Edexcel GCSE Comb Sci Phys

Topic 1 – Key concepts of physics

1.1 Recall and use the SI unit for physical quantities, as listed in Appendix 5

1. What is the SI unit for length?
2. What is the SI unit for mass?
3. What is the SI unit for time?
4. What is the SI unit for temperature?
5. What is the SI unit for electric current?
6. State the SI units for force, energy, power, pressure and charge.

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)

1. What multiplier does giga (G) represent?
2. What multiplier does mega (M) represent?
3. What multiplier does kilo (k) represent?
4. What multiplier does centi (c) represent?
5. What multipliers do milli (m), micro (μ) and nano (n) represent?
6. Convert 4.5 km, 320 mm, 7.2 μm and 8.0 ns into metres or seconds.

1.3 Be able to convert between different units, including hours to seconds

1. How many seconds are there in one minute?
2. How many seconds are there in one hour?
3. Convert 2.5 hours into seconds.
4. Convert 7,200 seconds into hours.
5. Convert 3.6 km into metres.
6. A car travels 1500 m in 2.0 minutes. Express the distance in kilometres and the time in seconds.

1.4 Use significant figures and standard form where appropriate

1. How many significant figures are there in 0.00450?
2. How many significant figures are there in 2500 when it is given to 2 significant figures?
3. Write 0.000072 in standard form.
4. Write 6.3×10^5 as an ordinary number.
5. Calculate $(3.2 \times 10^4) \times (2.0 \times 10^{-3})$, giving your answer in standard form.

6. A measurement is 0.006784 m. Give the measurement to 3 significant figures and express your answer in standard form.

Topic 2 – Motion and forces

2.1 Explain that a scalar quantity has magnitude (size) but no specific direction

1. What is meant by the term scalar quantity?
2. What information is given by the magnitude of a scalar quantity?
3. Does a scalar quantity have a specific direction?
4. Why is distance a scalar quantity?
5. Why is speed a scalar quantity?
6. Give two examples of scalar quantities and explain why each is a scalar.

2.2 Explain that a vector quantity has both magnitude (size) and a specific direction

1. What is meant by the term vector quantity?
2. What two pieces of information are required to describe a vector quantity?
3. Why is displacement a vector quantity?
4. Why is velocity a vector quantity?
5. Why is force a vector quantity?
6. Give two examples of vector quantities and explain why each is a vector.

2.3 Explain the difference between vector and scalar quantities

1. What is the key difference between a scalar quantity and a vector quantity?
2. Which type of quantity has magnitude only: scalar or vector?
3. Which type of quantity has both magnitude and direction: scalar or vector?
4. Explain why speed and velocity are different types of quantity.
5. Explain why distance and displacement are different types of quantity.
6. A car travels at 20 m/s north. Is this information describing speed or velocity? Explain your answer.

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

1. Which is a vector quantity: distance or displacement?
2. Which is a vector quantity: speed or velocity?
3. Which of acceleration, force, weight, momentum and energy are vector quantities?
4. Which of acceleration, force, weight, momentum and energy are scalar quantities?
5. Classify mass and weight as either scalar or vector quantities.

6. Classify each of the following as a scalar or vector quantity: displacement, distance, velocity, speed, acceleration, force, weight, mass, momentum and energy.

2.5 Recall that velocity is speed in a stated direction

1. What is velocity?
2. What additional information must be given with speed to describe velocity?
3. A car travels at 15 m/s east. What is its velocity?
4. A cyclist has a velocity of 8 m/s south. What is their speed?
5. Explain why an object can have constant speed but changing velocity.
6. A runner travels at 6 m/s north and then at 6 m/s south. Has their velocity changed? Explain why.

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)

1. What is the equation used to calculate average speed?
2. A car travels 240 m in 12 s. Calculate its average speed.
3. A cyclist travels at an average speed of 8.0 m/s for 25 s. Calculate the distance travelled.
4. A runner travels 1500 m at an average speed of 5.0 m/s. Calculate the time taken.
5. A train travels 18 km in 15 minutes. Calculate its average speed in m/s.
6. A car travels at 22 m/s for 3.5 minutes. Calculate the distance travelled in kilometres.

2.7 Analyse distance/time graphs including determination of speed from the gradient

1. What does the gradient of a distance/time graph represent?
2. How would you calculate the speed of an object from a distance/time graph?
3. What does a horizontal section of a distance/time graph represent?
4. What does a straight sloping line on a distance/time graph indicate about an object's speed?
5. A distance/time graph has a gradient of 12 m/s. What is the speed of the object?
6. A straight section of a distance/time graph rises from 20 m at 4 s to 80 m at 9 s. Calculate the speed of the object.

2.8 Recall and use the equation: acceleration (metre per second squared, m/s2) = change in velocity (metre per second, m/s) ÷ time taken (second, s) ( ) t v u a − =

1. What is the equation used to calculate acceleration?
2. A car's velocity increases from 5 m/s to 25 m/s in 4 s. Calculate its acceleration.
3. A cyclist accelerates from 2 m/s to 14 m/s in 6 s. Calculate the acceleration.
4. An object accelerates at 3.0 m/s^2 for 8.0 s from an initial velocity of 4.0 m/s. Calculate its final velocity.
5. A car slows from 30 m/s to 10 m/s in 5.0 s. Calculate its acceleration.
6. A vehicle has an acceleration of 2.5 m/s^2 and its velocity increases by 20 m/s. Calculate the time taken.

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/s2) × distance (metre, m) v − u = 2× a× x

1. What equation relates final velocity, initial velocity, acceleration and distance travelled?
2. A car accelerates from rest at 4.0 m/s^2 over a distance of 50 m. Calculate its final velocity.
3. A cyclist travelling at 5.0 m/s accelerates at 2.0 m/s^2 over 20 m. Calculate their final velocity.
4. **A car travelling at 25 m/s brakes with an acceleration of −5.0 m/s^2. Calculate the stopping distance.**
5. An object accelerates from 10 m/s to 30 m/s over 100 m. Calculate its acceleration.
6. A train accelerates from 8.0 m/s to 20 m/s at 1.5 m/s^2. Calculate the distance travelled.

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)

1. What does the gradient of a velocity/time graph represent?
2. How can the accelerations of two objects be compared using their velocity/time graphs?
3. What does the area between a velocity/time graph and the time axis represent?
4. A velocity/time graph shows a velocity increasing uniformly from 0 m/s to 20 m/s in 5 s. Calculate the acceleration.

5. A car accelerates uniformly from 10 m/s to 30 m/s in 4 s. Calculate the distance travelled using the area under the velocity/time graph.
6. A velocity/time graph shows an object travelling at a constant velocity of 12 m/s for 8 s. Calculate the distance travelled.

2.11 Describe a range of laboratory methods for determining the speeds of objects such as the use of light gates

1. How can a light gate be used to measure the speed of an object?
2. What measurements are needed to calculate the speed of an object using a light gate?
3. How can two light gates be used to determine the average speed of a trolley?
4. Why is a card of known length attached to a trolley when using a light gate?
5. State one advantage of using light gates instead of manually timing an object with a stopwatch.
6. Describe one suitable laboratory method for measuring the speed of a moving trolley and explain how the speed is calculated.

2.12 Recall some 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 in everyday conditions?
6. Compare the typical speeds of walking, running, cycling, a car and sound.

2.13 Recall that the acceleration, g, in free fall is 10 m/s2 and be able to estimate the magnitudes of everyday accelerations

1. What is the acceleration due to gravity, g, near the Earth's surface?
2. What happens to the velocity of an object in free fall if air resistance is negligible?
3. What acceleration would an object experience when falling freely near the Earth's surface?
4. An object is dropped from rest. What will its velocity increase by each second if air resistance is negligible?
5. Estimate the acceleration of a car that increases its velocity from 0 to 20 m/s in 10 s.
6. Compare the acceleration due to gravity with a typical acceleration of a car and explain which is greater.

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)

1. State Newton's first law of motion.
2. What happens to an object when the resultant force acting on it is zero?
3. What happens to an object's motion when the resultant force is not zero?
4. A car travels at a constant velocity on a straight road. What is the resultant force acting on the car?
5. A stationary book remains at rest on a table. What does Newton's first law tell you about the resultant force on the book?
6. Explain why an object moving in a circle at constant speed still has a resultant force acting on it.

2.15 Recall and use Newton's second law as: force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s2) F = m× a

1. State Newton's second law in equation form.
2. Calculate the force required to accelerate a 5.0 kg object at 4.0 m/s^2.
3. A 1200 kg car accelerates at 2.5 m/s^2. Calculate the resultant force.
4. A force of 600 N produces an acceleration of 3.0 m/s^2. Calculate the mass of the object.
5. A 20 kg object experiences a resultant force of 80 N. Calculate its acceleration.
6. A 1500 kg car experiences a resultant force of 4500 N. Calculate its acceleration and state what happens to its velocity.

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× g

1. What is meant by the weight of an object?
2. State the equation relating weight, mass and gravitational field strength.
3. Calculate the weight of a 60 kg person on Earth using g = 10 N/kg.
4. An object has a weight of 250 N on Earth. Calculate its mass.
5. A 5.0 kg object is on a planet where the gravitational field strength is 4.0 N/kg. Calculate its weight.
6. A person's mass is 70 kg. Calculate their weight on Earth and on a planet where g = 3.0 N/kg.

2.17 Describe how weight is measured

1. What instrument can be used to measure weight?
2. What physical quantity does a newton meter measure?
3. How does a newton meter measure the weight of an object?

4. Why must the newton meter be suitable for the size of the force being measured?
5. Describe how you would use a newton meter to measure the weight of an object.
6. What unit should be used when recording a measurement of weight?

2.18 Describe the relationship between the weight of a body and the gravitational field strength

1. How is the weight of an object related to gravitational field strength?
2. What happens to an object's weight if the gravitational field strength increases while its mass remains constant?
3. Why does an object have a different weight on the Moon compared with Earth?
4. Does the mass of an object change when it is moved to a different planet? Explain your answer.
5. A person's mass is 60 kg. Compare their weight on Earth where g = 10 N/kg with their weight on a planet where g = 5 N/kg.
6. Explain why two objects with different masses have different weights in the same gravitational field.

2.19 Core Practical: Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys

1. What relationship between force, mass and acceleration is investigated in this practical?
2. Which variable should be changed when investigating how force affects the acceleration of a trolley?
3. Which variables should be controlled when investigating the effect of force on acceleration?
4. How can the acceleration of a trolley be measured experimentally?
5. Describe how the masses added to a trolley can be varied to investigate the relationship between mass and acceleration.
6. A trolley experiences a resultant force of 2.0 N and has a mass of 0.50 kg. Calculate its acceleration and explain how the result could be tested experimentally.

2.20 Explain that an object moving in a circular orbit at constant speed has a changing velocity (qualitative only)

1. Why does an object moving in a circle at constant speed have changing velocity?
2. What changes about the velocity of an object moving in a circular path?
3. Does the speed of an object have to change for its velocity to change?
4. At what point in a circular path does the direction of velocity change?

5. Explain why a satellite moving at constant speed around Earth is accelerating.
6. An object moves around a circular track at constant speed. Explain why its velocity is continuously changing.

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

1. What is meant by centripetal force?
2. In which direction does the centripetal force act?
3. Why is a resultant force required for an object to move in a circle?
4. What would happen to an object if the centripetal force acting on it suddenly disappeared?
5. Give one example of a situation where a centripetal force keeps an object moving in a circular path.
6. Explain why the force acting towards the centre of a circular path changes the direction of an object's velocity.

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

1. What is meant by inertial mass?
2. What does a larger inertial mass indicate about how difficult it is to change an object's velocity?
3. State the equation defining inertial mass in terms of force and acceleration.
4. An object requires a force of 50 N to produce an acceleration of 2.0 m/s^2. Calculate its inertial mass.
5. Two objects experience the same force. The first accelerates at 4 m/s^2 and the second at 2 m/s^2. Which has the greater inertial mass?
6. Explain how the ratio of force to acceleration can be used to determine the inertial mass of an object.

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

1. State Newton's third law of motion.
2. What are the two forces in a Newton's third-law pair?
3. A book rests on a table. Identify the Newton's third-law pair involving the book and Earth.
4. Two cars collide. Explain how Newton's third law applies to the forces between the cars.
5. How is Newton's third law related to the conservation of momentum during a collision?

6. Two objects collide and exert equal and opposite forces on each other. Explain why the total momentum of the system remains constant if no external resultant force acts.

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) ρ = m × v

1. What is momentum?
2. State the equation used to calculate momentum.
3. Calculate the momentum of a 4.0 kg object travelling at 6.0 m/s.
4. A car has a mass of 1200 kg and travels at 20 m/s. Calculate its momentum.
5. An object has a momentum of 150 kg m/s and a mass of 30 kg. Calculate its velocity.
6. A 2.0 kg ball travels at 8.0 m/s east. Calculate its momentum and state its direction.

2.25 Describe examples of momentum in collisions

1. What happens to the momentum of an isolated system during a collision?
2. Give an example of a collision in which momentum is transferred between objects.
3. Explain what happens to the momentum of a moving car when it collides with a stationary car.
4. Why can a heavy, slow-moving object have the same momentum as a light, fast-moving object?
5. A moving trolley collides with a stationary trolley. Explain how momentum is transferred between the trolleys.
6. Explain how momentum conservation can be used to analyse the motion of objects before and after a collision.

2.26 Use Newton's second law as: force (newton, N) = change in momentum (kilogram metre per second, kg m/s) ÷ time (second, s) ( ) t mv mu F − =

1. State the equation relating force, change in momentum and time.
2. A force of 20 N acts on an object for 0.50 s. Calculate the change in momentum.
3. An object's momentum changes from 10 kg m/s to 40 kg m/s in 2.0 s. Calculate the resultant force.
4. A 5.0 kg object changes velocity from 2.0 m/s to 8.0 m/s in 3.0 s. Calculate the change in momentum and the resultant force.
5. A 1200 kg car slows from 25 m/s to 10 m/s in 5.0 s. Calculate the resultant braking force.
6. A force of 500 N acts on an object for 0.20 s, changing its velocity from 5.0 m/s to 15 m/s. Calculate the object's mass.

2.27 Explain methods of measuring human reaction times and recall typical results

1. What is meant by human reaction time?
2. Describe how a ruler-drop test can be used to measure reaction time.
3. What measurements are required to calculate reaction time using a ruler-drop test?
4. Give a typical human reaction time to a simple visual stimulus.
5. State two factors that can affect human reaction time.
6. Explain why repeating a reaction-time experiment and calculating a mean improves the reliability of the result.

2.28 Recall that the stopping distance of a vehicle is made up of the sum of the thinking distance and the braking distance

1. What is meant by thinking distance?
2. What is meant by braking distance?
3. What is the relationship between stopping distance, thinking distance and braking distance?
4. A vehicle has a thinking distance of 15 m and a braking distance of 25 m. Calculate its stopping distance.
5. A vehicle has a stopping distance of 60 m and a thinking distance of 20 m. Calculate its braking distance.
6. Explain why a vehicle can continue travelling during the driver's reaction time before braking begins.

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

1. How does increasing the mass of a vehicle affect its stopping distance?
2. How does increasing the speed of a vehicle affect its stopping distance?
3. How does increasing the driver's reaction time affect thinking distance?
4. How can worn or faulty brakes affect braking distance?
5. How can the state of the road and the friction between the tyres and road affect braking distance?
6. Explain why increasing both the speed and mass of a vehicle can increase the force and energy involved in stopping it.

2.30 Describe the factors affecting a driver's reaction time including drugs and distractions

1. What is meant by a driver's reaction time?
2. How can drugs affect a driver's reaction time?

3. How can distractions affect a driver's reaction time?
4. Explain why an increased reaction time increases the thinking distance.
5. Give two factors that can increase a driver's reaction time.
6. Explain why using a mobile phone while driving can increase the stopping distance of a vehicle.

2.31 Explain the dangers caused by large decelerations and estimate the forces involved in typical situations on a public road

1. Why can a large deceleration be dangerous to vehicle occupants?
2. How does increasing the deceleration of a vehicle affect the force experienced by an occupant?
3. Why can seat belts reduce the forces experienced by vehicle occupants during a collision?
4. A 70 kg passenger experiences a deceleration of 10 m/s^2. Estimate the force acting on the passenger.
5. A 1000 kg car decelerates at 8.0 m/s^2. Calculate the resultant force acting on the car.
6. A 60 kg passenger is brought to rest with a deceleration of 20 m/s^2. Calculate the force experienced and explain why this could cause injury.

Topic 3 – Conservation of energy

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) $\Delta GPE = m \times g \times \Delta h$

1. What equation is used to calculate the change in gravitational potential energy of an object?
2. Calculate the change in gravitational potential energy of a 5.0 kg object raised through 8.0 m using g = 10 N/kg.
3. A 2.0 kg object gains 120 J of gravitational potential energy. Calculate the vertical height through which it was raised using g = 10 N/kg.
4. A 60 kg person climbs a vertical height of 4.0 m. Calculate the increase in their gravitational potential energy using g = 10 N/kg.
5. An object of mass 10 kg is raised from a height of 2 m to a height of 7 m. Calculate the change in gravitational potential energy using g = 10 N/kg.
6. A 4.0 kg object gains 200 J of gravitational potential energy when raised vertically. Calculate the change in height using g = 10 N/kg.

3.2 Recall and use the equation to calculate the amounts of energy associated with a moving object: kinetic energy (joule, J) = 1/2 × mass (kilogram, kg) × $(speed)^2$ ($(metre/second)^2$, $(m/s)^2$) $KE = 1/2 \times m \times v^2$

1. What equation is used to calculate the kinetic energy of a moving object?
2. Calculate the kinetic energy of a 4.0 kg object travelling at 5.0 m/s.
3. A car has a mass of 1200 kg and travels at 20 m/s. Calculate its kinetic energy.
4. An object has a kinetic energy of 250 J and a mass of 2.0 kg. Calculate its speed.
5. A cyclist and bicycle have a combined mass of 80 kg and travel at 6.0 m/s. Calculate their kinetic energy.
6. An object's speed doubles while its mass remains constant. By what factor does its kinetic energy change?

3.3 Draw and interpret diagrams to represent energy transfers

1. What is meant by an energy transfer?
2. What information should an energy transfer diagram show?
3. Draw an energy transfer diagram for an electric kettle transferring energy from the electrical store to the thermal store of the water.
4. Draw an energy transfer diagram for a falling object showing the change in its energy stores.
5. How can an energy transfer diagram show that some energy has been dissipated?
6. An electric motor transfers electrical energy into kinetic energy and thermal energy. Draw an energy transfer diagram showing these transfers.

3.4 Explain what is meant by conservation of energy

1. What is meant by conservation of energy?
2. Can energy be created or destroyed during an energy transfer?
3. What happens to the total amount of energy in a system when energy is transferred?
4. Explain how conservation of energy applies when an object falls towards the ground.
5. A machine transfers 500 J of energy, with 350 J becoming useful energy and the remainder dissipated. How much energy is dissipated?
6. Explain why energy being dissipated does not mean that the energy has been destroyed.

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

1. What happens to the kinetic and gravitational potential energy stores when an object is projected upwards?
2. What energy-store changes occur when a moving object hits an obstacle?
3. What happens to the energy stores of an object when it is accelerated by a constant force?
4. What happens to the kinetic energy store of a vehicle as it slows down, and where is much of this energy transferred?
5. What energy-store changes occur when an electric kettle brings water to its boiling point?
6. Describe the energy-store changes when a ball is projected up a slope, slows down, stops momentarily and then rolls back down.

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

1. What is meant by a closed system in terms of energy?
2. What happens to the total energy in a closed system when energy is transferred between stores?
3. Why is there no net change in the total energy of a closed system?
4. A closed system initially contains 800 J of energy. How much total energy does it contain after 300 J is transferred between its energy stores?
5. Explain how energy can be transferred between different stores without changing the total energy of a closed system.
6. A system transfers energy from a gravitational potential store to kinetic and thermal stores. Explain why the total energy remains unchanged.

3.7 Explain that mechanical processes become wasteful when they cause a rise in temperature so dissipating energy in heating the surroundings

1. Why can mechanical processes become wasteful when they cause a rise in temperature?
2. How does friction cause energy to be dissipated?
3. What happens to the temperature of surfaces when friction transfers energy to their thermal stores?
4. Explain why friction in a machine can reduce the amount of useful energy transferred.
5. A moving bicycle eventually stops because of friction. Where is the kinetic energy transferred?
6. Explain why a machine becoming hot during operation is evidence of an unwanted energy transfer.

3.8 Explain, using examples, how in all system changes energy is dissipated so that it is stored in less useful ways

1. What is meant by dissipated energy?

2. Why is energy stored in the thermal stores of the surroundings often described as less useful?
3. How is energy dissipated when a car brakes?
4. How is energy dissipated when an electrical appliance operates?
5. Give an example of energy being dissipated by friction and explain the energy transfer involved.
6. A ball eventually stops bouncing. Explain how energy is dissipated during the process.

3.9 Explain ways of reducing unwanted energy transfer including through lubrication, thermal insulation

1. How does lubrication reduce unwanted energy transfer caused by friction?
2. Why does lubrication make mechanical systems more efficient?
3. How does thermal insulation reduce unwanted energy transfer?
4. Explain how loft insulation reduces unwanted energy transfer from a house.
5. Give one method of reducing unwanted energy transfer in a moving machine and explain how it works.
6. Explain why both lubrication and thermal insulation can reduce unwanted energy transfers but work in different ways.

3.10 Describe the effects of the thickness and thermal conductivity of the walls of a building on its rate of cooling qualitatively

1. How does increasing the thickness of a building's walls affect its rate of cooling?
2. How does increasing the thermal conductivity of a building's walls affect its rate of cooling?
3. Why do materials with low thermal conductivity reduce the rate of cooling?
4. Which would cool more slowly: a building with thick walls or thin walls made from the same material?
5. Which would cool more slowly: a building with walls of high thermal conductivity or low thermal conductivity?
6. Explain why thick walls made from a material with low thermal conductivity can reduce the rate at which a building cools.

3.11 Recall and use the equation: efficiency = useful energy transferred by the device ÷ total energy supplied to the device

1. What equation is used to calculate the efficiency of a device?
2. Calculate the efficiency of a machine that receives 500 J of energy and transfers 350 J usefully.
3. A motor has an efficiency of 0.75 and receives 800 J of energy. Calculate the useful energy transferred.

4. A device transfers 240 J of useful energy and has an efficiency of 0.60. Calculate the total energy supplied.
5. A machine receives 2000 J of energy and wastes 500 J. Calculate its efficiency.
6. Express an efficiency of 0.82 as a percentage.

3.12 Explain how efficiency can be increased

1. What does it mean for a device to have a high efficiency?
2. How can lubrication increase the efficiency of a mechanical system?
3. How can reducing friction increase the efficiency of a machine?
4. How can thermal insulation increase the efficiency of a system?
5. A machine wastes a large amount of energy as thermal energy due to friction. Explain how its efficiency could be increased.
6. Explain why reducing unwanted energy transfers increases the efficiency of a device.

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

1. What are the main non-renewable energy sources used on Earth?
2. What are the main renewable energy sources used on Earth?
3. Why are fossil fuels described as non-renewable energy sources?
4. How does a hydroelectric power station generate electrical energy?
5. Compare the advantages and disadvantages of using wind power and fossil fuels to generate electricity.
6. Compare renewable and non-renewable energy resources in terms of availability, environmental impact and reliability.

3.14 Explain patterns and trends in the use of energy resources

1. What factors can cause patterns and trends in the use of energy resources to change?
2. Why has the use of some renewable energy resources increased over time?
3. Why are fossil fuels still widely used despite their environmental impacts?
4. How can changes in population affect the demand for energy?
5. Explain how technological developments can change the use of different energy resources.
6. Explain how environmental concerns, energy demand, cost and availability can influence trends in the use of energy resources.

Topic 4 – Waves

4.1 Recall that waves transfer energy and information without transferring matter

1. What do waves transfer from one place to another?
2. What do waves transfer without transferring matter?
3. How can a wave transfer energy without causing matter to travel with the wave?
4. What happens to the medium when a wave passes through it?
5. A water wave travels across a tank. Does the water itself travel across the tank with the wave?
6. How does the transfer of energy by a wave differ from the transfer of matter?

4.2 Describe evidence that with water and sound waves it is the wave and not the water or air itself that travels

1. What observation provides evidence that a water wave travels without the water itself travelling with it?
2. How can a floating object be used to show that water does not travel with a water wave?
3. What motion does a floating object make as a water wave passes it?
4. What evidence shows that air itself does not travel from a sound source to the listener?
5. How can a sound wave transfer energy to a listener without the air travelling from the source to the listener?
6. Why does the movement of a floating object provide evidence that the wave, rather than the water, is travelling?

4.3 Define and use the terms frequency and wavelength as applied to waves

1. What is meant by the frequency of a wave?
2. What is the unit of frequency?
3. What is meant by the wavelength of a wave?
4. What symbol is commonly used for wavelength?
5. A wave has a frequency of 50 Hz. What does this tell you about the wave?
6. How would you determine the wavelength of a wave from a wave diagram?

4.4 Use the terms amplitude, period, wave velocity and wavefront as applied to waves

1. What is meant by the amplitude of a wave?
2. What is meant by the period of a wave?
3. What is meant by the wave velocity of a wave?
4. What is meant by a wavefront?
5. How is the amplitude measured on a transverse wave diagram?

6. How are wavefronts represented on a diagram of waves spreading across a water surface?

4.5 Describe the difference between longitudinal and transverse waves by referring to sound, electromagnetic, seismic and water waves

1. What is the difference between the direction of oscillation and direction of energy transfer in a transverse wave?
2. What is the difference between the direction of oscillation and direction of energy transfer in a longitudinal wave?
3. Is a sound wave longitudinal or transverse?
4. Are electromagnetic waves longitudinal or transverse?
5. How can seismic waves and water waves demonstrate the difference between longitudinal and transverse waves?
6. What is the difference between compressions and rarefactions in a longitudinal wave?

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) t x v =

1. What equation is used to calculate wave speed from frequency and wavelength?
2. Calculate the wave speed of a wave with a frequency of 25 Hz and a wavelength of 0.40 m.
3. A wave travels at 12 m/s and has a frequency of 6 Hz. Calculate its wavelength.
4. What equation is used to calculate wave speed from distance and time?
5. A sound wave travels 680 m in 2.0 s. Calculate its speed.
6. A wave travels at 15 m/s for 4.0 s. Calculate the distance travelled by the wave.

4.7 Describe how to measure the velocity of sound in air and ripples on water surfaces

1. How could you measure the velocity of sound in air using two microphones?
2. Why should the microphones be placed a known distance apart when measuring the velocity of sound?
3. How could an oscilloscope be used to measure the time taken for sound to travel between two microphones?
4. How could you calculate the velocity of sound from the measured distance and time?
5. How could a stroboscope be used to investigate ripples on the surface of water?

6. How could the wavelength and frequency of water ripples be measured so that their velocity can be calculated?

4.10 Explain how waves will be refracted at a boundary in terms of the change of direction and speed

1. What is meant by refraction of a wave?
2. What happens to the speed of a wave when it enters a different medium?
3. Why does a wave change direction when it enters a different medium at an angle?
4. What happens to the direction of a wave when it enters a medium in which it travels more slowly?
5. What happens to the wavelength of a wave when its speed changes but its frequency remains constant?
6. Describe what happens to a wave's speed and direction when it passes obliquely across a boundary into a different medium.

4.11 Recall that different substances may absorb, transmit, refract or reflect waves in ways that vary with wavelength

1. What is meant by the absorption of a wave by a substance?
2. What is meant by the transmission of a wave through a substance?
3. What is meant by the reflection of a wave from a substance?
4. What is meant by the refraction of a wave by a substance?
5. Why can a substance affect different wavelengths of a wave in different ways?
6. How can the behaviour of a wave at a material boundary depend on its wavelength?

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

1. What equipment could be used to produce and observe waves in a fluid?
2. What equipment could be used to measure the frequency of a wave?
3. How could the wavelength of a wave in a fluid be measured experimentally?
4. How could the speed of a wave be calculated from measurements of its frequency and wavelength?
5. How could you investigate the suitability of different pieces of equipment for measuring waves in a solid compared with a fluid?
6. What variables and measurements would need to be considered when evaluating the accuracy and suitability of the equipment used in this practical?

Topic 5 – Light and the electromagnetic spectrum

5.7 Recall that all electromagnetic waves are transverse, that they travel at the same speed in a vacuum

1. What type of wave are all electromagnetic waves?
2. What is meant by a transverse wave?
3. What is the speed of all electromagnetic waves in a vacuum?
4. Do different electromagnetic waves travel at different speeds in a vacuum?
5. Why can radio waves and gamma rays travel at the same speed in a vacuum despite having different frequencies?
6. What happens to the speed of electromagnetic waves when they travel through a substance rather than a vacuum?

5.8 Explain, with examples, that all electromagnetic waves transfer energy from source to observer

1. What do all electromagnetic waves transfer from a source to an observer?
2. How does visible light transfer energy from the Sun to Earth?
3. How do microwaves transfer energy from a microwave oven to food?
4. How does infrared radiation transfer energy from a heater to a person?
5. How do x-rays transfer energy to the body during an x-ray scan?
6. Give an example of an electromagnetic wave transferring energy from a source to an observer.

5.9 Core Practical: Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter

1. What equipment can be used to investigate the refraction of light through a rectangular glass block?
2. How can the angle of incidence and angle of refraction be measured when investigating a glass block?
3. What happens to the direction of a light ray when it enters glass at an angle?
4. Why does light change direction when it passes from air into glass?
5. How can a ray diagram be used to investigate refraction through a rectangular glass block?
6. What measurements could be taken to determine how the angle of incidence affects the angle of refraction?

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

1. What are the seven main regions of the electromagnetic spectrum in order from longest to shortest wavelength?
2. Which electromagnetic waves have the longest wavelength?
3. Which electromagnetic waves have the shortest wavelength?
4. What are the colours of visible light in order from longest to shortest wavelength?
5. Which region of the electromagnetic spectrum lies between infrared and ultraviolet?
6. Which regions of the electromagnetic spectrum have shorter wavelengths than visible light?

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

1. Why is the electromagnetic spectrum described as continuous?
2. In what order are electromagnetic waves arranged when moving from radio waves to gamma rays?
3. What happens to wavelength as you move from radio waves towards gamma rays?
4. What happens to frequency as you move from radio waves towards gamma rays?
5. Which has the higher frequency: infrared radiation or ultraviolet radiation?
6. Which has the longer wavelength: microwaves or visible light?

5.12 Recall that our eyes can only detect a limited range of frequencies of electromagnetic radiation

1. Which part of the electromagnetic spectrum can the human eye detect?
2. Why can humans not see radio waves or microwaves?
3. What is meant by visible light?
4. Which regions of the electromagnetic spectrum lie immediately outside the visible range?
5. Why is the range of electromagnetic radiation detected by the human eye described as limited?
6. How does the frequency range detected by the human eye compare with the full electromagnetic spectrum?

5.13 Recall that different substances may absorb, transmit, refract or reflect electromagnetic waves in ways that vary with wavelength

1. What happens when a substance absorbs electromagnetic radiation?
2. What happens when a substance transmits electromagnetic radiation?
3. What happens when electromagnetic radiation is reflected by a substance?
4. What happens when electromagnetic radiation is refracted by a substance?
5. Why can the same substance interact differently with different wavelengths of electromagnetic radiation?
6. Give one example of how a substance could transmit one wavelength of electromagnetic radiation but absorb another.

5.14 Explain the effects of differences in the velocities of electromagnetic waves in different substances

1. Why can electromagnetic waves travel at different speeds in different substances?
2. What happens to the speed of an electromagnetic wave when it enters a substance from a vacuum?
3. Why can a change in the velocity of an electromagnetic wave cause refraction?
4. What happens to the direction of an electromagnetic wave when its velocity changes at a boundary?
5. What happens to the frequency of an electromagnetic wave when it enters a different substance?
6. How can differences in the velocity of electromagnetic waves in different substances cause their wavelengths to change?

5.20 Recall that the potential danger associated with an electromagnetic wave increases with increasing frequency

1. How does the potential danger of electromagnetic radiation change as frequency increases?
2. Which is potentially more dangerous: infrared radiation or ultraviolet radiation?
3. Which is potentially more dangerous: visible light or x-rays?
4. Which regions of the electromagnetic spectrum have the greatest potential danger?
5. Why are gamma rays potentially more dangerous than radio waves?
6. What relationship exists between the frequency of electromagnetic radiation and its potential danger?

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

1. What harmful effect can excessive exposure to microwaves have on the body?
2. What harmful effect can excessive exposure to infrared radiation have on the skin?
3. How can excessive exposure to ultraviolet radiation damage surface cells and eyes?
4. How can excessive exposure to ultraviolet radiation increase the risk of skin cancer?
5. How can excessive exposure to x-rays damage cells in the body?
6. How can excessive exposure to gamma rays cause mutations or damage to cells?

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

1. What are three uses of radio waves?
2. What are three uses of microwaves?
3. What are three uses of infrared radiation?
4. What are three uses of visible light?
5. What are three uses of ultraviolet radiation?
6. What are three uses of x-rays and three uses of gamma rays?

5.23 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 is meant by an oscillation in an electrical circuit?
3. How can radio waves induce oscillations in an electrical circuit?
4. What happens in an electrical circuit when a radio wave is received by an aerial?
5. How are oscillating electrical currents related to the production of radio waves?
6. How can the interaction between radio waves and electrical circuits be used in communication systems?

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

1. How can changes in atoms generate electromagnetic radiation?
2. How can changes in nuclei generate electromagnetic radiation?
3. What does it mean that changes in atoms and nuclei can generate radiation over a wide frequency range?
4. How can atoms be affected by absorbing electromagnetic radiation?
5. How can nuclei be affected by absorbing electromagnetic radiation?
6. What is the relationship between changes in atoms or nuclei and the absorption or emission of electromagnetic radiation?

Topic 6 – Radioactivity

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

1. What particles make up the nucleus of an atom?
2. What is the charge of the nucleus?
3. What particle surrounds the nucleus and has a negative charge?
4. How does the radius of the nucleus compare with the radius of the whole atom?
5. Where is almost all of the mass of an atom concentrated?
6. Describe the structure of an atom in terms of its nucleus and electrons.

6.2 Recall the typical size (order of magnitude) of atoms and small molecules

1. What is the typical order of magnitude of the diameter of an atom?
2. What is the approximate size of an atom in metres?
3. How does the size of a small molecule compare with the size of an atom?
4. What does the term "order of magnitude" mean when describing the size of an atom?
5. Convert 1 nm into metres.
6. An atom has a diameter of approximately 1×10^{-10} m. What is this value in nanometres?

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 ${}^{13}_{6}C$

1. What does the atomic number of an element represent?
2. What does the mass number of an isotope represent?
3. How can the number of neutrons in an isotope be calculated from its mass number and atomic number?
4. What information is represented by the symbol $^{13}{}_{6}C$?
5. How many protons, neutrons and electrons are present in a neutral atom of $^{13}{}_{6}C$?
6. Write the nuclear symbol for an atom containing 8 protons and 10 neutrons.

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

1. What determines the positive charge of an atomic nucleus?
2. Why do all atoms of the same element have the same nuclear charge?
3. What is an isotope?
4. How do isotopes of the same element differ from one another?
5. Why do isotopes of the same element have different masses?
6. How many neutrons are present in $^{35}{}_{17}Cl$ and $^{37}{}_{17}Cl$?

6.5 Recall the relative masses and relative electric charges of protons, neutrons, electrons and positrons

1. What are the relative mass and relative charge of a proton?
2. What are the relative mass and relative charge of a neutron?
3. What are the relative mass and relative charge of an electron?
4. What are the relative mass and relative charge of a positron?
5. Which particles have equal relative masses but opposite electric charges?
6. **Which particles have a relative charge of +1 and which have a relative charge of −1?**

6.6 Recall that in an atom the number of protons equals the number of electrons and is therefore neutral

1. Why is an atom electrically neutral?
2. What is the relationship between the number of protons and electrons in a neutral atom?
3. How many electrons are present in a neutral atom with 12 protons?
4. How many protons are present in a neutral atom with 17 electrons?
5. What happens to the charge of an atom if it gains one electron?
6. What happens to the charge of an atom if it loses one electron?

6.7 Recall that in each atom its electrons orbit the nucleus at different set distances from the nucleus

1. What is meant by an electron orbit?
2. How are electron orbits arranged around the nucleus?
3. Why are electrons in different orbits at different distances from the nucleus?
4. How does the energy of an electron change as it moves to a higher orbit?
5. Which electrons are generally furthest from the nucleus?
6. What happens to the distance from the nucleus as an electron moves into a higher orbit?

6.8 Explain that electrons change orbit when there is absorption or emission of electromagnetic radiation

1. What happens to an electron when an atom absorbs electromagnetic radiation of the correct energy?
2. What happens when an electron moves from a lower-energy orbit to a higher-energy orbit?
3. What happens when an electron moves from a higher-energy orbit to a lower-energy orbit?
4. What happens to electromagnetic radiation when an electron moves to a lower-energy orbit?
5. Why can only certain frequencies of electromagnetic radiation cause an electron to change between particular orbits?
6. How are electron transitions related to the absorption and emission of electromagnetic radiation?

6.9 Explain how atoms may form positive ions by losing outer electrons

1. How can an atom become a positive ion?
2. Why does losing an electron give an atom a positive charge?
3. Which electrons are most likely to be lost when an atom forms a positive ion?
4. What charge is produced when a neutral atom loses one electron?
5. A neutral atom has 11 protons and 11 electrons. What charge does it have after losing one electron?
6. A neutral atom loses two electrons. What is the charge of the resulting ion?

6.10 Recall that alpha, β– (beta minus), β+ (positron), gamma rays and neutron radiation are emitted from unstable nuclei in a random process

1. What types of radiation can be emitted from unstable nuclei?
2. What is meant by radioactive decay being a random process?
3. Which type of radiation consists of helium nuclei?
4. Which type of beta radiation consists of positrons?
5. Which type of radiation is electromagnetic radiation?

6. Can the exact time at which a particular unstable nucleus will decay be predicted?

6.11 Recall that alpha, β– (beta minus), β+ (positron) and gamma rays are ionising radiations

1. What is meant by ionising radiation?
2. Which four types of radiation in this specification are ionising?
3. Does alpha radiation cause ionisation?
4. Does beta minus radiation cause ionisation?
5. Does beta plus radiation cause ionisation?
6. Does gamma radiation cause ionisation?

6.12 Explain what is meant by background radiation

1. What is background radiation?
2. Why is background radiation detected even when no radioactive source has deliberately been placed nearby?
3. Is background radiation naturally present in the environment?
4. Why must background radiation be considered when measuring the activity of a radioactive source?
5. How could a background radiation measurement be used when investigating a radioactive source?
6. Why would a radiation detector normally give a non-zero reading when no radioactive source is present?

6.13 Describe the origins of background radiation from Earth and space

1. What are the two broad sources of background radiation?
2. How can radioactive materials in rocks and soil contribute to background radiation?
3. How can radon gas contribute to background radiation?
4. How does radiation from space contribute to background radiation?
5. Why can the level of background radiation vary between different locations?
6. Give examples of sources of background radiation originating from Earth and from space.

6.14 Describe methods for measuring and detecting radioactivity limited to photographic film and a Geiger–Müller tube

1. How can photographic film be used to detect radioactive radiation?
2. What happens to photographic film when it is exposed to ionising radiation?
3. What is a Geiger–Müller tube used to detect?

4. How does a Geiger–Müller tube indicate the presence of radioactive radiation?
5. What does a Geiger–Müller tube measure when detecting radioactive decay?
6. Why can a Geiger–Müller tube produce a non-zero count even when no radioactive source is present?

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

1. What is an alpha particle equivalent to?
2. What particles make up an alpha particle?
3. What is a beta minus particle?
4. Where does the electron emitted during beta minus decay come from?
5. What type of radiation is a gamma ray?
6. Compare the nature of alpha particles, beta particles and gamma rays.

6.16 Compare alpha, beta and gamma radiations in terms of their abilities to penetrate and ionise

1. Which of alpha, beta and gamma radiation has the greatest ionising ability?
2. Which of alpha, beta and gamma radiation has the greatest penetrating ability?
3. Which type of radiation can be stopped by paper or a few centimetres of air?
4. Which type of radiation can be stopped by a thin sheet of aluminium?
5. What material can be used to significantly reduce the intensity of gamma radiation?
6. How do the ionising and penetrating abilities of alpha, beta and gamma radiation compare?

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

1. What did the plum pudding model propose about the structure of the atom?
2. What did Rutherford's alpha particle scattering experiment provide evidence for?
3. What observation from Rutherford's experiment suggested that most of the atom is empty space?
4. What observation suggested that the atom contains a small, dense, positively charged nucleus?

5. What did the Bohr model propose about the arrangement of electrons?
6. Why did experimental evidence cause scientists to change the atomic model over time?

6.18 Describe the process of β– decay (a neutron becomes a proton plus an electron)

1. What happens to a neutron during beta minus decay?
2. What particle is produced when a neutron undergoes beta minus decay?
3. What happens to the proton number during beta minus decay?
4. What happens to the mass number during beta minus decay?
5. Complete the particle change: neutron → proton + ______.
6. How does beta minus decay change the composition of the nucleus?

6.19 Describe the process of β+ decay (a proton becomes a neutron plus a positron)

1. What happens to a proton during beta plus decay?
2. What particle is produced when a proton undergoes beta plus decay?
3. What happens to the proton number during beta plus decay?
4. What happens to the mass number during beta plus decay?
5. Complete the particle change: proton → neutron + ______.
6. How does beta plus decay change the composition of the nucleus?

6.20 Explain the effects on the atomic (proton) number and mass (nucleon) number of radioactive decays (α, β, γ and neutron emission)

1. What happens to the proton number and mass number during alpha decay?
2. What happens to the proton number and mass number during beta minus decay?
3. What happens to the proton number and mass number during beta plus decay?
4. What happens to the proton number and mass number during gamma emission?
5. What happens to the proton number and mass number when a neutron is emitted?
6. A nucleus undergoes alpha decay followed by beta minus decay. What is the overall change in its proton number and mass number?

6.21 Recall that nuclei that have undergone radioactive decay often undergo nuclear rearrangement with a loss of energy as gamma radiation

1. What can happen to a nucleus after it has undergone radioactive decay?
2. What is meant by nuclear rearrangement?

3. What happens to the energy of the nucleus during nuclear rearrangement?
4. What type of radiation can be emitted when a nucleus loses energy during rearrangement?
5. Does gamma emission change the proton number of a nucleus?
6. Why can gamma radiation be emitted after another type of radioactive decay?

6.22 Use given data to balance nuclear equations in terms of mass and charge

1. What quantities must be conserved when balancing a nuclear equation?
2. How can mass number be used to check whether a nuclear equation is balanced?
3. How can proton number be used to check whether a nuclear equation is balanced?
4. Complete the alpha decay equation: $^{238}{}_{92}U \longrightarrow {}^{234}{}_{90}Th$ + ?
5. Complete the beta minus decay equation: $^{14}{}_{6}C \longrightarrow {}^{14}{}_{7}N$ + ?
6. A nucleus $^{210}{}_{84}Po$ undergoes alpha decay. Write the balanced nuclear equation.

6.23 Describe how the activity of a radioactive source decreases over a period of time

1. What happens to the activity of a radioactive source as time passes?
2. Why does the activity of a radioactive source decrease over time?
3. What happens to the number of undecayed radioactive nuclei as time passes?
4. What shape does a typical graph of radioactive activity against time have?
5. Why does the activity decrease rapidly at first and then more slowly?
6. How is the activity of a radioactive source related to the number of undecayed nuclei present?

6.24 Recall that the unit of activity of a radioactive isotope is the Becquerel, Bq

1. What is the unit of radioactive activity?
2. What symbol is used for the Becquerel?
3. What does an activity of 1 Bq mean?
4. What does an activity of 500 Bq mean in terms of nuclear decays?
5. Which source has the greater activity: one measuring 200 Bq or one measuring 800 Bq?
6. What does a higher activity indicate about the rate of radioactive decay?

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

1. What is meant by the half-life of a radioactive isotope?

2. How can half-life be determined from the number of undecayed nuclei?
3. How can half-life be determined from the activity of a radioactive source?
4. A source has an activity of 800 Bq. What activity will it have after one half-life?
5. A radioactive sample has 40,000 undecayed nuclei. How many remain after two half-lives?
6. A source has an activity of 640 Bq and a half-life of 3 hours. What will its activity be after 9 hours?

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

1. Can the exact time at which a particular radioactive nucleus will decay be predicted?
2. Why is radioactive decay described as random?
3. What does half-life allow us to predict for a large number of radioactive nuclei?
4. Why can the behaviour of a large radioactive sample be predicted even though individual decays are random?
5. A radioactive source has a half-life of 5 years. What fraction of its original activity would be expected to remain after 5 years?
6. How does the random nature of individual nuclear decay differ from the predictable decay pattern of a large sample?

6.27 Use the concept of half-life to carry out simple calculations on the decay of a radioactive isotope, including graphical representations

1. A radioactive isotope has a half-life of 10 days. What fraction of the original nuclei remain after 30 days?
2. A source has an initial activity of 640 Bq and a half-life of 2 hours. What is its activity after 6 hours?
3. A radioactive sample has an initial mass of 80 g and a half-life of 5 years. What mass remains after 15 years?
4. A source has an activity of 1000 Bq. What is its activity after three half-lives?
5. A radioactive source has an activity of 960 Bq and a half-life of 4 days. After how many days will its activity be 120 Bq?
6. How can the half-life of a radioactive isotope be determined from an activity-time graph?

6.29 Describe the dangers of ionising radiation in terms of tissue damage and possible mutations and relate this to the precautions needed

1. Why can ionising radiation be harmful to living tissue?

2. How can ionising radiation damage cells?
3. How can ionising radiation cause mutations?
4. Why can mutations caused by ionising radiation be harmful?
5. Why should exposure to ionising radiation be kept as low as reasonably possible?
6. What precautions can reduce the risks associated with exposure to ionising radiation?

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

1. Why should the dose of ionising radiation received by a patient be limited?
2. Why are medical personnel at risk when working with ionising radiation?
3. How can the exposure time of medical personnel to radiation be reduced?
4. Why should medical personnel keep as far away as practical from a radioactive source?
5. How can shielding reduce the radiation dose received by medical personnel?
6. Why are radiation doses carefully controlled during medical procedures involving ionising radiation?

6.32 Describe 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. How does contamination differ from irradiation?
4. Why can radioactive contamination continue to expose a person to radiation after they leave the original source?
5. Why does irradiation stop when the external source of radiation is removed?
6. Which is potentially more difficult to control: contamination or irradiation, and why?

Topic 8 – Energy – forces doing work

8.1 Describe the changes involved in the way energy is stored when systems change

1. What happens to the energy stores of a system when the system changes?
2. What energy store increases when an object is raised above the ground?
3. What energy store increases when an object is accelerated?

4. What happens to the energy stores of an object when it is slowed down by friction?
5. Describe the energy store changes when a stretched spring is released.
6. Describe the energy store changes when a moving object comes to rest due to friction.

8.2 Draw and interpret diagrams to represent energy transfers

1. What information does an energy transfer diagram represent?
2. How can arrows be used to show energy transfers between stores?
3. Draw an energy transfer diagram for a battery-powered motor.
4. Draw an energy transfer diagram for a falling object.
5. How can an energy transfer diagram show that some energy has been dissipated?
6. What does the width of an arrow represent in a Sankey diagram?

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

1. What is meant by a closed system?
2. What happens to the total energy in a closed system when energy is transferred between stores?
3. Why is there no net change in the total energy of a closed system?
4. A ball falls and its gravitational potential energy decreases. What happens to the total energy of the closed system?
5. How does the conservation of energy apply to energy transfers within a closed system?
6. If 500 J is transferred from one energy store to another within a closed system, what is the change in the total energy of the 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

1. What are the three ways in which the energy of a system can be changed?
2. How can forces transfer energy to or from a system?
3. How can electrical equipment transfer energy to a system?
4. How can heating transfer energy to a system?
5. Give an example of energy being transferred by work done by forces.
6. Give an example of energy being transferred electrically and an example of energy being transferred by 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)

1. How can the work done by a force be measured?

2. What two quantities need to be measured to calculate work done?
3. What is the unit of work done?
4. What is the relationship between energy transferred and work done?
5. A force moves an object through a distance. What determines how much work is done?
6. Why is work done equal to the energy transferred when a force acts on an object?

8.6 Recall and use the equation: work done (joule, J) = force (newton, N) × distance moved in the direction of the force (metre, m) $E = F \times d$

1. What equation is used to calculate work done?
2. What are the units of work done, force and distance in the work done equation?
3. Calculate the work done when a force of 50 N moves an object 4 m in the direction of the force.
4. A force of 120 N does 600 J of work. Calculate the distance moved in the direction of the force.
5. An object is moved 8 m and 240 J of work is done. Calculate the force acting in the direction of movement.
6. A force of 75 N acts on an object, moving it 12 m in the direction of the force. Calculate the energy transferred.

8.7 Describe and calculate the changes in energy involved when a system is changed by work done by forces

1. How can work done by a force change the energy stored in a system?
2. What happens to the kinetic energy store when work is done to accelerate an object?
3. What happens to the gravitational potential energy store when work is done to raise an object?
4. A force of 40 N moves an object 5 m. How much energy is transferred by the force?
5. A 2 kg object is lifted vertically through 3 m using a force of 20 N. How much work is done by the lifting force?
6. Explain how work done by friction changes the energy stores of a moving object and its surroundings.

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) $\Delta GPE = m \times g \times \Delta h$

1. What equation is used to calculate the change in gravitational potential energy?
2. What quantities and units are used in the equation $\Delta GPE = m \times g \times \Delta h$?
3. Calculate the change in gravitational potential energy when a 5 kg object is raised by 4 m. Take g = 10 N/kg.
4. A 2 kg object gains 60 J of gravitational potential energy. Calculate the increase in height. Take g = 10 N/kg.
5. A 10 kg object is raised vertically by 3 m. Calculate the increase in gravitational potential energy using g = 9.8 N/kg.
6. An object gains 980 J of gravitational potential energy when raised by 5 m. Calculate its mass using g = 9.8 N/kg.

8.9 Recall and use the equation to calculate the amounts of energy associated with a moving object: kinetic energy (joule, J) = 1/2 × mass (kilogram, kg) × $(\text{speed})^2$ ($(\text{metre/second})^2$, $(m/s)^2$) $KE = 1/2 \times m \times v^2$

1. What equation is used to calculate the kinetic energy of a moving object?
2. What quantities and units are used in the equation $KE = 1/2 \times m \times v^2$?
3. Calculate the kinetic energy of a 4 kg object travelling at 5 m/s.
4. A 2 kg object has a kinetic energy of 100 J. Calculate its speed.
5. A car of mass 1000 kg travels at 20 m/s. Calculate its kinetic energy.
6. An object's speed doubles. By what factor does its kinetic energy change?

8.10 Explain, using examples, how in all system changes 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. How is energy dissipated when a car brakes?
4. How is energy dissipated when an object falls through air?
5. How is energy dissipated when an electrical appliance operates?
6. Explain why energy dissipation does not mean that energy has been destroyed.

8.11 Explain that mechanical processes become wasteful when they cause a rise in temperature so dissipating energy in heating the surroundings

1. Why do mechanical processes often cause a rise in temperature?
2. How does friction make a mechanical process wasteful?
3. Where is energy dissipated when friction acts between moving surfaces?
4. Why does heating the surroundings reduce the usefulness of transferred energy?
5. Give an example of a mechanical process where friction causes energy to be dissipated.

6. Explain why a machine that produces a large amount of heating is less efficient than one that produces less heating for the same useful output.

8.12 Define power as the rate at which energy is transferred and use examples to explain this definition

1. What is meant by power?
2. What does the rate of energy transfer mean?
3. What is the unit of power?
4. Which transfers energy more quickly: a 2000 W appliance or a 500 W appliance?
5. Two machines transfer the same amount of energy, but one does it in a shorter time. Which machine has greater power?
6. Explain what it means for a device to have a power rating of 100 W.

8.13 Recall and use the equation: power (watt, W) = work done (joule, J) ÷ time taken (second, s) P = E ÷ t

1. What equation is used to calculate power?
2. What are the units of power, energy transferred and time in the equation P = E ÷ t?
3. Calculate the power of a device that transfers 600 J of energy in 20 s.
4. A motor has a power of 1500 W and operates for 10 s. Calculate the energy transferred.
5. A machine does 12,000 J of work at a power of 600 W. Calculate the time taken.
6. A device transfers 3600 J of energy in 2 minutes. Calculate its power in watts.

8.14 Recall that one watt is equal to one joule per second, J/s

1. What is one watt equal to in terms of joules and seconds?
2. What does a power rating of 1 W mean?
3. How many joules of energy does a 100 W device transfer each second?
4. A device has a power of 500 W. How much energy does it transfer in 1 second?
5. How many joules per second are transferred by a 2 kW device?
6. Convert 3 kW into watts and state the equivalent energy transfer rate in J/s.

8.15 Recall and use the equation: efficiency = useful energy transferred by the device ÷ total energy supplied to the device

1. What equation is used to calculate the efficiency of a device?
2. What is meant by useful energy transferred by a device?

3. What is meant by total energy supplied to a device?
4. Calculate the efficiency of a device that receives 500 J of energy and transfers 350 J usefully.
5. A machine has an efficiency of 0.75 and receives 800 J of energy. Calculate the useful energy transferred.
6. A device transfers 240 J of useful energy from a total energy input of 600 J. Calculate its efficiency.

Topic 9 – Forces and their effects

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

1. What three types of force can act between objects without physical contact?
2. How does a gravitational field allow objects to exert forces on each other at a distance?
3. How do electrostatic and magnetic fields allow forces to act between objects without contact?
4. What are the normal contact force and friction, and when do they act?
5. What is meant by a pair of forces acting between two interacting objects?
6. How can a pair of forces acting between two objects be represented using vectors?

9.2 Explain the difference between vector and scalar quantities using examples

1. What is a scalar quantity?
2. What is a vector quantity?
3. What is the difference between a scalar and a vector quantity?
4. Give two examples of scalar quantities.
5. Give two examples of vector quantities.
6. Why is force a vector quantity rather than a scalar quantity?

9.3 Use vector diagrams to illustrate resolution of forces, a net force, and equilibrium situations (scale drawings only)

1. What is meant by the resultant or net force acting on an object?
2. How can vectors be used to represent the size and direction of forces?
3. What is meant by resolving a force?
4. How can a scale drawing be used to determine the resultant force of two forces?

5. What does a vector diagram show when an object is in equilibrium?
6. Two forces of 6 N and 8 N act at right angles. How could a scale drawing be used to determine their resultant force?

9.4 Draw and use free body force diagrams

1. What is a free body force diagram?
2. What does each arrow represent on a free body force diagram?
3. What information should be included about each force on a free body force diagram?
4. Draw a free body force diagram for a book resting on a horizontal table.
5. Draw a free body force diagram for a car accelerating forwards, including the main forces acting on it.
6. How can a free body force diagram be used to determine whether the forces acting on an object are balanced?

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

1. What is meant by the resultant force acting on an object?
2. What happens to the motion of an object when the resultant force acting on it is not zero?
3. What happens to the motion of an object when the resultant force acting on it is zero?
4. Give an example of an object experiencing balanced forces.
5. A car has a driving force of 2000 N forwards and a resistive force of 500 N backwards. What is the resultant force?
6. An object has forces of 15 N to the right and 15 N to the left acting on it. What is the resultant force and what does this tell you about the forces?

9.10 Explain ways of reducing unwanted energy transfer through lubrication

1. How does lubrication reduce unwanted energy transfers?
2. How does lubrication affect friction between moving surfaces?
3. Why does reducing friction reduce unwanted heating of the surroundings?
4. Give an example of a situation where lubrication can reduce unwanted energy transfer.
5. Why is oil used to lubricate moving parts in machines?
6. Explain how lubrication can make a mechanical system more efficient.

Topic 10 – Electricity and circuits

10.1 Describe the structure of the atom, limited to the position, mass and charge of protons, neutrons and electrons

1. Where are protons, neutrons and electrons located within an atom?
2. What is the relative mass and relative charge of a proton?
3. What is the relative mass and relative charge of a neutron?
4. What is the relative mass and relative charge of an electron?
5. Why is an atom electrically neutral when it contains equal numbers of protons and electrons?
6. An atom has 11 protons, 12 neutrons and 11 electrons. What are the relative charges and masses of these particles?

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

1. What circuit symbol represents a cell, and how are its positive and negative terminals shown?
2. What circuit symbol is used for a battery?
3. What circuit symbols are used for an ammeter and a voltmeter?
4. What circuit symbols are used for a resistor and a variable resistor?
5. What circuit symbols are used for a lamp, motor, diode, thermistor and LDR?
6. What circuit symbol represents an LED, and how should the components be connected using standard circuit conventions?

10.3 Describe the differences between series and parallel circuits

1. What is meant by a series circuit?
2. What is meant by a parallel circuit?
3. How does the current behave in a series circuit compared with a parallel circuit?
4. How does the potential difference behave across components in series compared with components in parallel?
5. What happens to the other components in a series circuit if one component breaks?
6. What happens to the other branches of a parallel circuit if one component breaks?

10.4 Recall that a voltmeter is connected in parallel with a component to measure the potential difference (voltage), in volt, across it

1. How should a voltmeter be connected to a component to measure its potential difference?

2. Why is a voltmeter connected in parallel rather than in series?
3. What quantity does a voltmeter measure?
4. What is the unit of potential difference?
5. A student wants to measure the potential difference across a lamp. Where should the voltmeter be connected?
6. What would be wrong with connecting a voltmeter in series with a lamp?

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

1. What does the potential difference across a component tell you about energy transfer?
2. What does it mean if a component has a potential difference of 5 V?
3. How is potential difference related to the energy transferred and charge passed?
4. What is the relationship between a volt and a joule per coulomb?
5. A charge of 2 C passes through a component with a potential difference of 6 V. How much energy is transferred?
6. A component transfers 40 J of energy when 8 C of charge passes through it. What is the potential difference?

10.6 Recall and use the equation: energy transferred (joule, J) = charge moved (coulomb, C) × potential difference (volt, V) $E = Q \times V$

1. What equation links energy transferred, charge moved and potential difference?
2. Calculate the energy transferred when 4 C of charge passes through a 12 V component.
3. Calculate the charge moved when 60 J of energy is transferred by a 15 V potential difference.
4. Calculate the potential difference when 100 J of energy is transferred by 20 C of charge.
5. A 9 V battery moves 250 C of charge. Calculate the energy transferred.
6. A component transfers 720 J of energy when 120 C of charge passes through it. Calculate its potential difference.

10.7 Recall that an ammeter is connected in series with a component to measure the current, in amp, in the component

1. How should an ammeter be connected to a component to measure its current?
2. Why is an ammeter connected in series?
3. What quantity does an ammeter measure?
4. What is the unit of electric current?

5. A student wants to measure the current through a resistor. Where should the ammeter be placed?
6. What would be wrong with connecting an ammeter in parallel across a 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

1. What is meant by electric current?
2. What does it mean to say that current is the rate of flow of charge?
3. What particles carry charge through a metal?
4. In what direction do electrons move through a metal when there is a current?
5. How does increasing the rate of flow of charge affect the current?
6. A current of 3 A flows through a wire. What does this tell you about the rate at which charge flows?

10.9 Recall and use the equation: charge (coulomb, C) = current (ampere, A) × time (second, s) $Q = I \times t$

1. What equation links charge, current and time?
2. Calculate the charge transferred by a current of 3 A flowing for 20 s.
3. Calculate the current when 120 C of charge flows in 30 s.
4. Calculate the time taken for 500 C of charge to flow at 5 A.
5. A current of 0.5 A flows for 4 minutes. Calculate the charge transferred.
6. A device transfers 1800 C of charge in 2 minutes. Calculate the current.

10.10 Describe that when a closed circuit includes a source of potential difference there will be a current in the circuit

1. What two conditions are required for a current to flow in a circuit?
2. What is meant by a closed circuit?
3. What does a source of potential difference provide to a circuit?
4. Why does a current not flow around an open circuit?
5. What happens to the current when a switch in a circuit is opened?
6. A circuit contains a battery but has a broken wire. Explain why there is no current.

10.11 Recall that current is conserved at a junction in a circuit

1. What does it mean to say that current is conserved at a junction?
2. What is the relationship between the current entering a junction and the currents leaving it?
3. A current of 5 A enters a junction and 2 A leaves through one branch. What current leaves through the other branch?

4. Two currents of 1.5 A and 2.5 A enter a junction. What is the total current leaving the junction?
5. Three branches carry currents of 2 A, 3 A and 4 A away from a junction. What current must enter the junction?
6. Why is current conserved at a junction in an electric circuit?

10.12 Explain how changing the resistance in a circuit changes the current and how this can be achieved using a variable resistor

1. How does increasing the resistance of a circuit affect the current when the potential difference is constant?
2. How does decreasing the resistance affect the current when the potential difference is constant?
3. How can a variable resistor be used to change the resistance of a circuit?
4. Explain how a variable resistor can be used to control the brightness of a lamp.
5. A variable resistor is increased from 5 ohms to 20 ohms while the potential difference remains constant. What happens to the current?
6. Why can a variable resistor be useful when investigating the relationship between current and potential difference?

10.13 Recall and use the equation: potential difference (volt, V) = current (ampere, A) × resistance (ohm, Ω) $V = I \times R$

1. What equation links potential difference, current and resistance?
2. Calculate the potential difference across a 6 ohm resistor carrying a current of 2 A.
3. Calculate the current through a 10 ohm resistor connected to 20 V.
4. Calculate the resistance of a component with a potential difference of 12 V and a current of 3 A.
5. A resistor carries a current of 0.5 A when connected to 9 V. Calculate its resistance.
6. A 240 V supply produces a current of 4 A through a device. Calculate the resistance of the device.

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

1. What happens to the total resistance when two resistors are connected in series?
2. Why does adding a resistor in series increase the net resistance?
3. What happens to the net resistance when two resistors are connected in parallel?
4. Why is the net resistance of two resistors in parallel less than the resistance of either individual resistor?

5. Two 10 ohm resistors are connected in series. What is their total resistance?
6. Two 10 ohm resistors are connected in parallel. Is their total resistance greater than, equal to, or less than 10 ohms?

10.15 Calculate the currents, potential differences and resistances in series circuits

1. Two resistors of 4 ohms and 6 ohms are connected in series. Calculate the total resistance.
2. A 12 V supply is connected to a 4 ohm resistor and a 2 ohm resistor in series. Calculate the current in the circuit.
3. A series circuit has a current of 2 A and resistors of 3 ohms and 5 ohms. Calculate the potential difference of the supply.
4. A 24 V supply produces a current of 3 A in a series circuit. One resistor has a resistance of 4 ohms. Calculate the resistance of the second resistor.
5. A 9 V supply is connected to two series resistors of 2 ohms and 7 ohms. Calculate the potential difference across each resistor.
6. A series circuit contains resistors of 5 ohms, 10 ohms and 15 ohms connected to a 60 V supply. Calculate the current and the potential difference across each resistor.

10.16 Explain the design and construction of series circuits for testing and measuring

1. Why might a series circuit be used when investigating electrical components?
2. Where should an ammeter be placed when constructing a series circuit for testing current?
3. Where should a voltmeter be placed when measuring the potential difference across a component?
4. How could a variable resistor be included in a series circuit to allow current to be changed?
5. What should be kept constant when investigating the relationship between potential difference and current for a resistor?
6. Why should circuit connections be checked before switching on a circuit used for measurements?

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

1. How would you construct a circuit to investigate the relationship between potential difference, current and resistance for a resistor?

2. Where would you place the ammeter and voltmeter when investigating a resistor?
3. How could you vary the potential difference across a resistor during the investigation?
4. How would the results for a filament lamp differ from those for a fixed resistor when potential difference is increased?
5. How would you construct circuits containing resistors and filament lamps to compare series and parallel arrangements?
6. What measurements would you take to compare the behaviour of series and parallel circuits, and how could you improve the reliability of the results?

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

1. How does the current through a fixed resistor vary as its potential difference increases, provided its temperature remains constant?
2. Why does the resistance of a filament lamp increase as the current and temperature increase?
3. How does the current through a filament lamp change as its potential difference increases?
4. How does the current through a diode vary when the potential difference is increased in the forward direction?
5. Why does a diode have a very high resistance when connected in the reverse direction?
6. How can the shape of a current-potential difference graph be used to compare the resistance of a filament lamp, diode and fixed resistor?

10.19 Describe how the resistance of a light-dependent resistor (LDR) varies with light intensity

1. What happens to the resistance of an LDR when light intensity increases?
2. What happens to the resistance of an LDR when light intensity decreases?
3. Why can an LDR be used to detect changes in light intensity?
4. What happens to the current through an LDR when the potential difference is constant and the light intensity increases?
5. How could you experimentally investigate the relationship between light intensity and the resistance of an LDR?
6. Give one practical application of an LDR and explain why its changing resistance is useful.

10.20 Describe how the resistance of a thermistor varies with change of temperature (negative temperature coefficient thermistors only)

1. What happens to the resistance of a negative temperature coefficient thermistor when its temperature increases?
2. What happens to the resistance of an NTC thermistor when its temperature decreases?
3. What does negative temperature coefficient mean?
4. How does the current through an NTC thermistor change as its temperature increases, if the potential difference is constant?
5. How could you experimentally investigate how the resistance of an NTC thermistor changes with temperature?
6. Give one application of an NTC thermistor and explain why its changing resistance is useful.

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

1. How could a circuit be designed to investigate how the resistance of a filament lamp changes with temperature?
2. How could current and potential difference measurements be used to determine the resistance of a diode?
3. How could a circuit be used to investigate how the resistance of an NTC thermistor changes with temperature?
4. How could a circuit be used to investigate how the resistance of an LDR changes with light intensity?
5. Which variables would need to be measured when investigating the resistance of each of these devices?
6. How could a variable resistor be used when investigating the resistance of filament lamps, diodes, thermistors and LDRs?

10.22 Recall that, when there is an electric current in a resistor, there is an energy transfer which heats the resistor

1. What happens to a resistor when an electric current passes through it?
2. What form of energy is transferred when a resistor is heated by an electric current?
3. Why does a resistor become hotter when current passes through it?
4. What happens to the heating effect if the current through a resistor is increased?
5. What happens to the heating effect if the resistance is increased while current remains constant?
6. Give two examples of devices that deliberately use the heating effect of an electric current.

10.23 Explain that electrical energy is dissipated as thermal energy in the surroundings when an electrical current does work against electrical resistance

1. What happens to electrical energy when current flows through a resistance?
2. What is meant by electrical energy being dissipated?
3. Why does electrical resistance result in energy being transferred to the surroundings?
4. What form does the dissipated energy mainly take?
5. Why is the heating of a resistor described as an energy transfer rather than energy being destroyed?
6. Explain why electrical resistance can cause unwanted energy dissipation in electrical circuits.

10.24 Explain the energy transfer (in 10.22 above) as the result of collisions between electrons and the ions in the lattice

1. What particles move through a metal when an electric current flows?
2. What do the electrons in a metal collide with as they move through the lattice?
3. How do collisions between electrons and ions transfer energy to the lattice?
4. Why does the temperature of a resistor increase when electrons collide with ions?
5. How does the lattice of a metal contribute to electrical resistance?
6. Explain how electron-ion collisions result in electrical energy being transferred into thermal energy.

10.25 Explain ways of reducing unwanted energy transfer through low resistance wires

1. Why does using low-resistance wires reduce unwanted energy transfer?
2. How does the resistance of a wire affect the energy dissipated as thermal energy?
3. Why are low-resistance wires useful for transmitting electrical energy?
4. What properties of a wire can be changed to reduce its resistance?
5. Why can thicker wires reduce unwanted heating compared with thinner wires?
6. Explain why electrical cables used to transmit large amounts of power are designed to have low resistance.

10.26 Describe the advantages and disadvantages of the heating effect of an electric current

1. Give two useful applications of the heating effect of an electric current.
2. Why is the heating effect useful in an electric kettle?
3. Why is the heating effect useful in an electric heater?
4. Why can the heating effect be unwanted in electrical cables?

5. How can unwanted heating in wires reduce the efficiency of an electrical system?
6. Compare one advantage and one disadvantage of the heating effect of an electric current.

10.27 Use the equation: energy transferred (joule, J) = current (ampere, A) × potential difference (volt, V) × time (second, s) $E = I \times V \times t$

1. What equation links energy transferred, current, potential difference and time?
2. Calculate the energy transferred by a current of 2 A through a 12 V device for 30 s.
3. Calculate the energy transferred by a 5 A current through a 230 V appliance operating for 60 s.
4. Calculate the current when 36 000 J of energy is transferred by a 12 V device in 300 s.
5. Calculate the time required to transfer 24 000 J of energy using a 10 A current at 12 V.
6. A device operates at 230 V and draws 4 A for 5 minutes. Calculate the energy transferred.

10.28 Describe power as the energy transferred per second and recall that it is measured in watt

1. What is meant by the power of an electrical device?
2. How is power related to the rate of energy transfer?
3. What is the unit of power?
4. What does a power rating of 60 W mean?
5. Which transfers energy at a greater rate: a 100 W device or a 500 W device?
6. A device transfers 1200 J of energy every 10 s. What is its power?

10.29 Recall and use the equation: power (watt, W) = energy transferred (joule, J) ÷ time taken (second, s) $P = E \div t$

1. What equation links power, energy transferred and time?
2. Calculate the power of a device that transfers 600 J in 20 s.
3. Calculate the energy transferred by a 100 W device operating for 30 s.
4. Calculate the time taken for a 200 W device to transfer 6000 J of energy.
5. A heater transfers 360 000 J of energy in 10 minutes. Calculate its power.
6. A lamp has a power rating of 60 W and operates for 5 minutes. Calculate the energy transferred.

10.30 Explain how the power transfer in any circuit device is related to the potential difference across it and the current in it

1. How is the power transferred by an electrical device related to the potential difference across it?
2. How is the power transferred by an electrical device related to the current through it?
3. What happens to the power transferred if the potential difference increases while current remains constant?
4. What happens to the power transferred if the current increases while potential difference remains constant?
5. A device operates at a fixed potential difference. Explain why increasing its current increases its power transfer.
6. Why does a high-power appliance transfer energy at a greater rate than a low-power appliance?

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 (ampere2, A2) × resistance (ohm, Ω) $P = I^2 \times R$

1. What equation links electrical power, current and potential difference?
2. Calculate the power of a device operating at 230 V with a current of 4 A.
3. What equation links electrical power, current and resistance?
4. Calculate the power dissipated by a 10 ohm resistor carrying a current of 3 A.
5. A resistor has a resistance of 20 ohms and dissipates 180 W. Calculate the current through it.
6. An appliance has a power rating of 920 W and operates at 230 V. Calculate the current it draws.

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

1. What energy transfer takes place in an electric motor?
2. What energy transfer takes place in an electric heating device?
3. How is energy transferred from a battery to the motor in a battery-powered device?
4. How is energy transferred from the a.c. mains to a heating device such as an electric kettle?
5. Give one domestic device that transfers electrical energy mainly into kinetic energy.
6. Give one domestic device that transfers electrical energy mainly into thermal energy.

10.33 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 an alternating voltage change with time?
4. How does direct voltage differ from alternating voltage in terms of polarity?
5. Which type of voltage is supplied by a cell?
6. Which type of voltage is supplied by the UK domestic mains?

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.)

1. What is meant by direct current?
2. In what direction does charge move in a d.c. circuit?
3. Which type of current is supplied by cells and batteries?
4. Why does a battery produce direct current rather than alternating current?
5. What happens to the direction of charge flow in a d.c. circuit?
6. Give two examples of devices that can be powered by the direct current supplied by batteries.

10.35 Describe that in alternating current (a.c.) the movement of charge changes direction

1. What is meant by alternating current?
2. What happens to the direction of charge movement in an a.c. circuit?
3. How does alternating current differ from direct current?
4. Does charge in an a.c. circuit continue moving in one direction only?
5. Why is the current described as alternating?
6. What happens repeatedly to the direction of current in an a.c. supply?

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

1. Is the UK domestic electricity supply a.c. or d.c.?
2. What is the frequency of the UK domestic a.c. supply?
3. What is the approximate voltage of the UK domestic supply?
4. What does a frequency of 50 Hz mean for an alternating supply?
5. A domestic appliance is connected to the UK mains. What voltage is it designed to operate from?
6. State the type of current, frequency and approximate voltage supplied by the UK domestic mains.

10.37 Explain the difference in function between the live and the neutral mains input wires

1. What is the function of the live wire in a domestic circuit?

2. What is the function of the neutral wire?
3. Which mains wire is at a high alternating potential relative to earth?
4. Why does current flow between the live and neutral wires when an appliance is operating?
5. Why is the live wire considered dangerous even when the appliance is switched off?
6. What is the difference between the functions of the live and neutral wires?

10.38 Explain the function of an earth wire and of fuses or circuit breakers in ensuring safety

1. What is the purpose of the earth wire in a domestic electrical appliance?
2. How does the earth wire help protect a person if a fault makes the metal case live?
3. What is the function of a fuse in a domestic circuit?
4. How does a circuit breaker protect an electrical circuit?
5. What happens to the circuit when a fuse melts because the current is too large?
6. Explain how the earth wire and a fuse or circuit breaker work together to reduce the risk of electric shock.

10.39 Explain why switches and fuses should be connected in the live wire of a domestic circuit

1. Why should a switch be connected in the live wire?
2. Why should a fuse be connected in the live wire?
3. What could happen if a switch were connected only in the neutral wire?
4. Why could an appliance still be dangerous if its switch disconnected only the neutral wire?
5. How does placing the fuse in the live wire protect the appliance and user?
6. Explain why connecting both switches and fuses in the live wire improves safety.

10.40 Recall the potential differences between the live, neutral and earth mains wires

1. What is the potential difference between the live and neutral wires in the UK domestic supply?
2. What is the potential difference between the live and earth wires?
3. What is the potential difference between the neutral and earth wires?
4. Which mains wire is approximately at 230 V relative to earth?
5. Which two mains wires are approximately at the same potential?
6. State the approximate potential differences of the live, neutral and earth wires relative to earth.

10.41 Explain the dangers of providing any connection between the live wire and earth

1. Why is it dangerous for the live wire to become connected to earth?
2. What can happen if a person provides a connection between the live wire and earth?
3. Why can a live-to-earth connection cause a large current to flow?
4. How can a live-to-earth fault cause an electric shock?
5. How can a fuse or circuit breaker reduce the danger caused by a live-to-earth connection?
6. Explain why touching a live wire while also being connected to earth can be dangerous.

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

1. What does the power rating of a domestic electrical appliance tell you?
2. How does the power rating relate to the rate at which an appliance transfers energy?
3. Which transfers more energy in the same amount of time: a 1 kW appliance or a 2 kW appliance?
4. A 2 kW heater operates for 10 minutes. What happens to the stored energy of the electrical supply during this time?
5. Explain why a higher-power appliance causes a greater change in stored energy in the same time.
6. Compare the energy transferred by a 1000 W kettle and a 2000 W kettle when both operate for 5 minutes.

Topic 12 – Magnetism and the motor effect

12.1 Recall that unlike magnetic poles attract and like magnetic poles repel

1. What happens when two unlike magnetic poles are brought close together?
2. What happens when two like magnetic poles are brought close together?
3. Which magnetic poles attract each other?
4. Which magnetic poles repel each other?
5. What happens when the north pole of one magnet is brought near the south pole of another magnet?

6. What happens when the north pole of one magnet is brought near the north pole of another magnet?

12.2 Describe the uses of permanent and temporary magnetic materials including cobalt, steel, iron and nickel

1. What is a permanent magnetic material?
2. What is a temporary magnetic material?
3. Why is steel suitable for making permanent magnets?
4. Why is iron suitable for making temporary magnets?
5. Give one use of a permanent magnet and identify a suitable material for it.
6. Give one use of a temporary magnet and identify a suitable material for it.

12.3 Explain the difference between permanent and induced magnets

1. What is a permanent magnet?
2. What is an induced magnet?
3. How does an induced magnet differ from a permanent magnet?
4. What happens to an induced magnet when the magnetising material is removed?
5. Why is iron commonly used to make induced magnets?
6. Give one example of where an induced magnet is useful.

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

1. What is meant by a magnetic field?
2. What is the direction of magnetic field lines outside a bar magnet?
3. What is the shape of the magnetic field around a bar magnet?
4. What does a uniform magnetic field look like?
5. How can the strength of a magnetic field be determined from the spacing of its field lines?
6. Where is the magnetic field strongest around a bar magnet, and how is this shown by the field lines?

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

1. How can plotting compasses be used to investigate the magnetic field around a bar magnet?
2. What does the north-seeking end of a plotting compass indicate?
3. How can a series of plotting compass positions be used to draw magnetic field lines?

4. How can plotting compasses be used to show the direction of the Earth's magnetic field?
5. Why should a plotting compass be moved to different positions around a magnet when mapping its field?
6. How can the results from plotting compasses be used to determine the shape and direction of a magnetic field?

12.6 Explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic

1. Why does a magnetic compass point approximately towards the Earth's north?
2. How does the behaviour of a compass provide evidence that the Earth has a magnetic field?
3. Why must the Earth's core be magnetic to explain the Earth's magnetic field?
4. What happens to a compass needle when it is placed in the Earth's magnetic field?
5. How does the Earth's magnetic field affect a compass regardless of where the compass is placed?
6. Explain how the behaviour of a magnetic compass provides evidence that the Earth's core is magnetic.

12.7 Describe how to show that a current can create a magnetic effect and relate the shape and direction of the magnetic field around a long straight conductor to the direction of the current

1. How can you demonstrate that an electric current produces a magnetic field?
2. What is the shape of the magnetic field around a long straight current-carrying conductor?
3. How is the direction of the magnetic field around a straight conductor related to the direction of the current?
4. How could plotting compasses be used to investigate the magnetic field around a current-carrying wire?
5. What happens to the direction of the magnetic field if the direction of current in the conductor is reversed?
6. How can the magnetic field around a straight conductor be shown experimentally?

12.8 Recall that the strength of the field depends on the size of the current and the distance from the long straight conductor

1. How does increasing the current in a straight conductor affect the strength of its magnetic field?

2. How does increasing the distance from a straight conductor affect the strength of its magnetic field?
3. Where is the magnetic field strongest around a current-carrying straight conductor?
4. What happens to the magnetic field strength when the current is doubled, assuming the distance is unchanged?
5. What happens to the magnetic field strength when a plotting compass is moved further from the conductor?
6. What two factors determine the strength of the magnetic field around a 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

1. What is a solenoid?
2. What happens to the magnetic fields from individual coils inside a solenoid?
3. Why is the magnetic field along the centre of a solenoid strong and almost uniform?
4. What happens to the magnetic fields from individual coils outside a solenoid?
5. Why is the magnetic field outside a solenoid much weaker than inside it?
6. Explain how the magnetic fields produced by individual coils combine to produce the overall field of a solenoid.

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

1. What happens when a current-carrying conductor is placed in a magnetic field?
2. What causes the force on a current-carrying conductor near a magnet?
3. What force acts on the magnet when the conductor experiences a force?
4. How are the forces on the conductor and magnet related in magnitude and direction?
5. What happens to the force if the direction of current in the conductor is reversed?
6. What happens to the force if the magnetic field direction is reversed?

12.11 Explain that magnetic forces are due to interactions between magnetic fields

1. What causes a magnetic force to act on a current-carrying conductor?
2. What two magnetic fields interact to produce the motor effect?

3. How does the magnetic field around a current-carrying conductor interact with the field of a permanent magnet?
4. Why can the interaction between magnetic fields produce a force?
5. What happens to the force when the direction of one of the interacting magnetic fields is reversed?
6. Explain how interactions between magnetic fields produce the force on a current-carrying conductor.

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

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 is represented by the thumb in Fleming's left-hand rule?
5. When using Fleming's left-hand rule, what must be true about the directions of the force, current and magnetic field?
6. A conductor has a current directed into the page and a magnetic field directed from north to south. How can Fleming's left-hand rule be used to determine the direction of the force?

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) $F = B \times I \times l$

1. What equation links force, magnetic flux density, current and conductor length?
2. Calculate the force on a 0.50 m conductor carrying a current of 4 A in a magnetic field of flux density 0.20 T.
3. Calculate the magnetic flux density when a 2 m conductor carrying 3 A experiences a force of 1.2 N.
4. Calculate the current required for a 0.40 m conductor to experience a force of 0.80 N in a magnetic field of 0.50 T.
5. A conductor experiences a force of 2.4 N in a magnetic field of 0.60 T while carrying a current of 4 A. Calculate the length of the conductor in the magnetic field.
6. A 0.25 m conductor carries a current of 6 A in a magnetic field of 0.40 T. Calculate the force acting on the conductor.

Topic 13 – Electromagnetic induction

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

1. What is meant by an induced potential difference?
2. What happens to the size of the induced potential difference when a magnet is moved faster through a coil?
3. How does the strength of the magnetic field affect the size of the induced potential difference?
4. How does the number of turns on a coil affect the size of the induced potential difference?
5. What determines the direction of the induced potential difference?
6. Why does the magnetic field produced by the induced current oppose the original change in magnetic field?

13.5 Explain how an alternating current in one circuit can induce a current in another circuit in a transformer

1. What happens when an alternating current flows through the primary coil of a transformer?
2. How does the primary coil produce a changing magnetic field?
3. How can the changing magnetic field induce a potential difference in the secondary coil?
4. Why does a transformer require an alternating current rather than a direct current?
5. What happens in the secondary coil when the induced potential difference causes charge to flow?
6. Explain how an alternating current in the primary circuit can produce a current in the secondary circuit.

13.6 Recall that a transformer can change the size of an alternating voltage

1. What is the function of a transformer?
2. What type of voltage can a transformer change?
3. What does a step-up transformer do to an alternating voltage?
4. What does a step-down transformer do to an alternating voltage?
5. Which part of a transformer determines whether the voltage is stepped up or stepped down?
6. Why is a transformer unable to change the size of a direct voltage?

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

1. Why is electrical energy transmitted through the national grid at high voltage?
2. What happens to the current needed to transmit a given power when the transmission voltage is increased?
3. Why does a lower current reduce heating in transmission lines?
4. How does heating of transmission lines reduce the efficiency of electricity transmission?
5. Why is the voltage reduced before electricity is supplied to homes?
6. Explain how transmitting electricity at high voltage reduces energy loss from the national grid.

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

1. Where are step-up transformers used in the national grid?
2. Why are step-up transformers used near power stations?
3. What happens to the voltage and current when a step-up transformer is used?
4. Where are step-down transformers used in the national grid?
5. Why are step-down transformers used before electricity reaches domestic consumers?
6. Describe the sequence of voltage changes from a power station to a domestic consumer and explain why transformers are used.

13.10 Use the power equation (for transformers with 100% 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) $V_p \times I_p = V_s \times I_s$

1. What equation relates the potential difference and current in the primary and secondary coils of an ideal transformer?
2. Calculate the secondary current when the primary voltage is 12 000 V, the primary current is 5 A and the secondary voltage is 240 V.
3. Calculate the secondary voltage when the primary voltage is 230 V, the primary current is 2 A and the secondary current is 0.5 A.
4. Calculate the primary current when a transformer has a primary voltage of 11 000 V, a secondary voltage of 230 V and a secondary current of 20 A.
5. An ideal transformer has a primary voltage of 400 V and primary current of 3 A. The secondary voltage is 120 V. Calculate the secondary current.
6. An ideal transformer transfers 9200 W of power. If the secondary voltage is 230 V, calculate the secondary current.

Topic 14 – Particle model

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

1. How are particles arranged in a solid?
2. How do particles move in a solid?
3. How are particles arranged in a liquid?
4. How do particles move in a liquid?
5. How are particles arranged and how do they move in a gas?
6. Use the kinetic theory model to explain why solids, liquids and gases have different properties.

14.2 Recall and use the equation: density (kilogram per cubic metre, kg/m3) = mass (kilogram, kg) ÷ volume (cubic metre, m3) ρ = m ÷ V

1. What equation links density, mass and volume?
2. Calculate the density of an object with a mass of 600 kg and a volume of 3 m3.
3. Calculate the mass of an object with a density of 800 kg/m3 and a volume of 0.5 m3.
4. Calculate the volume of an object with a mass of 120 kg and a density of 600 kg/m3.
5. A substance has a mass of 2.4 kg and a volume of 0.003 m3. Calculate its density.
6. A material has a density of 1000 kg/m3 and a mass of 5 kg. Calculate its volume.

14.3 Core Practical: Investigate the densities of solid and liquids

1. How can the density of a regular solid be determined experimentally?
2. How can the volume of an irregular solid be measured using displacement?
3. How can the mass of a solid be measured accurately?
4. How can the density of a liquid be determined experimentally?
5. What measurements are needed to calculate the density of a solid or liquid?
6. What precautions could be taken to improve the accuracy and reliability of a density investigation?

14.4 Explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules

1. Why are solids generally denser than gases?
2. How does the spacing between particles affect the density of a substance?
3. How are the particles arranged in a solid compared with a gas?
4. Why does a substance usually become less dense when it changes from a liquid to a gas?
5. How can the particle model explain the different densities of solids, liquids and gases?
6. Why can a gas have a much lower density than the same substance in its solid or liquid state?

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

1. What happens to the mass of a substance when it melts?
2. What happens to the mass of a substance when it evaporates?
3. What happens to the mass of a substance when it freezes, boils, condenses or sublimates?
4. Why are melting, freezing, evaporation, boiling, condensation and sublimation physical changes?
5. How can a physical change be distinguished from a chemical change using reversibility?
6. Explain why mass is conserved during a change of state.

14.6 Explain 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. How can heating a substance increase its temperature?
3. What happens to the stored energy when a substance is heated during a change of state?
4. Why can heating a substance produce a change of state without increasing its temperature?
5. What happens to the particles' energy when a substance is heated?
6. Explain how heating can either raise the temperature of a substance or cause it to change state.

14.7 Define the terms specific heat capacity and specific latent heat and explain the differences between them

1. What is meant by specific heat capacity?
2. What is meant by specific latent heat?
3. What is the difference between specific heat capacity and specific latent heat?

4. What does a substance with a high specific heat capacity require to increase its temperature by 1 °C?
5. What does specific latent heat tell you about the energy required during a change of state?
6. Why does energy supplied during a change of state not increase the temperature of the substance?

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) $\Delta Q = m \times c \times \Delta\theta$

1. What equation links change in thermal energy, mass, specific heat capacity and change in temperature?
2. Calculate the thermal energy required to heat 2 kg of a substance with a specific heat capacity of 500 J/kg °C by 20 °C.
3. Calculate the change in temperature when 10 000 J of energy is transferred to 2 kg of a substance with a specific heat capacity of 500 J/kg °C.
4. Calculate the mass of a substance when 15 000 J of energy produces a 10 °C temperature increase in a substance with a specific heat capacity of 750 J/kg °C.
5. A 3 kg material has a specific heat capacity of 400 J/kg °C. Calculate the energy required to increase its temperature from 20 °C to 70 °C.
6. A substance absorbs 24 000 J of thermal energy and its temperature increases by 30 °C. Its mass is 2 kg. Calculate its specific heat capacity.

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) $Q = m \times L$

1. What equation links thermal energy, mass and specific latent heat?
2. Calculate the energy required to melt 2 kg of a substance with a specific latent heat of 200 000 J/kg.
3. Calculate the mass of a substance that requires 600 000 J to change state when its specific latent heat is 300 000 J/kg.
4. Calculate the specific latent heat of a substance when 900 000 J is required to change the state of 3 kg.
5. How much energy is required to vaporise 0.5 kg of a substance with a specific latent heat of 2 000 000 J/kg?
6. A substance of mass 4 kg absorbs 1.2 MJ of energy during a change of state. Calculate its specific latent heat in J/kg.

14.10 Explain ways of reducing unwanted energy transfer through thermal insulation

1. What is meant by thermal insulation?
2. How does thermal insulation reduce unwanted energy transfer?

3. Why are materials containing trapped air often good thermal insulators?
4. How can the walls of a house be insulated to reduce thermal energy transfer?
5. How can loft insulation reduce energy transfer from a house?
6. Give two methods of reducing unwanted thermal energy transfer from a building and explain how each works.

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

1. How can the specific heat capacity of water be determined experimentally?
2. What measurements are needed when determining the specific heat capacity of water?
3. Why should the mass of water be measured accurately in the specific heat capacity experiment?
4. How can electrical energy supplied to the water be calculated?
5. What does a temperature-time graph for melting ice show?
6. Why does the temperature remain constant while ice is melting even though energy is being supplied?

14.12 Explain the pressure of a gas in terms of the motion of its particles

1. Why does a gas exert pressure on the walls of its container?
2. What happens when gas particles collide with the walls of their container?
3. How does the motion of gas particles produce a force on the container walls?
4. How is gas pressure related to the frequency of collisions with the container walls?
5. How is gas pressure related to the force produced by particle collisions?
6. Use the particle model to explain why a gas exerts pressure.

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)

1. What happens to the average velocity of gas particles when the temperature increases?
2. Why do faster-moving gas particles produce more frequent collisions with the container walls?
3. Why do faster-moving gas particles produce greater forces during collisions?
4. What happens to the pressure of a fixed mass of gas when its temperature increases at constant volume?

5. What happens to the pressure when the temperature of a gas decreases at constant volume?
6. Use the particle model to explain why increasing the temperature of a gas increases its pressure when the volume is constant.

14.14 Describe the term absolute zero, −273 °C, in terms of the lack of movement of particles

1. What is meant by absolute zero?
2. What is the temperature of absolute zero in degrees Celsius?
3. What does absolute zero represent in terms of particle movement?
4. What happens to the movement of particles as the temperature approaches absolute zero?
5. Why is absolute zero considered the lowest possible temperature?
6. **Explain the meaning of −273 °C in terms of the movement of particles.**

14.15 Convert between the kelvin and Celsius scales

1. What is the relationship between temperature in kelvin and temperature in degrees Celsius?
2. Convert 27 °C into kelvin.
3. Convert 100 °C into kelvin.
4. Convert 300 K into degrees Celsius.
5. Convert 250 K into degrees Celsius.
6. **A substance has a temperature of −73 °C. What is its temperature in kelvin?**

Topic 15 – Forces and matter

15.1 Explain, using springs and other elastic objects, that stretching, bending or compressing an object requires more than one force

1. Why are at least two forces required to stretch a spring?
2. How can two opposing forces cause a spring to stretch?
3. How can forces be used to compress a spring?
4. How can forces be used to bend an elastic object?
5. What happens to the shape of an elastic object when opposing forces are removed?
6. Describe an example where two forces cause an object to stretch, bend or compress.

15.2 Describe the difference between elastic and inelastic distortion

1. What is meant by elastic distortion?
2. What is meant by inelastic distortion?
3. What happens to an object after an elastic distortion when the forces are removed?
4. What happens to an object after an inelastic distortion when the forces are removed?
5. How can you determine experimentally whether a material has been elastically or inelastically distorted?
6. Give an example of a material or object that can undergo elastic distortion and explain what happens when the force is removed.

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) $F = k \times x$

1. What equation links force, spring constant and extension?
2. Calculate the force needed to extend a spring with a spring constant of 200 N/m by 0.05 m.
3. Calculate the spring constant of a spring that requires a force of 12 N to produce an extension of 0.03 m.
4. Calculate the extension of a spring with a spring constant of 400 N/m when a force of 20 N is applied.
5. A spring has a spring constant of 150 N/m. Calculate its extension when a force of 6 N is applied.
6. A spring extends by 0.08 m when a force of 16 N is applied. Calculate the spring constant.

15.4 Use the equation to calculate the work done in stretching a spring: energy transferred in stretching (joule, J) = 0.5 × spring constant (newton per metre, N/m) × (extension (metre, m))2 $E = 0.5 \times k \times x^2$

1. What equation can be used to calculate the energy transferred when stretching a spring?
2. Calculate the energy transferred when a spring with a spring constant of 200 N/m is extended by 0.10 m.
3. Calculate the energy transferred when a spring with a spring constant of 500 N/m is extended by 0.20 m.
4. Calculate the extension of a spring when 4 J of energy is transferred and its spring constant is 800 N/m.
5. Calculate the spring constant of a spring when 2 J of energy is transferred by extending it by 0.10 m.
6. A spring with a spring constant of 250 N/m is stretched from its natural length by 0.12 m. Calculate the energy transferred to the spring.

15.5 Describe the difference between linear and non-linear relationships between force and extension

1. What is meant by a linear relationship between force and extension?
2. What would a force-extension graph look like for a linear relationship?
3. What is meant by a non-linear relationship between force and extension?
4. How would the shape of a non-linear force-extension graph differ from a linear graph?
5. How can a force-extension graph be used to determine whether a spring obeys a linear relationship?
6. What does it mean if the extension of a spring is directly proportional to the applied force?

15.6 Core Practical: Investigate the extension and work done when applying forces to a spring

1. How could you experimentally investigate the relationship between force and extension for a spring?
2. What measurements should be taken during an investigation of the extension of a spring?
3. How could the force applied to a spring be increased in a controlled way?
4. How could the extension of the spring be calculated from measurements of its length?
5. How could a force-extension graph be used to determine whether the spring behaves linearly?
6. How could the work done in stretching the spring be determined from the results of the investigation?