coil to rotate?

Topic P4: Waves and radioactivity

P4.1 Wave motion

P4.1a — describe wave motion in terms of amplitude, wavelength, frequency and period

1. What is the amplitude of a wave?
2. What is the wavelength of a wave?

3. What is the frequency of a wave?
4. What is the period of a wave?
5. How does the amplitude of a wave relate to the maximum displacement from its equilibrium position?
6. How can the frequency of a sound wave be determined using an oscilloscope?

P4.1b — define wavelength and frequency

1. What is meant by the wavelength of a wave?
2. What is the SI unit of wavelength?
3. What is meant by the frequency of a wave?
4. What is the SI unit of frequency?
5. How many complete wavelengths are represented by the distance between two successive points that are in phase?
6. A wave has a frequency of 50 Hz. What does this mean about the wave's oscillations each second?

P4.1c — describe and apply the relationship between wavelength, frequency and wave velocity

1. What equation links wave velocity, frequency and wavelength?
2. What happens to the wavelength of a wave if its frequency increases while its velocity remains constant?
3. What happens to the frequency of a wave if its wavelength decreases while its velocity remains constant?
4. A wave has a frequency of 200 Hz and a wavelength of 1.5 m. Calculate its velocity.
5. A wave travels at 340 m/s and has a frequency of 170 Hz. Calculate its wavelength.
6. A wave has a velocity of 12 m/s and a wavelength of 0.4 m. Calculate its frequency.

P4.1d — apply formulae relating velocity, frequency and wavelength

1. What equation can be used to calculate wave velocity from frequency and wavelength?
2. A wave has a wavelength of 0.80 m and a frequency of 5 Hz. Calculate its velocity.
3. A wave travels at 20 m/s with a frequency of 4 Hz. Calculate its wavelength.
4. A wave travels at 300 m/s and has a wavelength of 2 m. Calculate its frequency.
5. A water wave has a frequency of 2.5 Hz and a wavelength of 0.40 m. Calculate its velocity.

6. A sound wave travels at 340 m/s and has a wavelength of 0.68 m. Calculate its frequency.

P4.1e — describe differences between transverse and longitudinal waves

1. What is a transverse wave?
2. What is a longitudinal wave?
3. In a transverse wave, how is the direction of vibration related to the direction of wave travel?
4. In a longitudinal wave, how is the direction of vibration related to the direction of wave travel?
5. What are the regions of high and low pressure in a longitudinal sound wave called?
6. How can a slinky be used to demonstrate the difference between transverse and longitudinal waves?

P4.1f — describe how ripples on water surfaces are used to model transverse waves whilst sound waves in air are longitudinal waves, and how the speed of each may be measured

1. Why can ripples on a water surface be used to model transverse waves?
2. Why are sound waves in air longitudinal waves?
3. How can the speed of water waves in a ripple tank be measured?
4. How can the wavelength of ripples in a ripple tank be measured?
5. How can the speed of a sound wave in air be measured experimentally?
6. What measurements are needed to calculate the speed of a wave using $v = f\lambda$

P4.1g — describe evidence for the cases of ripples on water surfaces and for sound waves in air that it is the wave that travels and not the water or the air

1. What happens to individual water particles as a ripple travels across the surface?
2. What observation in a ripple tank shows that water does not travel with the wave?
3. What happens to air particles as a sound wave travels through air?
4. Why does the movement of air particles provide evidence that the wave, rather than the air itself, travels?
5. How can a floating object in a ripple tank demonstrate that the water itself does not travel with the ripple?

6. What is transferred from one place to another by a wave even though the medium does not travel with the wave?

P4.2 The electromagnetic spectrum

P4.2a — recall that electromagnetic waves are transverse and are transmitted through space where they all have the same velocity

1. What type of wave are all electromagnetic waves?
2. What is the speed of all electromagnetic waves in a vacuum?
3. Can electromagnetic waves travel through a vacuum?
4. How is the direction of vibration related to the direction of travel in an electromagnetic wave?
5. Why can electromagnetic waves travel through space without a medium?
6. How does the speed of radio waves in a vacuum compare with the speed of gamma rays in a vacuum?

P4.2b — explain that electromagnetic waves transfer energy from source to absorber

1. What do electromagnetic waves transfer from a source to an absorber?
2. What happens to the energy of an electromagnetic wave when it is absorbed?
3. How does infrared radiation transfer energy to an object?
4. Give one example of an electromagnetic wave transferring energy from a source to an absorber.
5. Why can electromagnetic radiation transfer energy through a vacuum?
6. What determines the type of electromagnetic radiation emitted by a source?

P4.2c — apply the relationships between frequency and wavelength across the electromagnetic spectrum

1. What equation links the speed, frequency and wavelength of an electromagnetic wave?
2. What happens to the wavelength of an electromagnetic wave as its frequency increases?
3. An electromagnetic wave has a frequency of 6.0×10^8 Hz. Calculate its wavelength in a vacuum. (Use $c = 3.0 \times 10^8$ m/s.)
4. An electromagnetic wave has a wavelength of 2.0×10^{-2} m. Calculate its frequency in a vacuum. (Use $c = 3.0 \times 10^8$ m/s.)
5. Which has the greater frequency: an electromagnetic wave with a wavelength of 10^{-6} m or one with a wavelength of 10^{-2} m?

6. Which has the greater wavelength: an electromagnetic wave with a frequency of 10^{15} Hz or one with a frequency of 10^9 Hz?

P4.2d — describe the main groupings of the electromagnetic spectrum and that these groupings range from long to short wavelengths and from low to high frequencies

1. What are the eight main regions of the electromagnetic spectrum in order of increasing frequency?
2. What are the eight main regions of the electromagnetic spectrum in order of decreasing frequency?
3. Which region of the electromagnetic spectrum has the longest wavelengths?
4. Which region has the shortest wavelengths?
5. Which region has the lowest frequencies?
6. Which region has the highest frequencies?

P4.2e — describe that our eyes can only detect a limited range of the electromagnetic spectrum

1. Which region of the electromagnetic spectrum can human eyes detect?
2. Can human eyes detect infrared radiation?
3. Can human eyes detect ultraviolet radiation?
4. Why can humans not see radio waves?
5. What does the visible region represent within the electromagnetic spectrum?
6. How does the range of electromagnetic radiation detectable by human eyes compare with the full electromagnetic spectrum?

P4.2f — recall that light is an electromagnetic wave

1. What type of wave is visible light?
2. What region of the electromagnetic spectrum is visible light part of?
3. Can visible light travel through a vacuum?
4. What is the approximate speed of visible light in a vacuum?
5. What is the relationship between visible light and the electromagnetic spectrum?
6. Why is visible light able to travel through space from the Sun to Earth?

P4.2g — give examples of some practical uses of electromagnetic waves in the radio, microwave, infrared, visible, ultraviolet, X-ray and gamma ray regions

1. What is one use of radio waves?
2. What is one use of microwaves?
3. What is one use of infrared radiation?
4. What is one use of visible light?
5. What is one use of ultraviolet radiation?
6. What are one use of X-rays and one use of gamma rays?

P4.2h — describe how ultraviolet waves, X-rays and gamma rays can have hazardous effects, notably on human bodily tissues

1. Why can ultraviolet radiation be hazardous to human tissues?
2. What type of damage can excessive ultraviolet exposure cause to skin?
3. Why can X-rays be hazardous to human tissues?
4. Why can gamma rays be hazardous to human tissues?
5. Which is more penetrating into body tissue: visible light or X-rays?
6. Why must exposure to ultraviolet radiation, X-rays and gamma rays be controlled?

P4.2i — recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits

1. How can radio waves be produced by an electrical circuit?
2. What type of oscillation in an electrical circuit can produce radio waves?
3. What can radio waves induce in an electrical circuit?
4. How can an aerial be used to detect radio waves?
5. What happens in a receiving aerial when radio waves are detected?
6. How is the transmission of information by radio waves linked to oscillations in electrical circuits?

P4.2j — recall that different substances may absorb, transmit, refract, or reflect electromagnetic waves in ways that vary with wavelength

1. What can happen when electromagnetic waves meet a material?
2. What is meant by absorption of electromagnetic radiation?
3. What is meant by transmission of electromagnetic radiation?
4. What is meant by reflection of electromagnetic radiation?
5. What is meant by refraction of electromagnetic radiation?
6. Why can the same material affect different wavelengths of electromagnetic radiation differently?

P4.2k — explain how some effects are related to differences in the velocity of electromagnetic waves in different substances

1. What happens to the speed of an electromagnetic wave when it enters a different transparent substance?
2. Why does an electromagnetic wave change direction when it enters a different substance at an angle?
3. What is refraction?
4. How does a change in the velocity of an electromagnetic wave cause refraction?
5. What happens to the direction of a light ray when it enters glass from air at an angle?
6. Why does the amount of refraction depend on the substances through which the electromagnetic wave travels?

P4.3 Radioactivity

P4.3a — recall that atomic nuclei are composed of both protons and neutrons, that the nucleus of each element has a characteristic positive charge

1. What two types of particles make up an atomic nucleus?
2. What charge does a proton have?
3. What charge does a neutron have?
4. Why is an atomic nucleus positively charged?
5. What determines the identity of an element?
6. How is the positive charge of a nucleus related to its number of protons?

P4.3b — recall that atoms of the same elements can differ in nuclear mass by having different numbers of neutrons

1. What are isotopes?
2. How can two atoms of the same element have different masses?
3. Which particle varies in number between isotopes of the same element?
4. What remains the same in all isotopes of the same element?
5. Why do isotopes of the same element have the same atomic number?
6. How does the number of neutrons affect the mass of an isotope?

P4.3c — use the conventional representation for nuclei to relate the differences between isotopes identities, charges and masses

1. What does the atomic number represent in the nuclear notation ^A_ZX?
2. What does the mass number represent in the nuclear notation ^A_ZX?
3. What does the symbol X represent in nuclear notation?
4. How many protons and neutrons are present in ^23_11Na?
5. How many protons and neutrons are present in ^35_17Cl?

6. How does the nuclear notation of two isotopes of the same element show that they have different numbers of neutrons?

P4.3d — recall that some nuclei are unstable and may emit alpha particles, beta particles, or neutrons, and electromagnetic radiation as gamma rays

1. What is meant by an unstable nucleus?
2. What is an alpha particle?
3. What is a beta particle?
4. What is gamma radiation?
5. What happens when an unstable nucleus undergoes radioactive decay?
6. Which types of radiation can be emitted from an unstable nucleus according to the specification?

P4.3e — relate the emission of alpha particles, beta particles, gamma radiation and neutrons to possible changes in the mass or the charge of the nucleus, or both

1. What happens to the mass number when an alpha particle is emitted?
2. What happens to the atomic number when an alpha particle is emitted?
3. What happens to the atomic number when a beta particle is emitted?
4. What happens to the mass number and atomic number when gamma radiation is emitted?
5. What happens to the mass number when a neutron is emitted?
6. Which type of radioactive emission changes neither the mass number nor the atomic number?

P4.3f — use names and symbols of common nuclei and particles to write balanced equations that represent radioactive decay

1. What particle is represented by the symbol ^4_2He?
2. What particle is represented by the symbol ^0_-1e?
3. Complete the alpha decay equation: ^238_92U → ^234_90Th + ?
4. Complete the beta decay equation: ^14_6C → ^14_7N + ?
5. What must be conserved when writing a nuclear decay equation?
6. Write a balanced nuclear equation for the alpha decay of ^226_88Ra.

P4.3g — balance equations representing the emission of alpha, beta or gamma radiations in terms of the masses, and charges of the atoms involved

1. What must the total mass number be on each side of a balanced nuclear equation?
2. What must the total atomic number be on each side of a balanced nuclear equation?
3. Complete: ^210_84Po → ^206_82Pb + ?
4. Complete: ^90_38Sr → ^90_39Y + ?
5. Complete a gamma decay equation for ^99m_43Tc → ^99_43Tc + ?
6. How can mass number and atomic number be used to check whether a nuclear equation is balanced?

P4.3h — recall that in each atom its electrons are arranged at different distances from the nucleus, that such arrangements may change with absorption or emission of electromagnetic radiation and that atoms can become ions by loss of outer electrons

1. How are electrons arranged around the nucleus of an atom?
2. What happens to an electron when it absorbs energy from electromagnetic radiation?
3. What happens when an excited electron loses energy?
4. What is meant by ionisation?
5. How does an atom become a positive ion?
6. Why does losing an outer electron cause an atom to become positively charged?

P4.3i — recall that changes in atoms and nuclei can also generate and absorb radiations over a wide frequency range

1. What type of radiation can be emitted when an excited electron loses energy?
2. What causes an atom to absorb electromagnetic radiation?
3. What can changes in atomic nuclei produce?
4. Which region of the electromagnetic spectrum is emitted during gamma decay?
5. Can atomic changes produce electromagnetic radiation outside the visible region?
6. How is gamma radiation different from radiation produced by changes in electron energy levels?

P4.3j — explain the concept of half-life and how this is related to the random nature of radioactive decay

1. What is meant by the half-life of a radioactive isotope?
2. Why is radioactive decay described as random?

3. Can you predict exactly when a particular unstable nucleus will decay?
4. What happens to the number of undecayed nuclei after one half-life?
5. Why does the activity of a radioactive source decrease with time?
6. How can repeated random radioactive decays produce a predictable half-life for a large sample?

P4.3k — calculate the net decline, expressed as a ratio, during radioactive emission after a given (integral) number of half-lives

1. What fraction of a radioactive sample remains after one half-life?
2. What fraction remains after two half-lives?
3. What fraction remains after three half-lives?
4. A radioactive sample has an initial activity of 800 Bq. What is its activity after three half-lives?
5. A radioactive sample has an initial mass of 64 g. What mass remains after four half-lives?
6. What fraction of the original sample remains after five half-lives?

P4.3l — recall the differences in the penetration properties of alpha particles, beta particles and gamma rays

1. Which has the greatest penetrating power: alpha, beta or gamma radiation?
2. Which type of radiation can be stopped by a sheet of paper?
3. Which type of radiation can be stopped by a few millimetres of aluminium?
4. What material is commonly used to reduce the intensity of gamma radiation?
5. How does the penetrating power of alpha radiation compare with beta radiation?
6. How does the penetrating power of beta radiation compare with gamma radiation?

P4.3m — recall the differences between contamination and irradiation effects and compare the hazards associated with these two

1. What is meant by radioactive contamination?
2. What is meant by irradiation?
3. What is the difference between contamination and irradiation?
4. Why can radioactive contamination continue to expose a person to radiation after they leave the source?
5. Why does irradiation stop when the external radioactive source is removed?

6. Why is radioactive contamination generally considered more hazardous than irradiation from an external source?

Topic P5: Energy

P5.1 Work done

P5.1a — describe for situations where there are energy transfers in a system, that there is no net change to the total energy of a closed system

1. What is meant by the conservation of energy?
2. What happens to the total energy of a closed system when energy is transferred between stores?
3. Can energy be created or destroyed in a closed system?
4. A moving object slows down because of friction. What happens to the object's kinetic energy?
5. When energy is transferred from one store to another, what happens to the total amount of energy in the system?
6. What is meant by the statement that energy is redistributed rather than used up?

P5.1b — describe all the changes involved in the way energy is stored when a system changes for common situations

1. When an object is projected upwards, which energy store increases as its height increases?
2. When a moving object hits an obstacle and stops, what happens to its kinetic energy?
3. When an object is accelerated by a constant force, what happens to its kinetic energy store?
4. When a vehicle slows down due to friction, where is its kinetic energy mainly transferred?
5. When water is heated in an electric kettle, what happens to the thermal energy store of the water?
6. When an object is moved up a slope, what happens to its gravitational potential energy store?

P5.1c — describe the changes in energy involved when a system is changed by heating, by work done by forces, and by work done when a current flows

1. What happens to the thermal energy store of an object when it is heated?
2. How does the temperature change of a material relate to the change in its thermal energy store?
3. What energy transfer occurs when a force does work on an object?
4. What happens to the energy of a circuit when an electric current flows through a component?
5. What type of energy transfer occurs when a current passes through an electric heater?
6. What is the relationship between work done and energy transferred?

P5.1d — make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes

1. What equation is used to calculate the work done when a force moves an object through a distance?
2. A force of 50 N moves an object 4 m in the direction of the force. Calculate the work done.
3. What equation is used to calculate the energy transferred by an electrical appliance using power and time?
4. A 2 kW heater operates for 3 hours. Calculate the energy transferred in kWh.
5. What equation is used to calculate the energy transferred when an object is heated using its mass, specific heat capacity and temperature change?
6. A 2 kg block with a specific heat capacity of 500 J/kg°C is heated by 10°C. Calculate the energy transferred to the block.

P5.1e — calculate the amounts of energy associated with a moving body, a stretched spring and an object raised above ground level

1. What equation is used to calculate the kinetic energy of a moving object?
2. A 2 kg object travels at 5 m/s. Calculate its kinetic energy.
3. What equation is used to calculate the elastic potential energy stored in a stretched spring?
4. A spring with a spring constant of 200 N/m is stretched by 0.10 m. Calculate the elastic potential energy stored.
5. What equation is used to calculate the gravitational potential energy gained by an object raised above the ground?
6. A 5 kg object is raised through a vertical height of 3 m. Calculate the gravitational potential energy gained. (Use g = 10 N/kg.)

P5.2 Power and efficiency

P5.2a — describe, with examples, the process by which energy is dissipated, so that it is stored in less useful ways

1. What is meant by energy being dissipated?
2. Why is dissipated energy described as being stored in less useful ways?
3. What happens to energy when friction acts between two surfaces?
4. How is energy dissipated when a moving object experiences air resistance?
5. Give one example of useful energy being transferred to the thermal energy store of the surroundings.
6. Why does energy dissipation make an energy transfer less efficient?

P5.2b — describe how, in different domestic devices, energy is transferred from batteries or the a.c. from the mains

1. What energy transfer occurs when a battery powers an electric torch?
2. What energy transfer occurs when mains electricity powers an electric kettle?
3. In an electric motor, what energy store is increased when electrical energy is transferred to the motor?
4. How is energy wasted when an electric motor operates?
5. How is energy dissipated as thermal energy in domestic electrical devices?
6. What is the main difference between the electrical energy supplied by a battery and the electrical energy supplied by the a.c. mains?

P5.2c — describe, with examples, the relationship between the power ratings for domestic electrical appliances and how this is linked to the changes in stored energy when they are in use

1. What is meant by the power rating of an electrical appliance?
2. What does a higher power rating mean about the rate at which an appliance transfers energy?
3. Which transfers energy at a greater rate: a 2 kW kettle or a 1 kW kettle?
4. How is the power rating of an electric heater related to the rate at which it increases the thermal energy store of an object?
5. A 3 kW appliance operates for 10 seconds. How much energy does it transfer?
6. Why does a high-power appliance generally transfer more energy than a low-power appliance when both operate for the same time?

P5.2d — calculate energy efficiency for any energy transfer

1. What equation is used to calculate the efficiency of an energy transfer?
2. How can efficiency be expressed as a percentage?

3. An appliance transfers 800 J of useful energy from 1000 J of input energy. Calculate its efficiency.
4. A motor receives 5000 J of electrical energy and transfers 3500 J to useful kinetic energy. Calculate its efficiency.
5. An appliance has an efficiency of 75% and receives 2000 J of energy. Calculate the useful energy transferred.
6. What happens to the efficiency of a device when a greater proportion of the input energy is dissipated?

P5.2e — describe ways to increase efficiency

1. What does increasing the efficiency of a device mean?
2. How can lubrication increase the efficiency of a machine?
3. How can thermal insulation increase the efficiency of a heating system?
4. Why does reducing friction increase the efficiency of a machine?
5. Why does reducing unwanted thermal energy transfer increase the efficiency of a heating device?
6. What is the general aim of methods used to increase the efficiency of an energy transfer?

P5.2f — explain ways of reducing unwanted energy transfer through lubrication and thermal insulation

1. How does lubrication reduce unwanted energy transfer in moving mechanical parts?
2. Why does reducing friction reduce unwanted thermal energy transfer?
3. How does thermal insulation reduce unwanted energy transfer from a building?
4. Why are materials with low thermal conductivity useful as thermal insulators?
5. How does cavity-wall insulation reduce energy transfer from a house?
6. Why can lubrication and thermal insulation both increase the efficiency of energy transfers?

P5.2g — describe how the rate of cooling is affected by the thickness and thermal conductivity of its walls

1. What happens to the rate of cooling of a building when the thickness of its walls increases?
2. What happens to the rate of cooling when the thermal conductivity of the walls decreases?
3. Why do thick walls reduce the rate of cooling?
4. Why do materials with low thermal conductivity reduce the rate of cooling?

5. Which would lose thermal energy faster: a building with thin, highly conductive walls or thick, poorly conductive walls?
6. How could you investigate the effect of wall thickness on the rate of cooling of a model building?

Topic P6: Global challenges

P6.1 Physics on the move

P6.1a — recall typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems

1. What is a typical speed for a person walking?
2. What is a typical speed for a person running?
3. What is a typical speed for a person cycling?
4. What is the approximate speed of sound in air?
5. What is a typical speed for wind?
6. Give one typical speed for a form of transport such as a car, train, aircraft or boat.

P6.1b — estimate the magnitudes of everyday accelerations

1. What is meant by acceleration?
2. What is the approximate acceleration of an object in free fall near the Earth's surface?
3. What is a typical order of magnitude for the acceleration of a car during normal acceleration?
4. What is a typical order of magnitude for the acceleration of a person when running?
5. How can the acceleration of a moving vehicle be estimated from measurements of its change in velocity and time?
6. Why are everyday accelerations usually much smaller than the acceleration due to gravity?

P6.1c — make calculations using ratios and proportional reasoning to convert units and to compute rates

1. How many metres are there in 1 kilometre?
2. How many seconds are there in 1 hour?
3. Convert 72 km/h into m/s.

4. Convert 15 m/s into km/h.
5. A cyclist travels 600 m in 40 s. Calculate their average speed.
6. A car travels at 20 m/s for 30 s. Calculate the distance travelled.

P6.1d — explain methods of measuring human reaction times and recall typical results

1. How can a ruler-drop experiment be used to measure a person's reaction time?
2. What measurement is taken when carrying out a ruler-drop reaction-time experiment?
3. Why should a ruler-drop reaction-time experiment be repeated several times?
4. How can repeated reaction-time measurements be used to obtain a more reliable result?
5. What is a typical human reaction time?
6. Give one factor that can affect a person's reaction time.

P6.1e — explain the factors which affect the distance required for road transport vehicles to come to rest in emergencies

1. What is meant by thinking distance?
2. What is meant by braking distance?
3. What is meant by stopping distance?
4. What factors can increase a driver's thinking distance?
5. What factors can increase a vehicle's braking distance?
6. How does increasing the speed of a vehicle affect its stopping distance?

P6.1f — explain the dangers caused by large decelerations

1. What is meant by deceleration?
2. Why can a large deceleration be dangerous to passengers in a vehicle?
3. How can seat belts reduce the risk of injury during a large deceleration?
4. Why do airbags reduce injuries during a collision?
5. How does increasing the time taken to stop affect the force experienced by a passenger?
6. Why are crumple zones used in vehicles?

P6.2 Powering Earth

P6.2a — describe the main energy sources available for use on Earth, compare the ways in which they are used and distinguish between renewable and non-renewable sources

1. What is the difference between a renewable and a non-renewable energy source?
2. Which energy sources are classified as fossil fuels?
3. Why is nuclear fuel classified as a non-renewable energy source?
4. Which renewable energy sources use the Sun, wind, moving water or tides?
5. What is biofuel and why is it considered renewable?
6. Give one advantage and one disadvantage of using a renewable energy source compared with a fossil fuel.

P6.2b — explain patterns and trends in the use of energy resources

1. Why has the total use of energy resources increased over the last 150 years?
2. What general trend has occurred in the use of fossil fuels since the Industrial Revolution?
3. Why has the use of renewable energy sources increased in recent decades?
4. What factors can cause the use of an energy resource to increase or decrease over time?
5. Why has the use of coal for electricity generation decreased in the UK?
6. Why can data about energy-resource use be used to identify patterns and trends?

P6.2c — recall that, in the national grid, electrical power is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic use

1. At what voltage is electrical power transferred through the long-distance transmission network of the National Grid?
2. Why is electrical power transmitted at high voltage?
3. Where is the voltage reduced before electricity is supplied to homes?
4. Why is electricity supplied to homes at a lower voltage than that used for long-distance transmission?
5. What happens to the current when the voltage is increased for a given power?
6. What type of electrical supply is delivered to UK homes by the National Grid?

P6.2d — recall that step-up and step-down transformers are used to change the potential difference as power is transferred from power stations

1. What does a step-up transformer do to the potential difference?
2. What does a step-down transformer do to the potential difference?
3. Where are step-up transformers used in the National Grid?
4. Where are step-down transformers used in the National Grid?
5. Why is a step-up transformer used before electricity is transmitted over long distances?
6. Why is a step-down transformer used before electricity is supplied to homes?

P6.2e — explain how the national grid is an efficient way to transfer energy

1. Why does transmitting electricity at a high potential difference reduce energy losses?
2. For a given power, what happens to the current when the transmission voltage is increased?
3. Why does a lower current reduce heating losses in transmission cables?
4. What causes energy to be dissipated as thermal energy in National Grid cables?
5. Why would transmitting the same power at a lower voltage result in greater energy losses?
6. How does the National Grid reduce energy losses during long-distance transmission?

P6.2f — recall that the domestic supply in the UK is a.c. at 50 Hz and about 230 volts

1. What type of current is supplied to UK homes?
2. What is the frequency of the UK domestic a.c. supply?
3. What is the approximate potential difference of the UK domestic supply?
4. What does a frequency of 50 Hz mean for an a.c. supply?
5. How many complete cycles of an a.c. waveform occur each second in the UK domestic supply?
6. What is the approximate period of a 50 Hz a.c. supply?

P6.2g — explain the difference between direct and alternating voltage

1. What is meant by direct voltage?

2. What is meant by alternating voltage?
3. How does the direction of current differ between a d.c. and an a.c. supply?
4. What does the voltage-time graph of a steady d.c. supply look like?
5. What happens to the direction of the potential difference during an a.c. cycle?
6. Which type of voltage is supplied by the UK domestic mains supply?

P6.2h — recall the differences in function between the live, neutral and earth mains wires, and the potential differences between these wires

1. What is the function of the live wire in a UK mains circuit?
2. What is the function of the neutral wire in a UK mains circuit?
3. What is the function of the earth wire in a UK mains circuit?
4. What is the potential difference between the live and neutral wires in a UK domestic supply?
5. What is the potential difference between the live and earth wires in normal operation?
6. What is the potential difference between the neutral and earth wires in normal operation?

P6.2i — explain that a live wire may be dangerous even when a switch in a mains circuit is open, and explain the dangers of providing any connection between the live wire and earth

1. Why can the live wire remain at a dangerous potential difference when a switch is open?
2. Why should a person never touch an exposed live wire?
3. Why is connecting the live wire directly to earth dangerous?
4. What can happen if a live wire comes into contact with the earth wire?
5. How does insulation protect a person from electric shock?
6. Why must electrical devices be designed to prevent accidental connections between the live wire and earth?