Edexcel GCSE Triple Physics

Topic 1 – Key concepts of physics

1.1 Recall and use the SI unit for physical quantities, as listed in Appendix 3

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 electric current?
5. What is the SI unit for temperature?
6. What is the SI unit for energy?

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 the prefix giga (G) represent?
2. What multiplier does the prefix mega (M) represent?
3. What multiplier does the prefix kilo (k) represent?
4. What multiplier does the prefix centi (c) represent?
5. What multiplier does the prefix milli (m) represent?
6. What multipliers do the prefixes micro (μ) and nano (n) represent?

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. How would you convert a measurement in hours into seconds?
4. Convert 2.5 hours into seconds.
5. Convert 3600 seconds into hours.
6. Convert 5 kilometres into metres.

1.4 Use significant figures and standard form where appropriate

1. What is meant by significant figures?
2. How many significant figures does 0.00450 have?
3. How should 7.846 be rounded to three significant figures?

4. What is standard form?
5. Express 450,000 in standard form.
6. Express 0.000032 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 a scalar quantity?
2. What does the magnitude of a physical quantity describe?
3. Does a scalar quantity have a specific direction?
4. Is distance a scalar quantity?
5. Is speed a scalar quantity?
6. What is the defining feature of a scalar quantity?

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

1. What is a vector quantity?
2. What two properties does a vector quantity have?
3. Does a vector quantity have a specific direction?
4. Is velocity a vector quantity?
5. Is force a vector quantity?
6. What is the defining feature of a vector quantity?

2.3 Explain the difference between vector and scalar quantities

1. What is the difference between a scalar and a vector quantity?
2. Which type of quantity has magnitude but no specific direction?
3. Which type of quantity has both magnitude and direction?
4. Why is speed a scalar quantity?
5. Why is velocity a vector quantity?
6. What additional information is required for a vector quantity compared with a scalar quantity?

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: displacement or distance?
2. Which is a vector quantity: velocity or speed?

3. Is acceleration a scalar or vector quantity?
4. Are force, weight and momentum scalar or vector quantities?
5. Is mass a scalar or vector quantity?
6. Is energy a scalar or vector quantity?

2.5 Recall that velocity is speed in a stated direction

1. What is velocity?
2. What additional information does velocity provide compared with speed?
3. Why is velocity a vector quantity?
4. What is the difference between speed and velocity?
5. Can two objects have the same speed but different velocities?
6. What happens to an object's velocity when its direction changes but its speed remains constant?

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 for average speed?
2. What is the SI unit for speed?
3. What is the equation for distance travelled using average speed and time?
4. What is the average speed of an object that travels 150 m in 10 s?
5. How far does an object travel at 20 m/s for 5 s?
6. How can the speed equation be rearranged to calculate time?

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 is speed calculated from a distance/time graph?
3. What does a horizontal line on a distance/time graph represent?
4. What does a straight line with a constant positive gradient represent?
5. What does a steeper gradient on a distance/time graph indicate?
6. What does a changing gradient on a distance/time graph indicate?

2.8 Recall and use the equation: acceleration (metre per second squared, m/s^2) = change in velocity (metre per second, m/s) ÷ time taken (second, s) $(v - u) \div t = a$

1. What is the equation for acceleration?
2. What is the SI unit for acceleration?
3. What does u represent in the equation $a = (v - u) \div t$?

4. What does v represent in the equation $a = (v - u) \div t$?
5. What is the acceleration when velocity changes by 20 m/s in 5 s?
6. What does a negative acceleration indicate about an object's velocity?

2.9 Use the equation: (final velocity)² − (initial velocity)² = 2 × acceleration × distance, $v^2 - u^2 = 2 \times a \times x$

1. What equation relates final velocity, initial velocity, acceleration and distance?
2. What does v represent in $v^2 - u^2 = 2ax$?
3. What does u represent in $v^2 - u^2 = 2ax$?
4. What does a represent in $v^2 - u^2 = 2ax$?
5. What does x represent in $v^2 - u^2 = 2ax$?
6. What quantity can be calculated using $v^2 - u^2 = 2ax$ when the other three quantities are known?

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 acceleration of two objects be compared using their velocity/time graph gradients?
3. How is acceleration calculated from the gradient of a velocity/time graph?
4. What does the area between a velocity/time graph and the time axis represent?
5. How can the distance travelled be determined from a velocity/time graph?
6. What does a horizontal line on a velocity/time graph represent?

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

1. What is a light gate used to measure in a motion experiment?
2. How can light gates be used to determine the speed of an object?
3. What measurements are needed to calculate speed using a light gate?
4. Why can a light gate provide a more precise measurement of time than a stopwatch operated by a person?
5. What other laboratory method could be used to determine the speed of a moving object?
6. How can the length of an object passing through a light gate be used to calculate its speed?

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?
6. How do typical transportation speeds compare with walking and running speeds?

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 Earth's surface?
2. What is the SI unit for gravitational acceleration?
3. What does an acceleration of 10 m/s² mean for a freely falling object?
4. In which direction does gravitational acceleration act near Earth's surface?
5. How can the magnitude of an everyday acceleration be estimated?
6. How does gravitational acceleration compare with typical accelerations in everyday motion?

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. What does Newton's first law state?
2. What happens to an object when the resultant force acting on it is zero?
3. What is the velocity of an object moving at constant velocity when the resultant force is zero?
4. What happens to an object's motion when the resultant force is not zero?
5. Can an object be moving when the resultant force acting on it is zero?
6. What changes in motion can result from a non-zero resultant force?

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. What is Newton's second law equation?
2. What is the SI unit of force?

3. What happens to acceleration if force increases while mass remains constant?
4. What happens to acceleration if mass increases while force remains constant?
5. What force is needed to accelerate a 5 kg mass at 4 m/s^2?
6. What acceleration is produced by a 20 N force acting on a 4 kg mass?

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 weight?
2. What is the equation relating weight, mass and gravitational field strength?
3. What is the SI unit for weight?
4. What is the SI unit for gravitational field strength?
5. What is the weight of a 10 kg object in a gravitational field of 10 N/kg?
6. How does an object's weight change if its mass doubles in the same gravitational field?

2.17 Describe how weight is measured

1. What instrument can be used to measure weight?
2. What physical quantity does a spring balance measure?
3. What unit is normally used when measuring weight?
4. How does a spring balance indicate the weight of an object?
5. Why is a spring balance suitable for measuring weight?
6. How could the weight of an object be measured experimentally?

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

1. What is the relationship between weight and gravitational field strength for a fixed mass?
2. What happens to weight when gravitational field strength increases?
3. What happens to weight when gravitational field strength decreases?
4. How does gravitational field strength affect the weight of an object on different planets?
5. Why does an object's mass remain constant when its gravitational field changes?
6. Which equation shows the relationship between weight, mass and gravitational field strength?

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. What apparatus can be used to investigate force, mass and acceleration?
3. What variable can be changed by adding masses to a trolley?
4. What measurements are needed to determine acceleration?
5. What variable should be controlled when investigating the effect of force on acceleration?
6. What relationship between force and acceleration is expected when mass is kept constant?

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 component of velocity changes during circular motion at constant speed?
3. Is velocity constant when an object travels around a circle at constant speed?
4. Why can velocity change even when speed remains constant?
5. What happens to the direction of velocity during circular motion?
6. Why is circular motion considered accelerated motion even when speed is constant?

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 centripetal force?
2. In which direction does centripetal force act?
3. Why is a resultant force required for circular motion?
4. What effect does centripetal force have on the direction of velocity?
5. What would happen to an object moving in a circle if the centripetal force disappeared?
6. Why is centripetal force directed towards the centre of the circle?

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 inertial mass?
2. What does inertial mass measure?
3. How does greater inertial mass affect the difficulty of changing an object's velocity?
4. How is inertial mass defined using force and acceleration?
5. What is the equation for inertial mass?
6. How can inertial mass be determined experimentally using measurements of force and acceleration?

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. What does Newton's third law state?
2. What are the key features of a Newton's third-law pair of forces?
3. How does Newton's third law apply to objects in equilibrium?
4. How does Newton's third law apply when two objects collide?
5. What happens to total momentum before and after an isolated collision?
6. How is Newton's third law related to conservation of momentum in collisions?

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) $p = m \times v$

1. What is momentum?
2. What is the equation for momentum?
3. What is the SI unit for momentum?
4. What happens to momentum if mass doubles while velocity remains constant?
5. What happens to momentum if velocity doubles while mass remains constant?
6. What is the momentum of a 5 kg object travelling at 4 m/s?

2.25 Describe examples of momentum in collisions

1. What happens to the momentum of objects involved in a collision?
2. What is meant by conservation of momentum in a collision?
3. How can momentum be transferred between objects during a collision?
4. What happens to total momentum before and after an isolated collision?
5. How can the motion of two colliding objects demonstrate conservation of momentum?
6. Why is momentum important when analysing vehicle collisions?

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

1. How can Newton's second law be expressed in terms of change in momentum?
2. What is the equation relating force, change in momentum and time?
3. What does $mv - mu$ represent?
4. What happens to force for a fixed change in momentum if the time taken increases?
5. What force acts when momentum changes by 60 kg m/s in 3 s?
6. What is the SI unit of force when calculated using change in momentum and time?

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

1. What is meant by human reaction time?
2. How can a ruler-drop experiment be used to measure reaction time?
3. What measurement is taken in a ruler-drop reaction-time experiment?
4. How can a computer-based test measure human reaction time?
5. What factors can affect a person's reaction time?
6. What is a typical order of magnitude for human reaction time?

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 stopping distance?
2. What two distances make up the stopping distance of a vehicle?
3. What is thinking distance?
4. What is braking distance?
5. How is stopping distance calculated from thinking distance and braking distance?
6. Why does a vehicle continue travelling during the driver's reaction time?

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 the mass of a vehicle affect its stopping distance?
2. How does the speed of a vehicle affect its stopping distance?

3. How does a driver's reaction time affect stopping distance?
4. How can the condition of a vehicle's brakes affect stopping distance?
5. How can the condition of the road affect stopping distance?
6. How does friction between the tyres and road surface affect stopping distance?

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 tiredness affect a driver's reaction time?
3. How can distractions affect a driver's reaction time?
4. How can drugs affect a driver's reaction time?
5. Why does an increased reaction time increase thinking distance?
6. Why can distractions while driving increase the risk of a collision?

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

1. What is meant by a large deceleration?
2. Why can large decelerations be dangerous to vehicle occupants?
3. How does deceleration affect the force experienced by an object?
4. How can Newton's second law be used to estimate the force during rapid deceleration?
5. Why do vehicle safety features aim to reduce the deceleration experienced by passengers?
6. What quantities are needed to estimate the force acting during a vehicle's deceleration?

2.32P Estimate how the distance required for a road vehicle to stop in an emergency varies over a range of typical speeds

1. What two components make up a vehicle's total stopping distance?
2. How does thinking distance change as vehicle speed increases if reaction time is constant?
3. How does braking distance change as vehicle speed increases?
4. Why does stopping distance increase significantly at higher speeds?
5. How can stopping-distance data be used to estimate stopping distance at different speeds?
6. What factors should be considered when estimating the stopping distance of a road vehicle in an emergency?

2.33P Carry out calculations on work done to show the dependence of braking distance for a vehicle on initial velocity squared (work done to bring a vehicle to rest equals its initial kinetic energy)

1. What type of energy does a moving vehicle have because of its motion?
2. How does a vehicle's kinetic energy depend on its initial velocity?
3. What happens to the kinetic energy when a vehicle's initial velocity is doubled?
4. How is the work done to bring a vehicle to rest related to its initial kinetic energy?
5. How does braking distance depend on the initial velocity squared?
6. Why does a vehicle travelling at a higher initial velocity require a greater braking distance?

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 is the equation for calculating a change in gravitational potential energy?
2. What are the units of gravitational potential energy, mass, gravitational field strength and height?
3. A 5 kg object is raised by 4 m where g = 10 N/kg. What is its increase in gravitational potential energy?
4. A 20 kg object gains 600 J of gravitational potential energy when raised through 3 m. What is the gravitational field strength?
5. An object gains 1,500 J of gravitational potential energy when raised 5 m in a gravitational field of 10 N/kg. What is its mass?
6. A 2 kg object is raised through 8 m where g = 10 N/kg. What is its change in gravitational potential energy?

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 is the equation for kinetic energy?

2. What quantities are needed to calculate the kinetic energy of a moving object?
3. What is the kinetic energy of a 4 kg object travelling at 5 m/s?
4. What is the kinetic energy of a 1,000 kg car travelling at 10 m/s?
5. A 2 kg object has a kinetic energy of 100 J. What is its speed?
6. What happens to the kinetic energy of an object when its speed is doubled?

3.3 Draw and interpret diagrams to represent energy transfers

1. What is an energy transfer diagram used to represent?
2. What do arrows represent in an energy transfer diagram?
3. What is meant by a useful energy transfer?
4. What is meant by a wasted or dissipated energy transfer?
5. How could an energy transfer diagram represent the energy transfers in an electric kettle?
6. How can an energy transfer diagram show where energy is dissipated?

3.4 Explain what is meant by conservation of energy

1. What does conservation of energy mean?
2. Can energy be created or destroyed?
3. What happens to the total amount of energy during an energy transfer?
4. What happens to energy when it is described as being wasted?
5. Why does calling energy "wasted" not mean that the energy has been destroyed?
6. How does conservation of energy apply to a moving object that eventually comes to rest?

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 energy store increases when an object is projected upwards?
2. What energy transfers occur when a moving object hits an obstacle?
3. What happens to the energy stores of an object being accelerated by a constant force?
4. What happens to the kinetic energy store of a vehicle as it slows down?
5. What energy transfer occurs when an electric kettle brings water to its boiling point?

6. How is energy conserved when a vehicle slows down and its kinetic energy decreases?

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?
2. What happens to the total energy in a closed system during an energy transfer?
3. Why is there no net change in the total energy of a closed system?
4. How can energy be transferred within a closed system without changing the total energy?
5. What happens to the total energy of a closed system when some energy is dissipated?
6. Why does energy dissipation not violate conservation of energy?

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?
2. How does friction cause energy to be dissipated?
3. What happens to the temperature of surfaces when friction occurs?
4. What energy store increases when friction heats the surroundings?
5. Why does a rise in temperature indicate that energy has been dissipated?
6. How can friction make a mechanical process less efficient?

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 energy being dissipated?
2. In what form is energy commonly dissipated to the surroundings?
3. How is energy dissipated when a moving object slows down due to friction?
4. How can energy be dissipated by an electrical device?
5. Why is dissipated energy described as being stored in a less useful way?
6. Give an example of a system change in which energy is dissipated to the surroundings.

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

1. How does lubrication reduce unwanted energy transfer?
2. Why does lubrication reduce energy dissipation caused by friction?

3. How does thermal insulation reduce unwanted energy transfer?
4. Why are walls of buildings often fitted with insulating materials?
5. How can double glazing reduce unwanted thermal energy transfer?
6. Why can reducing unwanted energy transfers increase the efficiency of a system?

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 wall affect the rate of cooling?
3. Why do materials with low thermal conductivity reduce the rate of cooling?
4. Why does a thicker wall generally reduce the rate of thermal energy transfer?
5. Which would cool more slowly: a building with thick, low-conductivity walls or thin, high-conductivity walls?
6. How does thermal conductivity affect the suitability of a material for building insulation?

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

1. What is the equation for efficiency?
2. What is meant by useful energy transferred by a device?
3. What is meant by total energy supplied to a device?
4. A device receives 500 J of energy and transfers 400 J usefully. What is its efficiency?
5. A device has an efficiency of 0.75 and receives 800 J of energy. How much useful energy does it transfer?
6. A device transfers 300 J of useful energy from 600 J supplied. What is its efficiency 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 reducing unwanted energy transfers increase efficiency?
3. How can lubrication increase the efficiency of a mechanical system?
4. How can thermal insulation increase the efficiency of a system?
5. Why does reducing energy dissipated to the surroundings increase efficiency?
6. A device becomes more efficient without changing the total energy supplied. What must happen to the useful energy transferred?

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 classified as non-renewable?
4. Why are wind, hydroelectric, tidal and solar energy classified as renewable?
5. What is one advantage and one disadvantage of using fossil fuels to generate electricity?
6. How does nuclear fuel differ from renewable energy sources in terms of its availability?

3.14 Explain patterns and trends in the use of energy resources

1. What factors can affect the amount of energy obtained from different energy resources?
2. Why can the use of renewable energy resources increase over time?
3. Why might the use of fossil fuels decrease over time?
4. How can technological developments affect the use of energy resources?
5. How can government policies influence patterns in energy-resource use?
6. Why might different countries have different patterns of energy-resource use?

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. Do waves transfer matter from one place to another?
3. How can a wave transfer energy without transferring matter?
4. How can waves be used to transfer information?
5. What happens to the matter through which a wave travels?
6. Give one example of a wave transferring energy without transferring matter.

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

1. What happens to a floating object as a water wave passes it?
2. What does the motion of a floating object show about whether water is transported by a wave?
3. What evidence shows that air itself does not travel from a sound source to a listener?
4. What happens to air particles as a sound wave passes through them?
5. Why does the movement of water particles provide evidence that water waves transfer energy rather than water?
6. How does the motion of air particles in a sound wave demonstrate that the wave travels rather than the air itself?

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 SI unit for frequency?
3. What is meant by the wavelength of a wave?
4. What symbol is commonly used for wavelength?
5. What does a higher frequency mean about the number of waves passing a point each second?
6. How is wavelength measured on a transverse wave?

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 wave velocity?
4. What is a wavefront?
5. What is the relationship between the period and frequency of a wave?
6. How does the amplitude of a wave relate to the maximum displacement from its equilibrium position?

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 a longitudinal wave and a transverse wave?
2. In which direction do particles vibrate compared with the direction of travel in a longitudinal wave?
3. In which direction do particles vibrate compared with the direction of travel in a transverse wave?
4. What type of wave is sound in air?

5. What type of wave are electromagnetic waves?
6. How can seismic and water waves demonstrate transverse and longitudinal wave behaviour?

4.6 Recall and use both the equations below for all waves: wave speed (metre/second, m/s) = frequency (hertz, Hz) × wavelength (metre, m) $v = f \times \lambda$; wave speed (metre/second, m/s) = distance (metre, m) ÷ time (second, s) $v = x \div t$

1. What is the equation linking wave speed, frequency and wavelength?
2. What is the equation linking wave speed, distance and time?
3. A wave has a frequency of 5 Hz and a wavelength of 2 m. What is its speed?
4. A wave travels at 300 m/s and has a frequency of 150 Hz. What is its wavelength?
5. A wave travels 120 m in 4 s. What is its speed?
6. A wave has a speed of 20 m/s and a wavelength of 4 m. What is its frequency?

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

1. How can the velocity of sound in air be measured experimentally?
2. What measurements are needed to calculate the velocity of sound?
3. How can the velocity of ripples on a water surface be measured?
4. How can a known distance and measured time be used to calculate wave velocity?
5. Why can a large distance between two microphones improve the measurement of the speed of sound?
6. What equipment could be used to measure the wavelength of ripples on a water surface?

4.8P Calculate depth or distance from time and wave velocity

1. What equation can be used to calculate distance from wave velocity and time?
2. A wave travels at 1,500 m/s for 2 s. What distance does it travel?
3. A sound wave travels at 340 m/s for 0.5 s. What distance does it travel?
4. A wave travels 600 m at 300 m/s. How long does the journey take?
5. An echo returns 0.4 s after a sound pulse is emitted. If the sound speed is 340 m/s, what total distance does the sound travel?
6. An echo takes 0.6 s to return from the seabed. If sound travels through water at 1,500 m/s, what is the depth of the water?

4.9P Describe the effects of a reflection b refraction c transmission d absorption of waves at material interfaces

1. What happens to a wave during reflection?
2. What happens to a wave during refraction?
3. What happens to a wave during transmission?
4. What happens to a wave during absorption?
5. What happens to the direction of a wave when it is reflected?
6. What happens to the energy of a wave when it is absorbed by a material?

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

1. What happens to the speed of a wave when it enters a different medium?
2. Why does a wave change direction when it is refracted?
3. What happens to the direction of a wave entering a medium where its speed decreases?
4. What happens to the direction of a wave entering a medium where its speed increases?
5. What happens to the frequency of a wave when it crosses a boundary between two media?
6. How are changes in wave speed and direction related during refraction?

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

1. What does it mean for a material to absorb a wave?
2. What does it mean for a material to transmit a wave?
3. What does it mean for a material to reflect a wave?
4. What does it mean for a material to refract a wave?
5. Why can the same material interact differently with waves of different wavelengths?
6. How can wavelength affect whether a wave is absorbed or transmitted by a substance?

4.12P Describe the processes which convert wave disturbances between sound waves and vibrations in solids, and a explain why such processes only work over a limited frequency range b use this to explain the way the human ear works

1. How can a sound wave cause vibrations in a solid?
2. How can vibrations in a solid produce sound waves?

3. Why do processes converting sound waves into vibrations only work over a limited frequency range?
4. What part of the human ear vibrates in response to sound waves?
5. How are vibrations in the eardrum transferred through the middle ear?
6. How does the human ear convert sound vibrations into signals that can be processed by the brain?

4.13P Recall that sound with frequencies greater than 20 000 hertz, Hz, is known as ultrasound

1. What is ultrasound?
2. What frequency range defines ultrasound?
3. Is a sound wave with a frequency of 25,000 Hz ultrasound?
4. Is a sound wave with a frequency of 15,000 Hz ultrasound?
5. What is the minimum frequency required for a sound wave to be classified as ultrasound?
6. Why can humans not normally hear ultrasound?

4.14P Recall that sound with frequencies less than 20 hertz, Hz, is known as infrasound

1. What is infrasound?
2. What frequency range defines infrasound?
3. Is a sound wave with a frequency of 10 Hz infrasound?
4. Is a sound wave with a frequency of 25 Hz infrasound?
5. What is the maximum frequency for a sound wave to be classified as infrasound?
6. Why can humans not normally hear infrasound?

4.15P Explain uses of ultrasound and infrasound, including a sonar b foetal scanning c exploration of the Earth's core

1. How is ultrasound used in sonar?
2. How can ultrasound be used to produce images during foetal scanning?
3. Why is ultrasound suitable for foetal scanning?
4. How can infrasound provide information about the Earth's interior?
5. Why can seismic waves be useful for exploring the Earth's core?
6. How can the reflection or refraction of waves provide information about structures inside the Earth?

4.16P Describe how changes, if any, in velocity, frequency and wavelength, in the transmission of sound waves from one medium to another are inter-related

1. What happens to the speed of a sound wave when it enters a different medium?
2. What happens to the frequency of a sound wave when it enters a different medium?
3. What happens to the wavelength of a sound wave when its speed changes but its frequency remains constant?
4. Which equation links wave speed, frequency and wavelength?
5. A sound wave enters a medium where its speed increases while its frequency remains constant. What happens to its wavelength?
6. A sound wave has a frequency of 500 Hz and a speed of 340 m/s. What is 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 measurements are needed to calculate the speed of a wave?
2. How can the frequency of a wave be measured experimentally?
3. How can the wavelength of a wave be measured?
4. How can the equation $v = f \times \lambda$ be used to determine wave speed?
5. What equipment could be used to investigate waves travelling through a solid?
6. What equipment could be used to investigate waves travelling through a fluid?

Topic 5 – Light and the electromagnetic spectrum

5.1P Explain, with the aid of ray diagrams, reflection, refraction and total internal reflection (TIR), including the law of reflection and critical angle

1. What is reflection of light?
2. What is refraction of light?
3. What is the law of reflection?
4. What is meant by the critical angle?
5. What two conditions are required for total internal reflection to occur?
6. What happens to a ray of light when it travels from a higher refractive index medium to a lower refractive index medium at an angle greater than the critical angle?

5.2P Explain the difference between specular and diffuse reflection

1. What is specular reflection?
2. What is diffuse reflection?
3. How do the surfaces involved in specular and diffuse reflection differ?
4. Why does a smooth surface produce specular reflection?
5. Why does a rough surface produce diffuse reflection?
6. How do the reflected rays differ between specular and diffuse reflection?

5.3P Explain how colour of light is related to a differential absorption at surfaces b transmission of light through filters

1. Why does an object appear to have a particular colour under white light?
2. How can differential absorption at a surface affect the colour of an object?
3. What happens to different wavelengths of light when white light passes through a coloured filter?
4. Why does a red filter transmit mainly red light?
5. What happens to wavelengths that are absorbed by a coloured filter?
6. Why does the colour seen through a filter depend on the wavelengths it transmits?

5.4P Relate the power of a lens to its focal length and shape

1. What is meant by the power of a lens?
2. What is the relationship between the power and focal length of a lens?
3. What is the equation for the power of a lens?
4. What is the power of a lens with a focal length of 0.5 m?
5. What is the focal length of a lens with a power of 4 dioptres?
6. How does the shape of a lens affect its power?

5.5P Use ray diagrams to show the similarities and differences in the refraction of light by converging and diverging lenses

1. What does a converging lens do to parallel rays of light?
2. What does a diverging lens do to parallel rays of light?
3. Where do parallel rays converge after passing through a converging lens?
4. How do rays appear to behave after passing through a diverging lens?
5. What is the main difference between the ray diagrams for converging and diverging lenses?
6. What happens to a ray travelling through the optical centre of a thin lens?

5.6P Explain the effects of different types of lens in producing real and virtual images

1. What is a real image?
2. What is a virtual image?
3. Which type of lens can produce both real and virtual images depending on the object's position?
4. What type of image is normally produced by a diverging lens?
5. Can a real image be formed on a screen?
6. How does the position of an object affect the type of image formed by a converging lens?

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 the speed of electromagnetic waves in a vacuum?
3. Do all electromagnetic waves travel at the same speed in a vacuum?
4. How are vibrations oriented compared with the direction of travel in a transverse wave?
5. Do electromagnetic waves require a medium to travel through a vacuum?
6. Why can electromagnetic waves travel through empty space?

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

1. What do electromagnetic waves transfer from a source to an observer?
2. How does visible light transfer energy from the Sun to Earth?
3. How do infrared waves transfer energy from a warm object?
4. How do microwaves transfer energy to food?
5. How can gamma rays transfer energy to cells in the body?
6. Why can electromagnetic waves transfer energy through a vacuum?

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

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

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 is the correct order of the electromagnetic spectrum from lowest to highest frequency?
2. Which electromagnetic wave has the longest wavelength?
3. Which electromagnetic wave has the highest frequency?
4. What are the colours of visible light in order from longest to shortest wavelength?
5. Which region of the electromagnetic spectrum lies between microwaves and visible light?
6. Which region of the electromagnetic spectrum lies between ultraviolet and gamma rays?

5.11 Describe the electromagnetic spectrum as continuous from radio waves to gamma rays and that the radiations within it can be grouped in order of decreasing wavelength and increasing frequency

1. What does it mean that the electromagnetic spectrum is continuous?
2. In what order does wavelength decrease across the electromagnetic spectrum?
3. In what order does frequency increase across the electromagnetic spectrum?
4. Which has the greater frequency: infrared or ultraviolet?
5. Which has the longer wavelength: microwaves or visible light?
6. What happens to frequency as wavelength decreases across the electromagnetic spectrum?

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

1. Which region of the electromagnetic spectrum can human eyes detect?
2. Why can humans not normally see infrared radiation?
3. Why can humans not normally see ultraviolet radiation?
4. What is meant by the visible region of the electromagnetic spectrum?
5. How does the visible range compare with the full electromagnetic spectrum?
6. Why is visible light only a small part of the electromagnetic spectrum?

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

1. What does it mean for a substance to absorb electromagnetic radiation?
2. What does it mean for a substance to transmit electromagnetic radiation?
3. What does it mean for a substance to reflect electromagnetic radiation?
4. What does it mean for a substance to refract electromagnetic radiation?
5. Why can a substance interact differently with electromagnetic waves of different wavelengths?
6. Why might a material transmit visible light but absorb infrared radiation?

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

1. What happens to the speed of an electromagnetic wave when it enters a different substance?
2. Why can an electromagnetic wave be refracted when it enters a different substance?
3. What happens to the direction of an electromagnetic wave when its speed changes at a boundary?
4. Does the frequency of an electromagnetic wave change when it enters a different medium?
5. What happens to wavelength when the speed of an electromagnetic wave decreases but frequency remains constant?
6. Why does a difference in wave speed between two substances cause refraction?

5.15P Explain that all bodies emit radiation, that the intensity and wavelength distribution of any emission depends on their temperature

1. What type of radiation is emitted by all bodies?
2. What happens to the intensity of emitted radiation as an object's temperature increases?
3. How does temperature affect the wavelengths of radiation emitted by an object?
4. Which emits more thermal radiation: a hot object or a cooler object?
5. How does the wavelength distribution of radiation change as an object's temperature increases?
6. Why can thermal imaging detect differences in the temperatures of objects?

5.16P Explain that for a body to be at a constant temperature it needs to radiate the same average power that it absorbs

1. What condition must be met for an object to remain at a constant temperature?
2. What happens when the average power radiated by an object equals the average power absorbed?
3. What happens to an object's temperature if it absorbs more power than it radiates?
4. What happens to an object's temperature if it radiates more power than it absorbs?
5. Why does a constant-temperature object have no net change in its energy?
6. How is the balance between absorbed and emitted radiation related to temperature?

5.17P Explain what happens to a body if the average power it radiates is less or more than the average power that it absorbs

1. What happens to the temperature of a body if it absorbs more power than it radiates?
2. What happens to the temperature of a body if it radiates more power than it absorbs?
3. What happens when absorbed and radiated powers are equal?
4. Why does a body warm up when its absorbed power is greater than its emitted power?
5. Why does a body cool down when its emitted power is greater than its absorbed power?
6. What happens to the temperature of a body when the difference between absorbed and emitted power is zero?

5.18P Explain how the temperature of the Earth is affected by factors controlling the balance between incoming radiation and radiation emitted

1. What are the main sources of incoming radiation reaching Earth?
2. What happens to Earth's temperature when incoming radiation increases while emitted radiation remains constant?
3. What happens to Earth's temperature when emitted radiation increases while incoming radiation remains constant?
4. How can changes in Earth's atmosphere affect the balance between incoming and outgoing radiation?
5. Why does Earth reach a stable average temperature when incoming and emitted radiation are balanced?

6. How can an increase in absorbed radiation affect Earth's average temperature?

5.19P Core Practical: Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed

1. How does the nature of a surface affect thermal radiation?
2. Which type of surface is generally a better emitter of infrared radiation: dull or shiny?
3. Which type of surface is generally a better absorber of infrared radiation: dull or shiny?
4. What equipment could be used to compare the thermal radiation emitted by different surfaces?
5. What variables should be controlled when comparing the thermal radiation from different surfaces?
6. How could the results of this practical be used to compare the emissivity of different surfaces?

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 or ultraviolet radiation?
3. Which is potentially more dangerous: visible light or x-rays?
4. Which electromagnetic waves have the highest frequencies?
5. Why can high-frequency electromagnetic radiation be more damaging to living cells?
6. Which is potentially more dangerous: microwaves or gamma rays?

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

6. How can excessive exposure to gamma rays affect cells in the body?

5.22 Describe some uses of electromagnetic radiation a radio waves: including broadcasting, communications and satellite transmissions b microwaves: including cooking, communications and satellite transmissions c infrared: including cooking, thermal imaging, short range communications, optical fibres, television remote controls and security systems d visible light: including vision, photography and illumination e ultraviolet: including security marking, fluorescent lamps, detecting forged bank notes and disinfecting water f x-rays: including observing the internal structure of objects, airport security scanners and medical x-rays g gamma rays: including sterilising food and medical equipment, and the detection of cancer and its treatment

1. What are radio waves used for in broadcasting and communications?
2. What are microwaves used for in cooking and satellite communications?
3. What are infrared waves used for in thermal imaging and television remote controls?
4. What are some uses of visible light?
5. What are ultraviolet waves used for in security marking and disinfecting water?
6. What are x-rays and gamma rays used for in medicine and security?

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?
2. What happens in an electrical circuit when radio waves induce oscillations?
3. What type of motion in an electrical circuit can produce radio waves?
4. How can an oscillating electrical current produce electromagnetic radiation?
5. How can radio waves cause oscillations in an electrical circuit?
6. Why are oscillating electrical charges important in the production and detection of radio waves?

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 atomic nuclei generate electromagnetic radiation?
3. What determines the frequency of radiation produced by changes in atoms or nuclei?
4. How can atoms absorb electromagnetic radiation?
5. How can nuclei be affected by the absorption of electromagnetic radiation?
6. Why can changes in atoms and nuclei produce or absorb radiation across a wide range of frequencies?

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 particles surround the nucleus?
4. How does the radius of the nucleus compare with the radius of the atom?
5. Where is almost all of the mass of an atom concentrated?
6. Why is an atom overall electrically neutral when it contains equal numbers of protons 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 radius of an atom?
2. What is the approximate size of an atom in metres?
3. What is meant by the order of magnitude of a measurement?
4. How does the size of an atom compare with everyday objects?
5. What is the approximate order of magnitude of the size of a small molecule?
6. Why are atoms and small molecules described as being extremely small?

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 a nucleus be calculated from its mass number and atomic number?
4. How many protons and neutrons are in a carbon-13 nucleus, ${}^{13}_{6}C$?
5. What information does the symbol ${}^{23}_{11}Na$ provide about a sodium nucleus?
6. How are isotopes represented using atomic number and mass number?

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 number of protons?
3. What is an isotope?
4. How do isotopes of the same element differ?
5. Why do isotopes of the same element have different masses?
6. How many neutrons are in carbon-12 and carbon-14?

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

1. What is the relative mass and relative charge of a proton?
2. What is the relative mass and relative charge of a neutron?
3. What is the relative mass and relative charge of an electron?
4. What is the relative mass and relative charge of a positron?
5. Which has approximately the same mass as an electron but opposite charge?
6. Which of the proton, neutron, electron and positron has zero electric charge?

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 8 protons?
4. How many protons are present in a neutral atom with 17 electrons?
5. What happens to the electrical neutrality of an atom if it loses an electron?
6. What happens to the electrical neutrality of an atom if it gains an electron?

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

1. What do electrons do around the nucleus?
2. What determines the set distances at which electrons orbit the nucleus?
3. Are all electrons in an atom at the same distance from the nucleus?
4. What is meant by an electron shell?
5. Where are the electrons with the lowest energy generally found?
6. How does the distance of an electron from the nucleus relate to its energy level?

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?
2. What happens to an electron when an atom emits electromagnetic radiation?
3. Why does an electron move to a higher energy level when it absorbs energy?
4. Why does an electron emit electromagnetic radiation when moving to a lower energy level?
5. What determines the frequency of electromagnetic radiation emitted by an electron?
6. How is electromagnetic radiation involved in changes between electron energy levels?

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

1. What is a positive ion?
2. How can an atom become a positive ion?
3. Why does losing an electron give an atom a positive charge?
4. Which electrons are most likely to be lost when an atom forms a positive ion?
5. What happens to the number of protons when an atom loses an electron?
6. What charge does an atom have after losing two electrons?

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 type of nucleus emits radioactive radiation?
2. Which five types of radiation can be emitted from unstable nuclei?
3. What is emitted during beta minus decay?
4. What is emitted during beta plus decay?

5. Is it possible to predict exactly when a particular unstable nucleus will decay?
6. Why is radioactive decay described as a random process?

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

1. What is ionising radiation?
2. Which four types of radiation in the specification are ionising?
3. Is alpha radiation ionising?
4. Is gamma radiation ionising?
5. What happens to an atom when ionising radiation passes through it?
6. Why can ionising radiation damage living tissue?

6.12 Explain what is meant by background radiation

1. What is background radiation?
2. Where is background radiation found?
3. Is background radiation present even when no radioactive source has deliberately been introduced?
4. Why must background radiation be considered when measuring radioactivity?
5. Why is background radiation described as being present all around us?
6. How can background radiation affect measurements made using a Geiger–Müller tube?

6.13 Describe the origins of background radiation from Earth and space

1. What are the two broad origins of background radiation?
2. How do rocks and soil contribute to background radiation?
3. What are cosmic rays?
4. How can radioactive substances in buildings contribute to background radiation?
5. How does radiation from space reach Earth?
6. Why can the level of background radiation vary between different locations?

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 ionising 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. What does a Geiger–Müller tube produce when ionising radiation enters it?
5. How can a Geiger counter be used to measure the activity of a radioactive source?
6. Why should background radiation be measured when using a Geiger–Müller tube?

6.15 Recall that an alpha particle is equivalent to a helium nucleus, a beta particle is an electron emitted from the nucleus and a gamma ray is electromagnetic radiation

1. What is an alpha particle?
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 originate?
5. What type of radiation is a gamma ray?
6. How does the composition of an alpha particle differ from that of a beta particle?

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 is the most strongly ionising?
2. Which of alpha, beta and gamma radiation is the most penetrating?
3. What material can be used to stop alpha radiation?
4. What material can be used to reduce the intensity of beta radiation?
5. Why can gamma radiation penetrate much further than alpha radiation?
6. How are the ionising and penetrating abilities of alpha, beta and gamma radiation related?

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 an atom?
2. What did Rutherford's alpha particle scattering experiment provide evidence for?
3. What did Rutherford's model propose about the nucleus?
4. What observation from Rutherford's experiment showed that the nucleus was very small?
5. What did Bohr add to the nuclear model of the atom?

6. Why did experimental evidence cause scientists to change the atomic model?

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 emitted during beta minus decay?
3. What happens to the number of protons during beta minus decay?
4. What happens to the number of neutrons during beta minus decay?
5. What happens to the mass number during beta minus decay?
6. What happens to the atomic number during beta minus decay?

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 emitted during beta plus decay?
3. What happens to the number of protons during beta plus decay?
4. What happens to the number of neutrons during beta plus decay?
5. What happens to the mass number during beta plus decay?
6. What happens to the atomic number during beta plus decay?

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 atomic number and mass number during alpha decay?
2. What happens to the atomic number and mass number during beta minus decay?
3. What happens to the atomic number and mass number during beta plus decay?
4. What happens to the atomic number and mass number during gamma emission?
5. What happens to the mass number when a neutron is emitted from a nucleus?
6. What happens to the atomic number when a neutron is emitted from a nucleus?

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 radioactive decay?
2. What is meant by nuclear rearrangement?
3. What type of radiation can be emitted when an excited nucleus loses energy?
4. What happens to the energy of a nucleus when gamma radiation is emitted?
5. Does gamma emission change the number of protons in the nucleus?
6. Does gamma emission change the mass number of the nucleus?

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

1. What must be conserved when balancing a nuclear equation?
2. What happens to the mass number during alpha decay?
3. What happens to the atomic number during beta minus decay?
4. Complete the nuclear equation: $^{238}_{92}U \rightarrow {}^{234}_{90}Th + ?$
5. Complete the nuclear equation: $^{14}_{6}C \rightarrow {}^{14}_{7}N + ?$
6. Complete the nuclear equation: $^{22}_{11}Na \rightarrow {}^{22}_{10}Ne + ?$

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 over time?
2. Why does the activity of a radioactive source decrease?
3. What happens to the number of undecayed nuclei as time passes?
4. What type of curve is produced when activity is plotted against time for radioactive decay?
5. Does radioactive activity decrease at a constant rate?
6. How is the decrease in activity related to the number of radioactive nuclei remaining?

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

1. What is the SI unit of radioactive activity?
2. What symbol is used for the Becquerel?
3. What does one Becquerel represent?
4. What does an activity of 500 Bq mean?
5. Which source has the greater activity: 200 Bq or 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 a graph of activity against time?
3. What happens to the activity of a source after one half-life?
4. What fraction of the original undecayed nuclei remains after one half-life?
5. A radioactive source has an activity of 800 Bq. What is its activity after one half-life?
6. Why does the half-life remain constant for a particular radioactive isotope?

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 unstable nucleus decays be predicted?
2. Why is radioactive decay described as random?
3. What does half-life allow scientists to predict?
4. Why can the behaviour of a large number of radioactive nuclei be predicted even though individual decays are random?
5. How does half-life help predict the activity of a radioactive sample?
6. Why are predictions based on half-life more reliable for larger samples?

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 source has an activity of 640 Bq. What will its activity be after one half-life?
2. A source has an activity of 800 Bq and a half-life of 5 years. What will its activity be after 15 years?
3. A radioactive sample has 1,600 undecayed nuclei. How many remain after three half-lives?
4. A radioactive source decreases from 1,200 Bq to 150 Bq. How many half-lives have elapsed?
5. A source has a half-life of 4 hours. How long will it take for its activity to decrease from 400 Bq to 50 Bq?
6. How can the half-life of a radioactive isotope be determined from an activity-time graph?

6.28P Describe uses of radioactivity, including: a household fire (smoke) alarms b irradiating food c sterilisation of equipment d tracing and gauging thicknesses e diagnosis and treatment of cancer

1. How is radioactivity used in household smoke alarms?
2. How can radioactive radiation be used to irradiate food?
3. How can radioactivity be used to sterilise medical equipment?
4. How can radioactive sources be used to measure or gauge the thickness of materials?
5. How can radioactive tracers be used in medicine?
6. How can radioactivity be used in the diagnosis and treatment of cancer?

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

1. How can ionising radiation damage living tissue?
2. How can ionising radiation cause mutations?
3. Why can mutations caused by ionising radiation be harmful?
4. Why should exposure to ionising radiation be kept as low as reasonably possible?
5. What precautions can reduce exposure to ionising radiation?
6. How does reducing exposure time reduce the risk from ionising radiation?

6.30P Explain how the dangers of ionising radiation depend on half-life and relate this to the precautions needed

1. How does the half-life of a radioactive source affect the duration of its hazard?
2. Why can a long-half-life source remain hazardous for a long period?
3. Why can a short-half-life source have a high activity initially?
4. How does the half-life of a source affect decisions about handling and storage?
5. Why might a radioactive source with a long half-life require long-term precautions?
6. How can knowledge of half-life help determine appropriate safety precautions?

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 must exposure to ionising radiation be limited?
2. How can exposure time be reduced when working with radioactive sources?
3. How can distance from a radioactive source reduce exposure?
4. How can shielding reduce exposure to ionising radiation?
5. Why must medical patients receive only the necessary radiation dose?
6. Why are medical personnel particularly careful to minimise repeated exposure to 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. What is the difference between contamination and irradiation?
4. Why can contamination continue to expose a person after they leave the source?
5. Why does irradiation not necessarily leave radioactive material on a person?
6. Which can be particularly difficult to remove: contamination or irradiation?

6.33P Compare and contrast the treatment of tumours using radiation applied internally or externally

1. How can radiation be used to treat a tumour externally?
2. How can radiation be applied internally to treat a tumour?
3. What is the advantage of directing radiation externally at a tumour?
4. What is the advantage of placing a radioactive source close to or inside a tumour?
5. Why is it important to minimise radiation exposure to healthy tissue during cancer treatment?
6. What is the main difference between internal and external radiotherapy?

6.34P Explain some of the uses of radioactive substances in diagnosis of medical conditions, including PET scanners and tracers

1. What is a radioactive tracer?
2. Why are radioactive tracers useful in medical diagnosis?
3. What does a PET scanner detect?
4. Why are radioactive substances used in PET scans?
5. How can radioactive tracers show the function of organs or tissues?

6. Why must the radioactive substance used as a tracer be carefully selected?

6.35P Explain why isotopes used in PET scanners have to be produced nearby

1. Why do PET isotopes need to be produced close to where they are used?
2. How does the half-life of a PET isotope affect its transportation?
3. What happens to the activity of a PET isotope while it is being transported?
4. Why would a very long transport time be unsuitable for many PET isotopes?
5. Why must PET isotopes be produced shortly before they are needed?
6. How does radioactive decay limit the useful lifetime of isotopes used in PET scanners?

6.36P Evaluate the advantages and disadvantages of nuclear power for generating electricity, including the lack of carbon dioxide emissions, risks, public perception, waste disposal and safety issues

1. What is one advantage of nuclear power in terms of carbon dioxide emissions during electricity generation?
2. What is one disadvantage of nuclear power related to radioactive waste?
3. What safety risks are associated with nuclear power stations?
4. How can public perception affect the development of nuclear power?
5. Why does nuclear waste require careful long-term management?
6. How can nuclear power be evaluated against fossil fuels and renewable energy sources?

6.37P Recall that nuclear reactions, including fission, fusion and radioactive decay, can be a source of energy

1. What is nuclear fission?
2. What is nuclear fusion?
3. How can radioactive decay release energy?
4. Which nuclear process powers stars?
5. Which nuclear process is used in current nuclear power stations?
6. Why can changes in atomic nuclei release large amounts of energy?

6.38P Explain how the fission of U-235 produces two daughter nuclei and the emission of two or more neutrons, accompanied by a release of energy

1. What happens to a U-235 nucleus during fission?

2. What causes a U-235 nucleus to undergo fission in a nuclear reactor?
3. What is produced when a U-235 nucleus undergoes fission?
4. How many neutrons are typically emitted during the fission of U-235?
5. Why is energy released during nuclear fission?
6. How can the emitted neutrons lead to further fission reactions?

6.39P Explain the principle of a controlled nuclear chain reaction

1. What is a nuclear chain reaction?
2. How can one fission reaction lead to further fission reactions?
3. What role do neutrons play in a nuclear chain reaction?
4. What is meant by a controlled chain reaction?
5. Why must the rate of fission be controlled in a nuclear reactor?
6. What could happen if a chain reaction were not properly controlled?

6.40P Explain how the chain reaction is controlled in a nuclear reactor, including the action of moderators and control rods

1. What is the purpose of a moderator in a nuclear reactor?
2. How does a moderator affect the speed of neutrons?
3. What is the purpose of control rods?
4. How do control rods control the rate of the nuclear chain reaction?
5. What happens to the chain reaction when control rods are inserted further into the reactor?
6. Why must the moderator and control rods work together to control the reaction?

6.41P Describe how thermal (heat) energy from the chain reaction is used in the generation of electricity in a nuclear power station

1. What form of energy is released by the nuclear chain reaction?
2. How is thermal energy transferred from the reactor to water or another coolant?
3. How is steam produced in a nuclear power station?
4. What does the steam cause to rotate?
5. How does a turbine generate mechanical energy?
6. How is the turbine's mechanical energy converted into electrical energy?

6.42P Recall that the products of nuclear fission are radioactive

1. What happens to the daughter nuclei produced by nuclear fission?
2. Why are many fission products radioactive?
3. Why do radioactive fission products require careful handling?
4. What type of radiation can radioactive fission products emit?

5. Why must radioactive fission waste be stored safely?
6. How does the radioactivity of fission products change over time?

6.43P Describe nuclear fusion as the creation of larger nuclei resulting in a loss of mass from smaller nuclei, accompanied by a release of energy, and recognise fusion as the energy source for stars

1. What is nuclear fusion?
2. What happens to smaller nuclei during fusion?
3. Why is mass lost during nuclear fusion?
4. How is the lost mass related to the energy released?
5. Why is nuclear fusion the energy source of stars?
6. What happens to the nuclei and energy during fusion in the core of a star?

6.44P Explain the difference between nuclear fusion and nuclear fission

1. What is the main difference between nuclear fission and nuclear fusion?
2. What happens to a large nucleus during fission?
3. What happens to smaller nuclei during fusion?
4. Which process produces daughter nuclei from a larger nucleus?
5. Which process combines smaller nuclei to form a larger nucleus?
6. Why can both fission and fusion release energy?

6.45P Explain why nuclear fusion does not happen at low temperatures and pressures, due to electrostatic repulsion of protons

1. Why do positively charged nuclei repel each other?
2. What is electrostatic repulsion?
3. Why must nuclei have very high kinetic energies for fusion to occur?
4. How does increasing temperature help nuclei overcome electrostatic repulsion?
5. Why is high pressure useful for nuclear fusion?
6. Why does nuclear fusion not normally occur at low temperatures and pressures?

6.46P Relate the conditions for fusion to the difficulty of making a practical and economic form of power station

1. Why must extremely high temperatures be achieved for controlled fusion?
2. Why is maintaining the conditions required for fusion technically difficult?

3. Why must a fusion reactor keep the hot plasma away from the reactor walls?
4. Why is producing more energy than is required to sustain fusion important for a practical power station?
5. Why does the difficulty of maintaining fusion conditions affect the economic viability of fusion power?
6. What makes developing a practical fusion power station more difficult than simply achieving fusion?

Topic 7 – Astronomy

7.1P Explain how and why both the weight of any body and the value of g differ between the surface of the Earth and the surface of other bodies in space, including the Moon

1. What determines the weight of an object on the surface of a celestial body?
2. What determines the value of gravitational field strength, g, at the surface of a celestial body?
3. Why is an object's weight different on the Moon compared with Earth?
4. What happens to an object's mass when it is moved from Earth to the Moon?
5. An object has a mass of 6 kg on the Moon where g = 1.6 N/kg. What is its weight?
6. Why is the value of g different on different planets and moons?

7.2P Recall that our Solar System consists of the Sun (our star), eight planets and their natural satellites (such as our Moon); dwarf planets; asteroids and comets

1. What is at the centre of our Solar System?
2. How many planets are in our Solar System?
3. What is a natural satellite?
4. What is a dwarf planet?
5. What are asteroids?
6. What are comets?

7.3P Recall the names and order, in terms of distance from the Sun, of the eight planets

1. What is the closest planet to the Sun?

2. What is the second planet from the Sun?
3. What is the third planet from the Sun?
4. What is the fourth planet from the Sun?
5. What is the fifth planet from the Sun?
6. What are the eight planets in order of increasing distance from the Sun?

7.4P Describe how ideas about the structure of the Solar System have changed over time

1. What did the geocentric model propose about the structure of the Solar System?
2. What did the heliocentric model propose about the structure of the Solar System?
3. Who is associated with the development of the heliocentric model?
4. What is the main difference between the geocentric and heliocentric models?
5. How did observations of planets contribute to changes in models of the Solar System?
6. Why can scientific models of the Solar System change over time?

7.5P Describe the orbits of moons, planets, comets and artificial satellites

1. What causes moons and planets to remain in orbit?
2. What type of path does a planet follow around the Sun?
3. What type of object is a moon orbiting?
4. What type of orbit can an artificial satellite have around Earth?
5. How does a comet's orbit differ from the nearly circular orbits of many planets?
6. Why does an object in orbit continually change direction?

7.6P Explain for circular orbits how the force of gravity can lead to changing velocity of a planet but unchanged speed

1. What force keeps a planet in a circular orbit around the Sun?
2. In which direction does the gravitational force act on an orbiting planet?
3. Why does the velocity of a planet change during a circular orbit?
4. Why can the speed of a planet remain constant during a circular orbit?
5. What component of velocity changes during uniform circular motion?
6. Why is an object moving at constant speed around a circle still accelerating?

7.7P Explain how, for a stable orbit, the radius must change if orbital speed changes (qualitative only)

1. What happens to the radius of a stable circular orbit when orbital speed increases?
2. What happens to the radius of a stable circular orbit when orbital speed decreases?
3. Why must orbital radius change when orbital speed changes?
4. What happens to the gravitational force as an orbiting object's distance from the central body increases?
5. For a stable orbit, why cannot orbital speed and radius change independently?
6. How does a higher orbital speed relate qualitatively to the radius of a stable orbit?

7.8P Compare the Steady State and Big Bang theories

1. What does the Big Bang theory propose about the origin of the Universe?
2. What does the Steady State theory propose about the Universe?
3. How does the Big Bang theory describe the density of the Universe over time?
4. How does the Steady State theory differ from the Big Bang theory regarding the age of the Universe?
5. What is one major difference between the Big Bang and Steady State theories?
6. Which theory proposes that the Universe has changed significantly from a much hotter, denser early state?

7.9P Describe evidence supporting the Big Bang theory, limited to red-shift and the cosmic microwave background (CMB) radiation

1. What is red-shift?
2. How does red-shift provide evidence that the Universe is expanding?
3. What is cosmic microwave background radiation?
4. Why is the CMB considered evidence for the Big Bang theory?
5. What does the existence of the CMB suggest about the early Universe?
6. How do red-shift and CMB radiation together support the Big Bang theory?

7.10P Recall that as there is more evidence supporting the Big Bang theory than the Steady State theory, it is the currently accepted model for the origin of the Universe

1. Which theory is currently the accepted model for the origin of the Universe?
2. Why is the Big Bang theory currently accepted?
3. What evidence supports the Big Bang theory?
4. Why is the Steady State theory no longer the accepted model?
5. How does scientific evidence affect the acceptance of theories?
6. What does it mean to say that the Big Bang theory is the currently accepted model?

7.11P Describe that if a wave source is moving relative to an observer there will be a change in the observed frequency and wavelength

1. What happens to the observed frequency when a wave source moves towards an observer?
2. What happens to the observed frequency when a wave source moves away from an observer?
3. What happens to the observed wavelength when a source moves towards an observer?
4. What happens to the observed wavelength when a source moves away from an observer?
5. What is the relationship between the motion of a source and the observed frequency?
6. What is the name of the effect in which the observed frequency changes because of relative motion between a source and observer?

7.12P Describe the red-shift in light received from galaxies at different distances away from the Earth

1. What is meant by red-shift?
2. What happens to the observed wavelength of light from a red-shifted galaxy?
3. How does the amount of red-shift vary with the distance of a galaxy from Earth?
4. What does a greater red-shift indicate about a distant galaxy's motion relative to Earth?
5. Why does light from distant galaxies often appear red-shifted?
6. How can the red-shift of light from galaxies be used to investigate their motion?

7.13P Explain why the red-shift of galaxies provides evidence for the Universe expanding

1. What does the red-shift of light from galaxies indicate about their motion?

2. Why does the red-shift of distant galaxies provide evidence that they are moving away from Earth?
3. What does the widespread red-shift of galaxies suggest about the Universe?
4. How does the relationship between galaxy distance and red-shift support an expanding Universe?
5. Why would observations of red-shift be difficult to explain if the Universe were completely static?
6. How does galaxy red-shift provide evidence for expansion rather than simply the motion of one galaxy?

7.14P Explain how both the Big Bang and Steady State theories of the origin of the Universe both account for red-shift of galaxies

1. How does the Big Bang theory explain the red-shift of distant galaxies?
2. How does the Steady State theory account for the red-shift of galaxies?
3. What observation can both the Big Bang and Steady State theories explain?
4. Why does red-shift alone not distinguish completely between the Big Bang and Steady State theories?
5. What additional evidence supports the Big Bang theory over the Steady State theory?
6. How do the two theories differ in their explanation of the overall evolution of the Universe despite both accounting for galaxy red-shift?

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

1. What is the CMB?
2. Why was the discovery of CMB radiation important to cosmology?
3. What does the CMB provide evidence for about the early Universe?
4. Why does the CMB support the Big Bang theory more strongly than the Steady State theory?
5. How did the discovery of CMB radiation affect scientific views about the origin of the Universe?
6. Why did evidence from the CMB contribute to the Big Bang theory becoming the accepted model?

7.16P Describe the evolution of stars of similar mass to the Sun through the following stages: a nebula b star (main sequence) c red giant d white dwarf

1. What is a nebula?

2. What happens to a nebula as a star similar in mass to the Sun begins to form?
3. What is the main-sequence stage of a star?
4. What happens to a Sun-like star after it leaves the main sequence?
5. What happens to a red giant eventually to form a white dwarf?
6. What is the correct sequence of stages for a star with a mass similar to the Sun?

7.17P Explain how the balance between thermal expansion and gravity affects the life cycle of stars

1. What force tends to make a star contract under gravity?
2. What causes thermal pressure or expansion within a star?
3. What happens when gravity and thermal expansion are balanced in a stable star?
4. What happens to a star if gravity becomes greater than the outward thermal pressure?
5. What happens when the balance between gravity and thermal expansion changes as a star evolves?
6. How does the balance between gravity and thermal expansion influence the life cycle of a star?

7.18P Describe the evolution of stars with a mass larger than the Sun

1. How does the evolution of a massive star initially differ from that of a Sun-like star?
2. What happens to a massive star after its main-sequence stage?
3. What is a supernova?
4. What can remain after a massive star undergoes a supernova?
5. How can a massive star eventually form a neutron star?
6. Under what conditions can the remnant of a massive star become a black hole?

7.19P Describe how methods of observing the Universe have changed over time including why some telescopes are located outside the Earth's atmosphere

1. How have methods of observing the Universe changed over time?
2. Why are modern telescopes able to observe more of the electromagnetic spectrum than early optical telescopes?
3. Why can Earth's atmosphere interfere with astronomical observations?
4. Why are some telescopes placed above Earth's atmosphere?
5. What advantage does a space telescope have over a ground-based telescope?

6. Why are different types of telescope used to observe different regions of the electromagnetic spectrum?

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?
3. What energy store increases when an object speeds up?
4. What energy store decreases when a moving object slows down?
5. How can energy be transferred between different energy stores when a system changes?
6. What happens to the total energy of a closed system during a change?

8.2 Draw and interpret diagrams to represent energy transfers

1. What is an energy transfer diagram used to represent?
2. How can an energy transfer diagram show the initial and final energy stores of a system?
3. What does the width of an arrow represent in an energy transfer diagram?
4. How can an energy transfer diagram show that some energy has been dissipated?
5. Draw an energy transfer diagram for a battery powering an electric motor.
6. Interpret an energy transfer diagram showing chemical energy transferred into kinetic energy and thermal energy.

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 of a closed system when energy is transferred between stores?
3. Why is energy not destroyed during an energy transfer?
4. If 500 J of energy is transferred from one energy store to another in a closed system, how much total energy is lost?
5. A closed system initially contains 2,000 J of energy. How much total energy does it contain after internal energy transfers?
6. How does conservation of energy apply to a closed 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. How can doing work by forces change the energy of a system?
2. How can electrical equipment change the energy of a system?
3. How can heating change the energy of a system?
4. What energy transfer occurs when a force accelerates an object?
5. What energy transfer occurs when an electric heater heats water?
6. What energy transfer occurs when an object is heated by a flame?

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 are needed to calculate work done by a force?
3. What is the unit of work done?
4. What is the relationship between work done and energy transferred?
5. If a force does 250 J of work, how much energy is transferred?
6. Why is work done considered to be an energy transfer?

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 by a force?
2. What unit is used for work done in the equation $E = F \times d$?
3. A force of 20 N moves an object 5 m in the direction of the force. Calculate the work done.
4. A force of 150 N does 600 J of work. Calculate the distance moved.
5. An object moves 8 m while a force of 40 N acts in the direction of motion. Calculate the energy transferred.
6. A force does 900 J of work while moving an object 3 m. Calculate the force.

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

1. How does work done by a force transfer energy to or from a system?
2. What happens to the kinetic energy of an object when a resultant force accelerates it?
3. What happens to the gravitational potential energy of an object when work is done to raise it?

4. A force of 50 N moves an object 6 m. Calculate the energy transferred by the force.
5. A 4 kg object is raised vertically through 5 m where g = 10 N/kg. Calculate the increase in gravitational potential energy.
6. A 2 kg object accelerates from rest to 10 m/s. Calculate its increase in kinetic energy.

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 a change in gravitational potential energy?
2. What happens to gravitational potential energy when an object is raised?
3. Calculate the change in gravitational potential energy of a 5 kg object raised by 4 m when g = 10 N/kg.
4. A 2 kg object gains 120 J of gravitational potential energy when raised through 6 m. Calculate g.
5. An object gains 500 J of gravitational potential energy when raised through 5 m where g = 10 N/kg. Calculate its mass.
6. A 10 kg object is raised through 3 m on a planet where g = 8 N/kg. Calculate its change in gravitational potential energy.

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) × $(speed)^2$ ($(metre/second)^2$, $(m/s)^2$) $KE = 1/2 \times m \times v^2$

1. What equation is used to calculate the kinetic energy of a moving object?
2. What happens to kinetic energy when the speed of an object increases?
3. Calculate the kinetic energy of a 4 kg object moving at 5 m/s.
4. A 2 kg object has a kinetic energy of 100 J. Calculate its speed.
5. A 10 kg object moves at 8 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 slides across a rough surface?

5. How can friction cause energy to be dissipated?
6. Give an example of a system in which energy is transferred to the thermal energy store of the surroundings.

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

1. Why does friction make a mechanical process less efficient?
2. What happens to energy when friction causes surfaces to heat up?
3. Why is heating the surroundings considered a wasteful energy transfer?
4. How does friction affect the efficiency of a mechanical system?
5. What happens to the temperature of surfaces when mechanical energy is dissipated by friction?
6. Why does a rise in temperature indicate that energy has been dissipated in a mechanical process?

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 describe?
3. Which transfers energy more quickly: a 1,000 W device or a 500 W device?
4. Two machines transfer the same amount of energy, but one does so in less time. Which machine has greater power?
5. Why does a high-power appliance transfer energy more rapidly than a low-power appliance?
6. How can the power of an electrical appliance be interpreted in terms of energy transferred each second?

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

1. What equation is used to calculate power?
2. What are the units of power, energy and time in $P = E \div t$?
3. A machine transfers 6,000 J of energy in 20 s. Calculate its power.
4. A motor has a power of 500 W and operates for 30 s. Calculate the energy transferred.
5. A device transfers 12,000 J of energy at a power of 600 W. Calculate the time taken.
6. A machine does 9,000 J of work in 15 s. Calculate its power.

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

1. What is one watt equal to in joules per second?
2. What does a power rating of 1 W mean?
3. How many joules does a 100 W device transfer each second?
4. How much energy does a 2,000 W device transfer in 1 second?
5. A device transfers 500 J every second. What is its power?
6. A 60 W lamp operates for 10 s. How much energy does it transfer?

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 efficiency?
2. Why is efficiency usually expressed as a value between 0 and 1 or as a percentage?
3. A device receives 500 J of energy and transfers 400 J usefully. Calculate its efficiency.
4. A machine has an efficiency of 0.8 and receives 2,000 J of energy. Calculate the useful energy transferred.
5. A device transfers 600 J usefully from a total input of 1,000 J. Calculate its efficiency as a percentage.
6. A machine has an efficiency of 75% and receives 4,000 J of energy. Calculate the useful energy transferred.

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 field force can act between objects without physical contact?
2. How does a gravitational field allow two masses to interact at a distance?
3. How does an electrostatic field allow charged objects to interact at a distance?
4. What are the normal contact force and friction examples of?
5. What happens when two objects interact and produce a pair of forces?
6. How can forces acting on interacting 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 the information given by a scalar and a vector?
4. Is speed a scalar or vector quantity?
5. Is velocity a scalar or vector quantity?
6. Give one example of a force being represented as a vector.

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 resolution of a force?
2. What is a net force?
3. How can a vector diagram show the resultant or net force acting on an object?
4. What does a vector diagram show when forces are in equilibrium?
5. Two perpendicular forces of 3 N and 4 N act on an object. Using a scale drawing, what is the magnitude of the resultant force?
6. How can a scale drawing be used to determine the resultant of two forces?

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. How should the direction of an arrow represent a force?
4. What forces would normally be shown on a free body diagram of a falling object?
5. What would a free body diagram show for an object resting on a horizontal surface?
6. How can a free body diagram be used to determine the resultant force on an object?

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 when the resultant force on an object is zero?
3. What are balanced forces?

4. An object has forces of 15 N to the right and 9 N to the left. What is the resultant force?
5. An object has a 20 N upward force and a 20 N downward force. What is the resultant force?
6. How can a resultant force change the motion of an object?

9.6P Describe situations where forces can cause rotation

1. How can a force cause an object to rotate?
2. What determines how effective a force is at causing rotation?
3. Why can pushing a door near its handle produce more rotation than pushing it near its hinges?
4. Give an example of a force causing an object to rotate.
5. What happens when a force acts at a greater perpendicular distance from a pivot?
6. Why does the position of the pivot affect the rotational effect of a force?

9.7P Recall and use the equation: moment of a force (newton metre, N m) = force (newton, N) × distance normal to the direction of the force (metre, m)

1. What equation is used to calculate the moment of a force?
2. What is the unit of moment?
3. What does the perpendicular distance in the moment equation represent?
4. A force of 20 N acts at a perpendicular distance of 0.5 m from a pivot. Calculate the moment.
5. A force produces a moment of 60 N m at a perpendicular distance of 0.3 m. Calculate the force.
6. A force of 15 N produces a moment of 45 N m. Calculate its perpendicular distance from the pivot.

9.8P Recall and use the principle of moments in situations where rotational forces are in equilibrium: the sum of clockwise moments = the sum of anti-clockwise moments for rotational forces in equilibrium

1. What is the principle of moments for an object in rotational equilibrium?
2. What is the relationship between the total clockwise and anti-clockwise moments in equilibrium?
3. A 10 N force acts 2 m from a pivot. What anti-clockwise moment is needed for rotational equilibrium?

4. A 30 N force acts 0.4 m from a pivot. A second force acts 0.6 m from the pivot on the opposite side. Calculate the second force needed for equilibrium.
5. A force of 20 N produces a clockwise moment of 80 N m. What distance from the pivot does it act?
6. Why does an object remain rotationally stationary when clockwise and anti-clockwise moments are equal?

9.9P Explain how levers and gears transmit the rotational effects of forces

1. What is a lever?
2. How does a lever transmit the rotational effect of a force?
3. What is the purpose of gears in a mechanical system?
4. How can changing the sizes of gears affect rotational speed?
5. How can gears change the turning effect or torque transmitted by a system?
6. Why can a longer lever make it easier to turn or lift an object?

9.10 Explain ways of reducing unwanted energy transfer through lubrication

1. Why does friction cause unwanted energy transfer?
2. How does lubrication reduce friction between moving surfaces?
3. What form does much of the unwanted energy become when friction occurs?
4. Why can lubrication increase the efficiency of a mechanical system?
5. How does reducing friction affect the amount of thermal energy transferred to the surroundings?
6. Give an example of a mechanical system where lubrication can reduce unwanted energy transfer.

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 charge of a proton?
3. What is the relative charge of a neutron?
4. What is the relative charge of an electron?
5. Which two particles have approximately equal masses?

6. Which particle has a much smaller mass than a proton or neutron?

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?
2. How is a battery represented in a circuit diagram?
3. What circuit symbol represents an ammeter?
4. What circuit symbol represents a voltmeter?
5. Which circuit symbols represent a variable resistor, thermistor and LDR?
6. Which circuit symbols represent a diode, LED, lamp and motor?

10.3 Describe the differences between series and parallel circuits

1. What is a series circuit?
2. What is a parallel circuit?
3. How does the path taken by current differ between series and parallel circuits?
4. What happens to the current at a junction in a parallel circuit?
5. What happens to other components in a series circuit if one component breaks?
6. Why can components in a parallel circuit operate independently?

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 is a voltmeter connected to a component?
2. What quantity does a voltmeter measure?
3. What is the unit of potential difference?
4. Why must a voltmeter be connected in parallel?
5. Where should a voltmeter be connected to measure the potential difference across a resistor?
6. What would happen to the measurement if a voltmeter were incorrectly connected in series?

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 potential difference measure?
2. How is potential difference related to energy transferred and charge?
3. What does a potential difference of 1 V mean?
4. What is the relationship between volts, joules and coulombs?
5. A charge of 5 C transfers 20 J of energy. What is the potential difference?
6. A potential difference of 12 V transfers 60 J of energy. How much charge passes?

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

1. What equation links energy transferred, charge and potential difference?
2. Calculate the energy transferred when 4 C passes through a potential difference of 12 V.
3. A charge of 10 C transfers 240 J of energy. Calculate the potential difference.
4. A 9 V battery transfers 180 J of energy. Calculate the charge moved.
5. A charge of 2.5 C passes through a 6 V potential difference. Calculate the energy transferred.
6. A device transfers 1,200 J when 100 C of charge passes through it. Calculate the 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 is an ammeter connected to a component?
2. What quantity does an ammeter measure?
3. What is the unit of current?
4. Why must an ammeter be connected in series?
5. Where should an ammeter be placed to measure the current through a lamp?
6. What would happen to the circuit if an ammeter were incorrectly connected in parallel?

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 the rate of flow of charge describe?
3. Which particles carry electric charge through metals?
4. In which direction do electrons move through a metal circuit?
5. What happens to current when the same amount of charge passes a point in less time?

6. How is current different from the amount of charge flowing through a circuit?

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 passing through a circuit when a current of 3 A flows for 20 s.
3. A current of 0.5 A flows for 60 s. Calculate the charge transferred.
4. A charge of 240 C passes in 30 s. Calculate the current.
5. A current of 2 A transfers 500 C of charge. Calculate the time taken.
6. How much charge passes through a 12 A circuit in 5 s?

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

1. What is required for current to flow continuously in a circuit?
2. Why must a circuit be closed for current to flow?
3. What role does a cell or battery play in a circuit?
4. What happens to the current when a switch is opened?
5. What happens when a closed circuit contains a source of potential difference?
6. Why does a broken wire prevent current from flowing?

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

1. What happens to the total current at a junction?
2. What does conservation of current mean in a parallel circuit?
3. A junction has 5 A entering and 2 A leaving through one branch. What current leaves through the other branch?
4. A current of 6 A enters a junction and splits into 2 A and another current. What is the other current?
5. Why is the total current entering a junction equal to the total current leaving it?
6. How can conservation of current be used to calculate an unknown branch current?

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

1. What happens to current when resistance increases while potential difference remains constant?

2. What happens to current when resistance decreases while potential difference remains constant?
3. How can a variable resistor change the resistance of a circuit?
4. Why can a variable resistor be used to control current?
5. A fixed potential difference is applied to a circuit and its resistance is doubled. What happens to the current?
6. How could a variable resistor be used to investigate the relationship between resistance and current?

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

1. What equation links potential difference, current and resistance?
2. Calculate the potential difference across a 6 Ω resistor carrying 2 A.
3. A resistor has a potential difference of 12 V and a current of 3 A. Calculate its resistance.
4. A 20 Ω resistor has a potential difference of 100 V across it. Calculate the current.
5. A current of 0.5 A flows through a 16 Ω resistor. Calculate the potential difference.
6. What happens to current if resistance increases while potential difference remains constant?

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. Why does adding a resistor in series increase the total resistance?
2. What happens to the total resistance when resistors are connected in parallel?
3. Why does a parallel arrangement provide additional paths for current?
4. Two 5 Ω resistors are connected in series. What is their total resistance?
5. Two 10 Ω resistors are connected in parallel. Is their total resistance greater than, equal to, or less than 10 Ω?
6. Why is the total resistance of two parallel resistors less than the resistance of either individual resistor?

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

1. What happens to the current at every point in a series circuit?
2. How is the total potential difference shared between components in series?

3. Two resistors of 4 Ω and 6 Ω are connected in series across a 20 V supply. Calculate the total resistance.
4. A 12 V supply is connected to two series resistors of 2 Ω and 4 Ω. Calculate the current in the circuit.
5. A 10 V supply provides a current of 2 A through a series circuit containing a 3 Ω resistor and an unknown resistor. Calculate the resistance of the unknown resistor.
6. A series circuit has a current of 0.5 A and a total resistance of 20 Ω. Calculate the supply potential difference.

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

1. Why are components connected in series when measuring the current through them?
2. Where should an ammeter be placed in a series circuit?
3. How should a voltmeter be connected when measuring the potential difference across a component?
4. Why should the circuit include a switch when carrying out electrical measurements?
5. Why can a variable resistor be useful in a testing circuit?
6. What measurements are needed to determine the resistance of a component using R = V ÷ I?

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 can a circuit be constructed to investigate the relationship between potential difference and current?
2. How should an ammeter and voltmeter be connected when investigating a component?
3. How can the resistance of a resistor be calculated from experimental measurements?
4. How can the behaviour of a filament lamp be compared with that of a fixed resistor?
5. What should be measured when comparing series and parallel circuits containing lamps and resistors?
6. Why should repeated measurements be taken during an electrical investigation?

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 current vary with potential difference for a fixed resistor at constant temperature?
2. Why does the resistance of a filament lamp increase as its potential difference increases?
3. How does heating affect the resistance of a filament lamp?
4. How does current behave through a diode when it is forward biased?
5. Why does a diode have a very high resistance when reverse biased?
6. How can a current-potential difference graph be used to determine whether a component has constant resistance?

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 as a light sensor?
4. How could an LDR be used to switch a circuit on when it becomes dark?
5. What happens to the current through an LDR if its resistance decreases while potential difference remains constant?
6. How does light intensity affect the resistance of an LDR?

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 an NTC thermistor when temperature increases?
2. What happens to the resistance of an NTC thermistor when temperature decreases?
3. What does NTC mean for a thermistor?
4. Why can an NTC thermistor be used as a temperature sensor?
5. What happens to current through an NTC thermistor when its temperature increases at constant potential difference?
6. How could an NTC thermistor be used in a temperature-sensitive circuit?

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 can potential difference and current measurements be used to investigate resistance?
2. How can a variable resistor help investigate the resistance of a filament lamp?
3. How can the forward and reverse behaviour of a diode be investigated?
4. How can a thermistor circuit be used to investigate the effect of temperature on resistance?
5. How can an LDR circuit be used to investigate the effect of light intensity on resistance?
6. Why can a graph of potential difference against current help investigate how resistance varies?

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 energy when an electric current flows through a resistor?
2. Which energy store increases when a resistor heats up?
3. Why does a resistor become hot when current flows through it?
4. What happens to the temperature of a resistor when electrical energy is transferred to its thermal energy store?
5. What type of energy transfer occurs in an electrical resistor?
6. Give one example of a useful resistor heating effect.

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 encounters resistance?
2. What does it mean for electrical energy to be dissipated?
3. Why is thermal energy transferred to the surroundings by a resistor?
4. Why is energy dissipated in the wires and components of a circuit?
5. How does electrical resistance cause a transfer of energy to the thermal energy store?
6. Why can unwanted resistance reduce the efficiency of an electrical system?

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 particles form the lattice in a metal?
3. What happens when electrons collide with ions in the metal lattice?
4. How do electron-ion collisions cause a resistor to heat up?

5. How is electrical energy transferred to the thermal energy store during these collisions?
6. Why does increased resistance result in greater energy dissipation as heating?

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

1. Why does electrical resistance cause unwanted energy transfer as heating?
2. How can using low-resistance wires reduce unwanted energy transfer?
3. Why are thick wires generally useful for reducing resistance?
4. Why are low-resistance wires useful for transmitting electrical energy?
5. How does reducing resistance affect the amount of electrical energy dissipated as thermal energy?
6. Why are low-resistance materials used in electrical cables?

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

1. What is one useful application 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 heating caused by resistance be an unwanted energy transfer?
5. How can unwanted heating affect electrical cables?
6. What is the main advantage and disadvantage of the heating effect of 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. A current of 2 A flows through a 12 V device for 30 s. Calculate the energy transferred.
3. A 5 A current flows through a 20 V device for 10 s. Calculate the energy transferred.
4. A device transfers 6,000 J using a current of 5 A at 20 V. Calculate the operating time.
5. A device transfers 2,400 J in 60 s at a potential difference of 12 V. Calculate the current.
6. A current of 0.5 A flows for 120 s through a 10 V device. 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 power?
2. What does a high power rating indicate about the rate of energy transfer?
3. What is the unit of power?
4. What does a power rating of 1 W mean?
5. How much energy does a 500 W device transfer each second?
6. Which transfers energy faster: a 100 W device or a 1,000 W device?

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 is used to calculate electrical power from energy and time?
2. A device transfers 4,000 J in 20 s. Calculate its power.
3. A 600 W appliance operates for 30 s. Calculate the energy transferred.
4. A device transfers 9,000 J at a power of 300 W. Calculate the time taken.
5. A heater transfers 12,000 J in 60 s. Calculate its power.
6. A motor has a power of 250 W and operates for 2 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 a circuit device related to potential difference?
2. How is the power transferred by a circuit device related to current?
3. What happens to power if the potential difference across a device increases while current remains constant?
4. What happens to power if current increases while potential difference remains constant?
5. A device operates at 12 V and 2 A. What is its power?
6. Why does a device with both a greater potential difference and greater current transfer energy more rapidly?

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 calculates electrical power using current and potential difference?
2. What equation calculates electrical power using current and resistance?

3. A device draws 4 A from a 12 V supply. Calculate its power using $P = I \times V$.
4. A 5 Ω resistor carries a current of 3 A. Calculate its power using $P = I^2 \times R$.
5. A device has a power of 1,000 W and operates at 250 V. Calculate its current.
6. A resistor dissipates 200 W while carrying a current of 5 A. Calculate its resistance.

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 type of energy is transferred by a battery to an electrical device?
2. How does an electric motor transfer electrical energy?
3. How does an electric heater transfer electrical energy?
4. Give one domestic device that uses a motor to transfer energy.
5. Give one domestic device that uses electrical heating.
6. How can the same electrical supply produce different useful energy transfers in different domestic devices?

10.33 Explain the difference between direct and alternating voltage

1. What is direct voltage?
2. What is alternating voltage?
3. How does direct voltage differ from alternating voltage in terms of direction?
4. What type of voltage is supplied by a cell?
5. What type of voltage is supplied by the UK mains?
6. How does the direction of an alternating voltage change with time?

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 direct current?
2. In what direction does charge move in a d.c. circuit?
3. What devices supply direct current?
4. Do cells produce d.c. or a.c.?
5. Do batteries produce d.c. or a.c.?
6. How does the direction of charge movement in d.c. differ from a.c.?

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

1. What is alternating current?

2. What happens to the direction of charge movement in an a.c. circuit?
3. How does a.c. differ from d.c.?
4. Does charge in an a.c. circuit continually move in one direction?
5. Why is mains electricity described as alternating current?
6. What happens to the direction of current during one complete a.c. cycle?

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. What type of current is supplied to UK homes?
2. What is the frequency of the UK domestic a.c. supply?
3. What is the approximate voltage of the UK domestic supply?
4. What does a frequency of 50 Hz mean for the UK mains supply?
5. Is the UK domestic supply approximately 230 V d.c. or a.c.?
6. How many complete cycles occur each second in the UK mains supply?

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?
2. What is the function of the neutral wire?
3. Which mains wire carries the alternating potential difference to a domestic appliance?
4. Which mains wire provides the return path for current?
5. Why is the live wire dangerous even when the neutral wire is at approximately zero potential relative to Earth?
6. Why must the live and neutral wires have different functions in a domestic circuit?

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

1. What is the function of the earth wire in a domestic appliance?
2. Why is the earth wire important for appliances with metal cases?
3. What does a fuse do when the current becomes too large?
4. How does a circuit breaker protect a circuit?
5. Why can a fuse or circuit breaker prevent overheating of wires?
6. How do the earth wire and fuse or circuit breaker work together to improve electrical safety?

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 does disconnecting the live wire make an appliance safer when switched off?
5. How does a fuse in the live wire protect an appliance?
6. Why would placing a fuse only in the neutral wire be unsafe?

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 mains 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 under normal conditions?
4. Which mains wire is at approximately 230 V relative to earth?
5. Which mains wires are approximately at the same potential under normal conditions?
6. Why is the live wire dangerous relative to the neutral and earth wires?

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

1. Why is a connection between the live wire and earth dangerous?
2. What can happen if a person provides a path between live and earth?
3. Why can current flow through a person connected between live and earth?
4. How can an earth connection cause a large current to flow?
5. How can a fuse or circuit breaker respond to a live-to-earth fault?
6. Why should people never make direct connections between live wires and earth?

10.42 Describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use

1. What does the power rating of a domestic appliance indicate?
2. What happens to the rate of energy transfer when an appliance has a higher power rating?
3. Which transfers energy faster: a 2,000 W kettle or a 1,000 W kettle?
4. A 1,500 W heater operates for 60 s. How much energy does it transfer?
5. A 100 W lamp operates for 5 minutes. Calculate the energy transferred.

6. Why does a high-power appliance transfer more energy in the same amount of time than a low-power appliance?

Topic 11 – Static electricity

11.1P Explain how an insulator can be charged by friction, through the transfer of electrons

1. How can an insulator become electrically charged by friction?
2. Which particles are transferred when an insulator is charged by friction?
3. Why can electrons be transferred between two different insulating materials?
4. What happens when two insulating materials are rubbed together?
5. Why does rubbing an insulator not cause protons to transfer between the materials?
6. How does friction result in one insulator gaining electrons and the other losing electrons?

11.2P Explain how the material gaining electrons becomes negatively charged and the material losing electrons is left with an equal positive charge

1. What charge does a material gain when it gains electrons?
2. What charge does a material have when it loses electrons?
3. Why does gaining electrons make an object negatively charged?
4. Why does losing electrons make an object positively charged?
5. Why are the positive and negative charges equal in magnitude when electrons are transferred between two initially neutral materials?
6. A neutral insulator gains 5 electrons while another loses the same 5 electrons. What charge does each material acquire?

11.3P Recall that like charges repel and unlike charges attract

1. What happens when two positively charged objects are brought together?
2. What happens when two negatively charged objects are brought together?
3. What happens when a positive and negative charge are brought together?
4. What is meant by like charges?
5. What is meant by unlike charges?
6. How can the force between two charged objects be used to identify whether their charges are like or unlike?

11.4P Explain common electrostatic phenomena in terms of movement of electrons, including a shocks from everyday objects b lightning c attraction by induction such as a charged balloon attracted to a wall and a charged comb picking up small pieces of paper

1. How can an electrostatic shock occur when a person touches a charged object?
2. How does the movement of electrons contribute to the formation of lightning?
3. Why can a charged balloon be attracted to a neutral wall?
4. What is meant by electrostatic induction?
5. Why can a charged comb attract small pieces of paper?
6. How does the redistribution of electrons explain the attraction between a charged object and a neutral object?

11.5P Explain how earthing removes excess charge by movement of electrons

1. What is meant by earthing an electrically charged object?
2. How does earthing remove excess negative charge?
3. How does earthing remove a positive charge from an object?
4. In which direction do electrons move when a negatively charged object is earthed?
5. Why can Earth act as a source or sink of electrons?
6. How does earthing return a charged object towards electrical neutrality?

11.6P Explain some of the uses of electrostatic charges in everyday situations, including insecticide sprayers

1. How can electrostatic charges be used in an insecticide sprayer?
2. Why can charged insecticide droplets spread out from one another?
3. How can electrostatic charging help insecticide reach plant surfaces?
4. Why can charged droplets be attracted to oppositely charged or induced charges on plants?
5. What advantage does electrostatic charging provide when spraying insecticide?
6. How does electrostatic repulsion between similarly charged droplets affect the spray?

11.7P Describe some of the dangers of sparking in everyday situations, including fuelling cars, and explain the use of earthing to prevent dangerous build-up of charge

1. Why can electrostatic sparks be dangerous when fuelling a car?
2. How can a build-up of electrostatic charge produce a spark?
3. Why can sparks be particularly dangerous around flammable fuels?
4. How does earthing help prevent a dangerous build-up of charge?
5. Why can connecting equipment to Earth reduce the risk of electrostatic sparking?
6. How does the movement of excess electrons to Earth reduce the danger when handling flammable substances?

11.8P Define an electric field as the region where an electric charge experiences a force

1. What is an electric field?
2. What happens to a charge placed within an electric field?
3. Around what type of object does an electric field exist?
4. How can the presence of an electric field be detected?
5. What force does a charged object experience when placed in an electric field?
6. How is an electric field different from the physical movement of charged particles?

11.9P Describe the shape and direction of the electric field around a point charge and between parallel plates and relate the strength of the field to the concentration of lines

1. What is the shape of the electric field around an isolated positive point charge?
2. What is the direction of electric field lines around a positive point charge?
3. What is the direction of electric field lines around a negative point charge?
4. What do electric field lines look like between two oppositely charged parallel plates?
5. What does a greater concentration of electric field lines indicate about field strength?
6. Why is the electric field between parallel plates approximately uniform away from the edges?

11.10P Explain how the concept of an electric field helps to explain the phenomena of static electricity

1. How does an electric field explain the force between charged objects?
2. How can an electric field explain the attraction of a charged balloon to a neutral wall?

3. How does the electric field around a charged object affect nearby charges?
4. How can electric fields explain repulsion between like charges?
5. How can electric fields explain attraction between unlike charges?
6. Why is the concept of an electric field useful for explaining static electricity?

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 north magnetic poles are brought together?
2. What happens when two south magnetic poles are brought together?
3. What happens when a north pole and a south pole are brought together?
4. What is meant by like magnetic poles?
5. What is meant by unlike magnetic poles?
6. How can the interaction between two magnetic poles be used to determine whether they are like or unlike?

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. What are cobalt and nickel used for in magnetic materials?
6. What type of magnetic material would be suitable for an electromagnet core, and why?

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. Why does an induced magnet lose its magnetism when the external magnetic field is removed?
5. How can a magnetic material become temporarily magnetised?

6. Why are soft magnetic materials useful for making induced magnets?

12.4 Describe the shape and direction of the magnetic field around bar magnets and for a uniform field, and relate the strength of the field to the concentration of lines

1. What is the shape of the magnetic field around a bar magnet?
2. What is the direction of magnetic field lines outside a bar magnet?
3. In which direction do magnetic field lines point between the poles of a bar magnet?
4. What does a uniform magnetic field look like?
5. What does the concentration of magnetic field lines indicate about field strength?
6. Where is the magnetic field strongest around a bar magnet?

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 a magnetic field?
2. What does the needle of a plotting compass indicate?
3. How can several compass positions be used to map a magnetic field?
4. How can plotting compasses show the direction of a bar magnet's magnetic field?
5. How can plotting compasses be used to investigate Earth's magnetic field?
6. Why should the compass be moved to several different positions when plotting 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 compass needle point approximately north-south?
2. What does the alignment of a compass needle provide evidence for?
3. Why does Earth's magnetic field affect a compass?
4. What does the existence of Earth's magnetic field suggest about its interior?
5. Why does the compass behave as though it is interacting with a large magnet?
6. How does compass behaviour provide evidence that Earth's core is magnetic?

12.7 Describe how to show that a current can create a magnetic effect around a long straight conductor, describing the shape of the

magnetic field produced and relating the direction of the magnetic field to the direction of the current

1. How can you demonstrate that a current-carrying wire produces a magnetic field?
2. What is the shape of the magnetic field around a long straight current-carrying conductor?
3. How does the direction of the magnetic field depend on the direction of current?
4. What happens to the magnetic field when the current is switched off?
5. How can plotting compasses be used to investigate the magnetic field around a straight conductor?
6. What happens to the direction of the magnetic field if the current direction is reversed?

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. What happens to the magnetic field strength around a straight conductor when the current increases?
2. What happens to magnetic field strength as the distance from a straight conductor increases?
3. How does doubling the current qualitatively affect the magnetic field strength?
4. Where is the magnetic field strongest around a current-carrying straight conductor?
5. Why does the magnetic field become weaker further from the conductor?
6. Which 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?
4. Why is the magnetic field inside a solenoid approximately uniform?
5. What happens to the magnetic fields from the coils outside a solenoid?
6. Why is the magnetic field outside a solenoid much weaker than the field inside?

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?
3. What happens to the magnet when it exerts a force on the conductor?
4. How are the forces on the conductor and magnet related?
5. What happens to the force on the conductor if the current is switched off?
6. How does this interaction demonstrate Newton's third law?

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

1. What causes a magnetic force between two magnetic objects?
2. How do two interacting magnetic fields produce a force?
3. Why does a current-carrying conductor experience a force near a magnet?
4. How does the magnetic field around a conductor interact with the magnetic field of a magnet?
5. Why can changing the direction of one magnetic field change the direction of the force?
6. How can magnetic field interactions explain attraction and repulsion?

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 determine?
2. Which finger represents the direction of the magnetic field in Fleming's left-hand rule?
3. Which finger represents the direction of current?
4. Which direction does the thumb represent?
5. When can Fleming's left-hand rule be applied directly?
6. If the direction of the current is reversed while the magnetic field remains unchanged, what happens to 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 is used to calculate the force on a current-carrying conductor in a magnetic field?
2. What conditions must apply for F = B × I × l to be used directly?
3. A conductor carries a current of 4 A through a magnetic field of 0.5 T. If its length is 0.2 m, calculate the force.
4. A conductor experiences a force of 6 N in a 0.3 T magnetic field while carrying 5 A. Calculate its length.
5. A 0.4 m conductor carries 3 A and experiences a force of 2.4 N. Calculate the magnetic flux density.
6. A 0.5 m conductor in a 0.8 T magnetic field experiences a force of 4 N. Calculate the current.

12.14P Explain how the force on a conductor in a magnetic field is used to cause rotation in electric motor

1. What causes a current-carrying conductor in a magnetic field to experience a force?
2. How can forces on opposite sides of a current-carrying coil cause rotation?
3. Why do the forces on the two sides of a motor coil act in opposite directions?
4. What happens to the coil when the forces form a turning effect?
5. What is the function of the split-ring commutator in a simple electric motor?
6. How does an electric motor use the motor effect to produce continuous rotation?

Topic 13 – Electromagnetic induction

13.1P Explain how to produce an electric current by the relative movement of a magnet and a conductor a on a small scale in the laboratory b in the large-scale generation of electrical energy

1. How can a current be produced by moving a magnet relative to a conductor?
2. What happens when a magnet is moved through a coil of wire?
3. How can electromagnetic induction be demonstrated in a laboratory?
4. Why does relative movement between a magnet and conductor produce a potential difference?
5. How is electromagnetic induction used to generate electrical energy on a large scale?

6. What energy transfer occurs when mechanical movement is used to generate electrical energy by 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 factors affect the size of an induced potential difference?
2. How does increasing the speed of relative movement between a magnet and conductor affect the induced potential difference?
3. How does increasing the number of turns in a coil affect the induced potential difference?
4. How does increasing the strength of the magnetic field affect the induced potential difference?
5. How does reversing the direction of relative movement affect the direction of the induced potential difference?
6. How does the magnetic field produced by an induced current oppose the original change?

13.3P Explain how electromagnetic induction is used in alternators to generate current which alternates in direction (a.c.) and in dynamos to generate direct current (d.c.)

1. What is the purpose of an alternator?
2. How does electromagnetic induction generate an alternating current in an alternator?
3. Why does the direction of the induced current change repeatedly in an alternator?
4. What is the purpose of a dynamo?
5. How does a dynamo produce direct current?
6. What is the main difference between the electrical output of an alternator and a dynamo?

13.4P Explain the action of the microphone in converting the pressure variations in sound waves into variations in current in electrical circuits, and the reverse effect as used in loudspeakers and headphones

1. How does a microphone convert sound waves into an electrical signal?
2. What causes the diaphragm of a microphone to move?
3. How are pressure variations in sound waves converted into variations in current?
4. How does a loudspeaker convert electrical signals into sound?

5. How does a headphone work in converting electrical signals into sound?
6. What is the reverse process performed by a loudspeaker compared with a microphone?

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

1. How does an alternating current in the primary coil produce a current in the secondary coil of a transformer?
2. Why is an alternating current required for electromagnetic induction in a transformer?
3. What happens to the magnetic field in the transformer core when the primary current alternates?
4. How does the changing magnetic field produce a potential difference in the secondary coil?
5. Why are the primary and secondary coils electrically separate in a transformer?
6. How does a transformer transfer energy between two electrical circuits?

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

1. What does a transformer do to an alternating voltage?
2. What type of voltage can a transformer change?
3. What is the difference between a step-up and a step-down transformer?
4. What happens to the output voltage of a step-up transformer?
5. What happens to the output voltage of a step-down transformer?
6. Why can a transformer not directly change a steady direct voltage?

13.7P Use the turns ratio equation for transformers to calculate either the missing voltage or the missing number of turns: $N_s/N_p = V_s/V_p$

1. What equation relates the number of turns and voltages in a transformer?
2. A transformer has 500 primary turns and 2000 secondary turns. If the primary voltage is 12 V, calculate the secondary voltage.
3. A transformer has 1000 primary turns and 250 secondary turns. If the primary voltage is 240 V, calculate the secondary voltage.
4. A transformer has 600 primary turns and 1200 secondary turns and produces a secondary voltage of 20 V. Calculate the primary voltage.
5. A transformer has a primary voltage of 230 V and a secondary voltage of 46 V. If the primary coil has 1000 turns, calculate the number of secondary turns.

6. A transformer has 400 secondary turns and a primary voltage of 120 V. If the secondary voltage is 24 V, calculate the number of primary turns.

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 voltages?
2. How does increasing the transmission voltage affect the current for a given power transfer?
3. Why does a lower current reduce heating in transmission cables?
4. How does electrical resistance cause energy to be dissipated as heat in transmission lines?
5. Why are lower voltages used for domestic electrical supplies?
6. How does high-voltage transmission improve the efficiency of 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. Where are step-down transformers used in the national grid?
4. Why are step-down transformers used before electricity reaches homes?
5. How does a step-up transformer help reduce energy losses during transmission?
6. How do step-up and step-down transformers work together in the national grid?

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

1. What equation relates the input and output power of an ideal transformer?
2. An ideal transformer has a primary voltage of 240 V and a primary current of 5 A. If the secondary voltage is 60 V, calculate the secondary current.
3. An ideal transformer has a primary voltage of 230 V and a primary current of 2 A. If the secondary current is 10 A, calculate the secondary voltage.
4. An ideal transformer has a secondary voltage of 12 V and a secondary current of 20 A. If the primary voltage is 240 V, calculate the primary current.

5. An ideal transformer has a primary voltage of 400 V and a primary current of 3 A. Calculate the secondary current if the secondary voltage is 40 V.
6. Why does an ideal transformer have equal input and output power?

13.11P Explain the advantages of power transmission in high-voltage cables, using the equations in 10.29, 10.31, 13.7P and 13.10

1. Why does transmitting electrical power at high voltage reduce the current in transmission cables?
2. Using $P = I \times V$, how does increasing voltage allow the current to decrease for a fixed power transfer?
3. Using $P = I^2 \times R$, why does reducing current greatly reduce the power dissipated as heat in cables?
4. How does the transformer turns ratio allow the voltage to be increased before transmission?
5. How does a step-down transformer allow the voltage to be reduced after transmission?
6. Explain how high-voltage transmission reduces energy loss and improves the efficiency of the national grid.

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. How does the kinetic theory model explain the differences between solids, liquids and gases?

14.2 Recall and use the equation: density (kilogram per cubic metre, kg/m^3) = mass (kilogram, kg) ÷ volume (cubic metre, m^3) $\rho = m/V$

1. What equation is used to calculate density?
2. What is the SI unit of density?
3. A block has a mass of 600 kg and a volume of 0.5 m^3. Calculate its density.
4. A substance has a density of 800 kg/m^3 and a volume of 2 m^3. Calculate its mass.

5. An object has a mass of 4 kg and a density of 2000 kg/m³. Calculate its volume.
6. A liquid has a mass of 1.5 kg and a volume of 0.002 m³. Calculate its density.

14.3 Core Practical: Investigate the densities of solid and liquids

1. How can the density of a regularly shaped solid be determined experimentally?
2. How can the volume of an irregular solid be measured experimentally?
3. How can the density of a liquid be determined experimentally?
4. What measurements are required to calculate the density of a solid?
5. Why should measurements be repeated when determining density experimentally?
6. How can a density experiment be improved to reduce uncertainty?

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 density?
3. Why are particles in a liquid generally closer together than particles in a gas?
4. How does the arrangement of particles in a solid affect its density?
5. Why can substances have different densities in different states?
6. How does the particle model explain the generally lower density of gases?

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 mass when a substance changes state?
2. What is the difference between melting and freezing?
3. What is the difference between evaporation and boiling?
4. What is condensation?
5. What is sublimation?
6. Why are changes of state classified as physical changes rather than chemical changes?

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. Why can heating a substance cause a change of state instead of increasing its temperature?
4. What happens to the particles' energy when a substance is heated?
5. Why does the temperature remain constant during a change of state?
6. How can energy supplied to a system be stored without increasing its temperature?

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 happens to temperature when energy is transferred according to specific heat capacity?
5. What happens to temperature when energy is transferred as specific latent heat?
6. What does a high specific heat capacity mean about the energy required to increase a substance's temperature?

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 is used to calculate a change in thermal energy?
2. What does c represent in the equation $\Delta Q = m \times c \times \Delta\theta$?
3. Calculate the thermal energy needed to heat 2 kg of water by 10 °C if its specific heat capacity is 4200 J/kg °C.
4. A 3 kg substance gains 18,000 J of thermal energy and its temperature rises by 20 °C. Calculate its specific heat capacity.
5. A material has a specific heat capacity of 500 J/kg °C. How much energy is required to raise 4 kg of it by 15 °C?
6. A 2 kg substance with a specific heat capacity of 1000 J/kg °C receives 12,000 J of thermal energy. Calculate its temperature increase.

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 is used to calculate the thermal energy required for a change of state?
2. What does L represent in the equation Q = m × L?
3. Calculate the energy required to melt 0.5 kg of a substance with a specific latent heat of 200,000 J/kg.
4. A substance absorbs 600,000 J during a change of state and has a specific latent heat of 300,000 J/kg. Calculate its mass.
5. A 2 kg sample absorbs 800,000 J during a change of state. Calculate its specific latent heat.
6. Why does the temperature remain constant while energy is transferred during a change of state?

14.10 Explain ways of reducing unwanted energy transfer through thermal insulation

1. How does thermal insulation reduce unwanted energy transfer?
2. Why does trapped air reduce thermal energy transfer?
3. How can the thickness of insulation affect the rate of thermal energy transfer?
4. How can loft insulation reduce energy transfer from a building?
5. How can double glazing reduce energy transfer through windows?
6. Why is reducing unwanted thermal energy transfer useful in buildings?

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 to calculate the specific heat capacity of water?
3. Why should the power supplied to the water be measured or controlled?
4. How can a temperature-time graph be obtained while ice melts?
5. What feature of a temperature-time graph indicates that ice is undergoing a change of state?
6. What practical methods can reduce heat loss when determining the specific heat capacity of water?

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. Why do gas particles exert pressure in all directions?
5. What happens to gas pressure if the frequency of particle collisions with the walls increases?
6. How does the kinetic theory explain gas 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 or more energetic collisions?
3. What happens to the pressure of a fixed mass of gas when its temperature increases at constant volume?
4. What happens to particle velocity when the temperature of a gas decreases?
5. Why does cooling a gas at constant volume reduce its pressure?
6. How does increasing temperature affect the force exerted by gas particles on the container walls?

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

1. What is absolute zero in degrees Celsius?
2. What does absolute zero represent in terms of particle motion?
3. What happens to the movement of particles as a substance approaches absolute zero?
4. Why is absolute zero associated with the minimum possible thermal energy?
5. What temperature is equivalent to absolute zero on the Celsius scale?
6. How does the particle model describe matter at absolute zero?

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 to kelvin.
3. Convert 300 K to degrees Celsius.
4. Convert −73 °C to kelvin.
5. Convert 100 K to degrees Celsius.
6. What kelvin temperature corresponds to 0 °C?

14.16P Explain that gases can be compressed or expanded by pressure changes

1. What happens to the volume of a gas when external pressure is increased?
2. Why can gases be compressed more easily than liquids and solids?
3. What happens to a gas when the external pressure is reduced?
4. How does the spacing between gas particles change when a gas is compressed?
5. How does the spacing between gas particles change when a gas expands?
6. Why can changing pressure cause a gas to compress or expand?

14.17P Explain that the pressure of a gas produces a net force at right angles to any surface

1. How does gas pressure produce a force on a surface?
2. In what direction does the force from gas pressure act on a surface?
3. Why does gas pressure act at right angles to a surface?
4. What happens to the force on a surface if the gas pressure increases?
5. How does the area of a surface affect the total force produced by a given gas pressure?
6. How is the force produced by gas pressure different from the random motion of individual gas particles?

14.18P Explain the effect of changing the volume of a gas on the rate at which its particles collide with the walls of its container and hence on the pressure produced by a fixed mass of gas at constant temperature

1. What happens to the frequency of particle collisions with the container walls when the volume of a gas decreases?
2. Why does compressing a gas increase its pressure at constant temperature?
3. What happens to the collision rate when the volume of a gas increases?
4. Why does expanding a gas reduce its pressure at constant temperature?
5. How does the distance particles travel between collisions with the container walls change when volume decreases?
6. How does the particle model explain the inverse relationship between gas pressure and volume at constant temperature?

14.19P Use the equation: $P_1 \times V_1 = P_2 \times V_2$ to calculate pressure or volume for gases of fixed mass at constant temperature

1. What equation relates the pressure and volume of a fixed mass of gas at constant temperature?
2. A gas has a pressure of 100 kPa and a volume of 4 m^3. If its volume decreases to 2 m^3, calculate its new pressure.
3. A gas has a pressure of 200 kPa and a volume of 3 m^3. If its pressure decreases to 100 kPa, calculate its new volume.
4. A gas has an initial pressure of 150 kPa and volume of 2 m^3. Its final volume is 5 m^3. Calculate its final pressure.
5. A gas has an initial pressure of 80 kPa and volume of 6 m^3. Its final pressure is 120 kPa. Calculate its final volume.
6. A gas has a volume of 0.5 m^3 at a pressure of 400 kPa. What volume will it occupy at a pressure of 100 kPa?

14.20P Explain why doing work on a gas can increase its temperature, including a bicycle pump

1. How can doing work on a gas increase its temperature?
2. What happens to the internal energy of a gas when work is done on it?
3. Why can compressing a gas increase its temperature?
4. How does a bicycle pump demonstrate that doing work on a gas can increase its temperature?
5. What happens to the particles of a gas when it is compressed rapidly?
6. How does the energy transfer during compression explain the increase in gas temperature?

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. What happens to a spring when two opposing forces pull on its ends?
3. How can two forces cause an object to bend?
4. How can forces be used to compress an object?
5. What happens to the shape of an object when opposing forces act on it?
6. Why does stretching, bending or compressing an object require forces acting in different directions?

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 distortion is elastic?
6. What happens when an object is stretched beyond its elastic limit?

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 relates force, spring constant and extension for a linearly elastic spring?
2. What is the unit of spring constant?
3. A spring has a spring constant of 200 N/m and an extension of 0.05 m. Calculate the force.
4. A spring experiences a force of 12 N and extends by 0.03 m. Calculate its spring constant.
5. A spring has a spring constant of 150 N/m and experiences a force of 6 N. Calculate its extension.
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 (joules, 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 is used to calculate the energy transferred when stretching a spring?
2. A spring has a spring constant of 100 N/m and is extended by 0.2 m. Calculate the energy transferred.
3. A spring has a spring constant of 250 N/m and is extended by 0.04 m. Calculate the energy transferred.
4. A spring stores 9 J of energy when extended by 0.3 m. Calculate its spring constant.
5. A spring with a spring constant of 400 N/m stores 8 J of energy. Calculate its extension.
6. How does doubling the extension affect the energy transferred to a spring, assuming it remains within the linear elastic region?

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 the force-extension graph of a linearly elastic spring look like?
3. What is meant by a non-linear relationship between force and extension?
4. How can a force-extension graph be used to identify a non-linear relationship?
5. What does a constant gradient on a force-extension graph indicate?
6. Why might a spring have a non-linear relationship between force and extension?

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

1. How can the extension of a spring be measured experimentally?
2. What measurements are needed to investigate the relationship between force and extension?
3. How can the force applied to a spring be varied during the experiment?
4. How can the work done in stretching a spring be determined?
5. Why should the spring not be stretched beyond its elastic limit?
6. How can a force-extension graph be used to analyse the results of the spring experiment?

15.7P Explain why atmospheric pressure varies with height above the Earth's surface with reference to a simple model of the Earth's atmosphere

1. What happens to atmospheric pressure as height above Earth's surface increases?
2. Why is atmospheric pressure greatest near Earth's surface?
3. How does the number of air particles above a location affect atmospheric pressure?
4. Why does the density of the atmosphere generally decrease with increasing height?
5. Why does atmospheric pressure decrease at higher altitudes?
6. How does a simple particle model of the atmosphere explain the variation of pressure with height?

15.8P Describe the pressure in a fluid as being due to the fluid and atmospheric pressure

1. What contributes to the pressure experienced by an object beneath the surface of a liquid?
2. What is meant by atmospheric pressure?
3. How does the weight of a fluid contribute to pressure?
4. Why does a liquid exert pressure on objects immersed in it?
5. How do atmospheric pressure and liquid pressure combine below the surface of a liquid?
6. Why is the pressure in a liquid greater than atmospheric pressure alone at depth?

15.9P Recall that the pressure in fluids causes a force normal to any surface

1. What direction does the force caused by fluid pressure act on a surface?
2. What does normal mean when describing a force acting on a surface?
3. Why does fluid pressure produce a force perpendicular to a surface?
4. How does fluid pressure act on the walls of a container?
5. What happens to the force on a surface if the fluid pressure increases?
6. How does the direction of the pressure force change if the orientation of the surface changes?

15.10P Explain how pressure is related to force and area, using appropriate examples

1. How does increasing the force on a fixed area affect pressure?
2. How does increasing the area over which a fixed force acts affect pressure?
3. Why do sharp objects produce high pressures?
4. Why do wide tyres reduce the pressure exerted on the ground?
5. Why can a person standing on one foot exert greater pressure on the ground than when standing on two feet?
6. How can the same force produce different pressures depending on the area over which it acts?

15.11P Recall and use the equation: pressure (pascal, Pa) = force normal to surface (newton, N) ÷ area of surface (square metre, m^2) $P = F/A$

1. What equation is used to calculate pressure?
2. What is the SI unit of pressure?
3. A force of 500 N acts normally on an area of 2 m^2. Calculate the pressure.
4. A pressure of 20,000 Pa acts on an area of 0.5 m^2. Calculate the normal force.

5. A force of 800 N produces a pressure of 40,000 Pa. Calculate the area.
6. A force of 120 N acts normally over an area of 0.03 m^2. Calculate the pressure.

15.12P Describe how pressure in fluids increases with depth and density

1. What happens to liquid pressure as depth increases?
2. What happens to liquid pressure when the density of the liquid increases?
3. Why is pressure greater at the bottom of a liquid container than near the surface?
4. Which produces greater pressure at the same depth: a high-density liquid or a low-density liquid?
5. How does the weight of fluid above a point affect pressure at that point?
6. How do depth and density affect the pressure within a fluid?

15.13P Explain why the pressure in liquids varies with density and depth

1. Why does pressure in a liquid increase with depth?
2. Why does a denser liquid produce greater pressure at the same depth?
3. How does the mass of liquid above a point affect pressure?
4. Why does increasing depth increase the weight of liquid above a point?
5. Why would two liquids at the same depth produce different pressures if they have different densities?
6. How does the particle model of a liquid help explain why pressure depends on depth and density?

15.14P Use the equation to calculate the magnitude of the pressure in liquids and calculate the differences in pressure at different depths in a liquid: pressure due to a column of liquid (pascal, Pa) = height of column (metre, m) × density of liquid (kilogram per cubic metre, kg/m^3) × gravitational field strength (newton per kilogram, N/kg) $P = h \times \rho \times g$

1. What equation is used to calculate the pressure due to a column of liquid?
2. Calculate the pressure at a depth of 5 m in water with density 1000 kg/m^3, taking g = 10 N/kg.
3. A liquid has a density of 800 kg/m^3 and a depth of 4 m. Calculate the pressure due to the liquid, taking g = 10 N/kg.
4. A liquid produces a pressure of 30,000 Pa at a depth of 3 m. Taking g = 10 N/kg, calculate the liquid's density.

5. Water has a density of 1000 kg/m³. Calculate the difference in pressure between depths of 2 m and 7 m, taking g = 10 N/kg.
6. A liquid has a density of 1200 kg/m³. Calculate the depth required to produce a pressure of 48,000 Pa, taking g = 10 N/kg.

15.15P Explain why an object in a fluid is subject to an upwards force (upthrust) and relate this to examples including objects that are fully immersed in a fluid (liquid or gas) or partially immersed in a liquid

1. What is meant by upthrust?
2. Why does a fluid exert an upwards force on an immersed object?
3. Why is the pressure on the bottom of a fully immersed object greater than the pressure on its top?
4. How does the pressure difference between the top and bottom of an object produce upthrust?
5. Why does a partially immersed object also experience an upthrust?
6. How can upthrust act on an object immersed in a gas as well as an object immersed in a liquid?

15.16P Recall that the upthrust is equal to the weight of fluid displaced

1. What is the relationship between upthrust and the weight of displaced fluid?
2. What is meant by the fluid displaced by an immersed object?
3. An object displaces 0.02 m³ of water with density 1000 kg/m³. Taking g = 10 N/kg, calculate the upthrust.
4. An object experiences an upthrust of 50 N. What is the weight of the fluid it displaces?
5. How does the volume of fluid displaced affect the upthrust?
6. Why does an object displacing more fluid experience a greater upthrust?

15.17P Explain how the factors (upthrust, weight, density of fluid) influence whether an object will float or sink

1. What happens when the weight of an object is greater than its upthrust?
2. What happens when the upthrust on an object is greater than its weight?
3. What condition must be satisfied for an object to float in equilibrium?
4. How does the density of an object compared with the density of a fluid affect whether it floats or sinks?
5. Why does an object with a lower average density than the fluid tend to float?

6. Why does an object with a greater average density than the fluid tend to sink?