# Paper 1:

## P1: Matter

### P1.1 The Particle Model

#### P1.1a Describe how and why the atomic model has changed over time

1. What was Thomson's model of the atom called?
2. What did Rutherford discover about the structure of the atom?
3. How did the gold foil experiment change the atomic model?
4. What did Bohr add to Rutherford's model of the atom?
5. Explain why the atomic model has changed over time.
6. Compare the Thomson, Rutherford and Bohr models of the atom.

#### P1.1b Describe the atom as a positively charged nucleus surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with almost all of the mass in the nucleus

1. What is found in the centre of an atom?
2. What charge do electrons have?
3. Where is almost all of the mass of an atom found?
4. How does the size of the nucleus compare with the size of the atom?
5. Describe the structure of an atom.
6. Explain why atoms are mostly empty space.

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

1. What is the typical size of an atom?
2. State the order of magnitude of a small molecule.
3. What unit is used to measure the size of atoms?
4. Why are atoms difficult to see with the naked eye?
5. Explain what is meant by an order of magnitude.
6. A particle has a diameter of $1 \times 10^{-10}$ m. Identify the type of particle it could represent.

### P1.1d Define density

1. What is density?
2. State the equation for density.
3. What are the SI units of density?
4. What quantities are needed to calculate density?
5. A block has a mass of 2 kg and a volume of 0.001 $m^3$. Calculate its density.
6. Explain why density is a useful property of a material.

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

1. Which state of matter usually has the greatest density?
2. Why are gases much less dense than solids?
3. Describe the arrangement of particles in a liquid.
4. Explain why solids are generally denser than gases.
5. How does particle spacing affect density?
6. Compare the arrangement of particles in solids, liquids and gases and explain how this affects density.

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

1. State the equation linking density, mass and volume.
2. A substance has a mass of 4 kg and a density of 800 kg/$m^3$. Calculate its volume.
3. A metal block has a volume of 0.005 $m^3$ and a density of 2700 kg/$m^3$. Calculate its mass.
4. Explain what is meant by mass being conserved.
5. A solid melts without losing any material. Explain how its density may change even though its mass stays the same.
6. A gas is compressed without changing its mass. Explain what happens to its density.

## P1.2 Changes of State

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

1. What is meant by the conservation of mass?
2. What happens to the mass of a substance when it melts?
3. What happens to the mass of a substance when it freezes?

4. Why is mass conserved during evaporation and condensation in a closed system?
5. What is sublimation?
6. Explain why mass remains the same during changes of state.

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

1. What is a physical change?
2. What is a chemical change?
3. Why is melting ice a physical change?
4. Why is rusting iron a chemical change?
5. What happens if a physical change is reversed?
6. Compare a physical change with a chemical change.

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

1. What happens to the internal energy of a substance when it is heated?
2. What happens to the temperature of a substance when it is heated but not changing state?
3. What happens to the energy supplied during a change of state?
4. Why does the temperature stay constant during melting or boiling?
5. Explain the difference between heating a substance and changing its state.
6. Describe what happens to the particles when a substance is heated.

## P1.2d Define the term specific heat capacity and distinguish between it and the term specific latent heat

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 is specific latent heat of fusion?
5. What is specific latent heat of vaporisation?
6. Explain why energy is required during a change of state even though the temperature does not increase.

### P1.2e Apply the relationship between change in internal energy of a material and its mass, specific heat capacity and temperature change to calculate the energy change involved

1. State the equation linking thermal energy, mass, specific heat capacity and temperature change.
2. What does specific heat capacity measure?
3. A 2 kg block has a specific heat capacity of 500 J/kg°C and is heated by 10°C. Calculate the energy transferred.
4. A material gains 12 000 J of energy. Explain what happens to its internal energy.
5. Why do different materials require different amounts of energy to increase their temperature?
6. Explain how increasing the mass of a substance affects the energy needed to raise its temperature.

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

1. State the equation linking energy transferred, mass and specific latent heat.
2. What is meant by specific latent heat?
3. Calculate the energy required to melt 2 kg of a substance with a specific latent heat of fusion of 300 000 J/kg.
4. Why does the temperature remain constant during a change of state?
5. Explain why different substances have different values of specific latent heat.
6. Compare the energy required to melt a substance with the energy required to raise its temperature.

## P1.3 Pressure

### P1.3a Explain how the motion of the molecules in a gas is related both to its temperature and its pressure

1. What happens to gas particles when the temperature increases?
2. How does increasing the speed of gas particles affect the pressure of a gas?
3. Why does heating a gas in a sealed container increase its pressure?
4. Explain how gas pressure is produced.
5. Describe the relationship between the motion of gas particles and temperature.
6. Explain why cooling a gas in a closed container decreases its pressure.

## P1.3b Explain the relationship between the temperature of a gas and its pressure at constant volume (qualitative only)

1. What happens to the pressure of a gas when its temperature increases at constant volume?
2. What happens to the pressure of a gas when its temperature decreases at constant volume?
3. Why does increasing the temperature increase the pressure of a gas?
4. Why must the volume remain constant for this relationship?
5. Describe the relationship between temperature and pressure for a gas at constant volume.
6. Explain why the pressure of a gas changes even though its volume remains the same.

## P1.3c Recall that gases can be compressed or expanded by pressure changes and that the pressure produces a net force at right angles to any surface

1. Why can gases be compressed more easily than liquids?
2. What happens to the volume of a gas when the pressure increases?
3. What happens to the volume of a gas when the pressure decreases?
4. In which direction does gas pressure act on a surface?
5. Explain why gas pressure produces a force on the walls of a container.
6. Describe what happens to the particles when a gas is compressed.

## P1.3d Explain how increasing the volume in which a gas is contained, at constant temperature, can lead to a decrease in pressure

1. What happens to the pressure of a gas when its volume increases at constant temperature?
2. Why does increasing the volume reduce the pressure of a gas?
3. What happens to the frequency of particle collisions when the volume increases?
4. Explain why Boyle's law applies only at constant temperature.
5. Describe the relationship between pressure and volume for a gas at constant temperature.
6. Explain why reducing the volume of a gas increases its pressure.

## P1.3e Explain how doing work on a gas can increase its temperature

1. What is meant by doing work on a gas?
2. What happens to the temperature of a gas when it is compressed?
3. Why does compressing a gas increase its temperature?

4. Explain what happens inside a bicycle pump when air is compressed.
5. Describe the energy changes when work is done on a gas.
6. Explain why a bicycle pump becomes warm after repeated use.

### P1.3f Describe a simple model of the Earth's atmosphere and of atmospheric pressure

1. What is atmospheric pressure?
2. What causes atmospheric pressure?
3. Why does the Earth's atmosphere exert pressure on objects?
4. Describe a simple model of the Earth's atmosphere.
5. Why is the atmosphere assumed to have a uniform density in the simple model?
6. Explain how atmospheric pressure is produced.

### P1.3g Explain why atmospheric pressure varies with height above the surface of the planet

1. What happens to atmospheric pressure as height above the Earth's surface increases?
2. Why is atmospheric pressure greatest at sea level?
3. Explain why atmospheric pressure decreases with altitude.
4. Why is there less air above you at higher altitudes?
5. Describe the relationship between atmospheric pressure and height.
6. Explain why climbers experience lower atmospheric pressure on mountains.

## P1.3 Pressure

### P1.3h Describe the factors which influence floating and sinking

1. What is meant by floating?
2. What is meant by sinking?
3. How does the density of an object affect whether it floats or sinks?
4. How does the density of a liquid affect whether an object floats?
5. Explain why an object floats when the upward force is equal to its weight.
6. Describe the factors that determine whether an object will float or sink.

### P1.3i Explain why pressure in a liquid varies with depth and density and how this leads to an upwards force on a partially submerged object

1. What happens to liquid pressure as depth increases?

2. How does the density of a liquid affect its pressure?
3. Why is the pressure greater at the bottom of a submerged object than at the top?
4. What is the name of the upward force acting on an object in a liquid?
5. Explain how differences in liquid pressure produce an upward force on a partially submerged object.
6. Explain why an object experiences a greater upward force in a denser liquid.

### P1.3j Calculate the differences in pressure at different depths in a liquid

1. State the equation linking pressure difference, liquid density, gravitational field strength and depth.
2. What value should be used for gravitational field strength near the Earth's surface?
3. Calculate the pressure difference at a depth of 2 m in water of density 1000 $kg/m^3$.
4. Calculate the pressure difference between depths of 1 m and 4 m in water of density 1000 $kg/m^3$.
5. A liquid has a density of 800 $kg/m^3$. Calculate the pressure difference at a depth of 5 m.
6. Explain how increasing the depth or density of a liquid affects the pressure difference.

## P2.1 Motion

### P2.1a Describe how to measure distance and time in a range of scenarios

1. Which instrument can be used to measure a short distance accurately?
2. Which instrument can be used to measure the time taken for an event?
3. How could you measure the distance travelled by a person walking across a playground?
4. How could you measure the time taken for a trolley to travel down a ramp?
5. Why should repeated measurements be taken when measuring distance and time?
6. Describe how to measure the distance and time taken by a moving object in an investigation.

### P2.1b Describe how to measure distance and time and use these to calculate speed

1. State the equation linking speed, distance and time.
2. What units are normally used for speed?
3. A runner travels 100 m in 12.5 s. Calculate the runner's speed.
4. A car travels 450 m in 30 s. Calculate its speed.
5. Describe how you could measure the speed of a student walking along a corridor.
6. Explain how distance and time measurements can be used to calculate speed.

## P2.1c Make calculations using ratios and proportional reasoning to convert units and to compute rates

1. Convert 5 km into metres.
2. Convert 3 minutes into seconds.
3. Convert a speed of 72 km/h into m/s.
4. A cyclist travels 1500 m in 5 minutes. Calculate the cyclist's speed in m/s.
5. A car travels at 20 m/s. Calculate its speed in km/h.
6. Explain why units must be converted before using them in speed calculations.

## P2.1d Explain the vector–scalar distinction as it applies to displacement and distance, velocity and speed

1. What is a scalar quantity?
2. What is a vector quantity?
3. Why is distance a scalar quantity?
4. Why is displacement a vector quantity?
5. Explain the difference between speed and velocity.
6. A student walks 5 m east and then 5 m west. State the distance travelled and the final displacement.

## P2.1e Relate changes and differences in motion to appropriate distance–time and velocity–time graphs; interpret lines and slopes

1. What does the gradient of a distance–time graph represent?
2. What does a horizontal line on a distance–time graph show?
3. What does the gradient of a velocity–time graph represent?
4. What does a straight sloping line on a distance–time graph show?
5. Explain how acceleration is shown on a velocity–time graph.
6. Describe how a distance–time graph changes when an object moves at a greater speed.

## P2.1f Interpret enclosed area in velocity–time graphs

1. What does the area under a velocity–time graph represent?
2. How is the area under a rectangular section of a velocity–time graph calculated?
3. An object travels at 8 m/s for 5 s. Calculate the distance travelled using the graph area.
4. A velocity–time graph forms a triangle with a base of 6 s and a height of 10 m/s. Calculate the distance travelled.
5. Why can the area under a velocity–time graph be divided into simple shapes?
6. Explain how to calculate the total distance travelled from a velocity–time graph containing rectangles and triangles.

### P2.1g Calculate average speed for non-uniform motion

1. What is meant by non-uniform motion?
2. State the equation used to calculate average speed.
3. A cyclist travels 600 m in 40 s. Calculate the average speed.
4. A runner completes 5 km in 25 minutes. Calculate the average speed in m/s.
5. Why may an object's instantaneous speed differ from its average speed?
6. A car travels 20 km in 30 minutes and then 40 km in 45 minutes. Calculate its average speed for the whole journey.

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

1. What is meant by uniform motion?
2. State the equation linking distance, speed and time for uniform motion.
3. A train travels at a constant speed of 25 m/s for 40 s. Calculate the distance travelled.
4. A car travels 300 m at a constant speed of 15 m/s. Calculate the time taken.
5. An object accelerates uniformly from 4 m/s to 16 m/s in 6 s. Calculate its average speed.
6. An object accelerates uniformly from rest to 20 m/s in 8 s. Calculate the distance travelled.

## P2.2 Newton's Laws

## P2.2a Recall examples of ways in which objects interact

1. What is meant by an interaction between two objects?
2. Give an example of an interaction caused by gravity.
3. Give an example of an interaction caused by electrostatic forces.
4. Give an example of an interaction caused by magnetic forces.
5. Give two examples of contact forces.
6. State whether gravity, friction and normal contact force are contact or non-contact forces.

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

1. What happens when two objects interact?
2. Why do forces always act in pairs?
3. Explain what happens when you push against a wall.
4. Describe the pair of forces acting when a person stands on the ground.
5. Explain the forces acting between a book and a table.
6. Describe how two interacting objects each experience a force.

## P2.2c Represent forces as vectors

1. What is meant by a vector quantity?
2. What two pieces of information are needed to represent a force as a vector?
3. How is the direction of a force shown on a force diagram?
4. Why is force described as a vector quantity?
5. Draw and label the forces acting on a book resting on a table.
6. Explain why vector diagrams are useful when analysing forces.

## P2.2d Apply Newton's First Law to explain the motion of an object moving with uniform velocity and also an object where the speed and/or direction change

1. State Newton's First Law of Motion.
2. What happens to an object if the resultant force acting on it is zero?
3. Why does a passenger move forwards when a car brakes suddenly?
4. Explain why an object moving at constant velocity has zero resultant force.
5. Describe what happens when the resultant force on an object is no longer zero.
6. Explain how Newton's First Law applies to a car travelling around a bend.

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

1. What is meant by the resultant force?
2. What does it mean if an object is in equilibrium?
3. Two forces of 8 N and 5 N act in opposite directions. Calculate the resultant force.
4. Draw a vector diagram to show two equal and opposite forces acting on an object.
5. Explain how vector diagrams can be used to find the resultant force.
6. Describe the forces acting on an object that is in equilibrium.

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

1. What forces act on a skydiver before reaching terminal velocity?
2. What forces act on a car travelling at constant speed on a level road?
3. What forces act on a book resting on a table?
4. Describe the forces acting on a cyclist moving along a flat road.
5. Explain why the forces acting on a stationary object are balanced.
6. Describe the forces acting on a falling object after it reaches terminal velocity.

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

1. What is a free body diagram?
2. What information is shown on a free body diagram?
3. Draw a free body diagram for a box being pushed along the floor.
4. Explain how a free body diagram can be used to identify the resultant force.
5. Describe the forces acting on a parachutist before the parachute opens using a free body diagram.
6. Draw a free body diagram for a book resting on a table.

## P2.2h Describe, using free body diagrams, examples of special case where forces balance to produce a resultant force of zero (qualitative only)

1. What is meant by balanced forces?
2. What is the resultant force when forces are balanced?
3. Give an example of an object with balanced forces acting on it.
4. Draw a free body diagram for a stationary object.

5. Explain why an object moving at constant velocity has balanced forces.
6. Describe how a free body diagram shows that forces are balanced.

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

1. State the equation linking force, mass and acceleration.
2. A 5 kg object accelerates at 4 $m/s^2$. Calculate the resultant force.
3. A force of 36 N acts on an object with a mass of 9 kg. Calculate its acceleration.
4. A force of 50 N produces an acceleration of 10 $m/s^2$. Calculate the mass of the object.
5. Explain how increasing the mass affects the acceleration when the force remains constant.
6. Explain why a larger resultant force produces a greater acceleration for the same mass.

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

1. What is meant by inertia?
2. Which object has greater inertia: a car or a bicycle?
3. Why is it more difficult to accelerate a lorry than a car?
4. What is meant by inertial mass?
5. State the relationship between inertial mass, force and acceleration.
6. Explain why objects with greater mass have greater inertia.

## P2.2k Define momentum and describe examples of momentum in collisions

1. What is momentum?
2. State the equation used to calculate momentum.
3. What are the units of momentum?
4. Explain what happens to momentum during a collision in a closed system.
5. Give an example of momentum in a road traffic collision.
6. Describe the law of conservation of momentum.

## P2.2l Apply formulae relating force, mass, velocity and acceleration to explain how the changes involved are inter-related

1. State the equation linking force, mass and acceleration.
2. State the equation linking momentum, mass and velocity.

3. A 4 kg object accelerates at 3 $m/s^2$. Calculate the resultant force.
4. A 6 kg object travels at 5 m/s. Calculate its momentum.
5. Explain how increasing the force affects the acceleration of an object with constant mass.
6. Explain how increasing the mass affects both acceleration and momentum.

## P2.2m Use the relationship between work done, force, and distance moved along the line of action of the force and describe the energy transfer involved

1. State the equation linking work done, force and distance.
2. What are the units of work done?
3. A force of 20 N moves an object 5 m. Calculate the work done.
4. Describe the energy transfer when work is done lifting an object.
5. Explain what happens to the energy of an object when work is done against friction.
6. Explain why work done is equal to the energy transferred.

## P2.2n Calculate relevant values of stored energy and energy transfers; convert between newton-metres and joules

1. What is the SI unit of energy?
2. How many joules are equal to 15 newton-metres?
3. How many newton-metres are equal to 250 J?
4. A machine transfers 800 J of energy. State this value in newton-metres.
5. Explain why 1 J is equal to 1 N m.
6. Describe how energy is transferred when work is done.

## P2.2o Explain, with reference to examples, the definition of power as the rate at which energy is transferred

1. What is power?
2. State the equation linking power, energy transferred and time.
3. What is the unit of power?
4. A motor transfers 1200 J of energy in 60 s. Calculate its power.
5. Explain why a more powerful kettle boils water more quickly.
6. Describe what is meant by the rate of energy transfer.

## P2.2p Recall and apply Newton's Third Law

1. State Newton's Third Law.
2. What happens when one object exerts a force on another object?
3. Give an example of Newton's Third Law involving walking.

4. Explain how a rocket launches using Newton's Third Law.
5. Describe the action and reaction forces when a swimmer pushes against the water.
6. Explain why action and reaction forces do not cancel each other out.

### P2.2q Explain why an object moving in a circle with a constant speed has a changing velocity (qualitative only)

1. Why does an object moving in a circle have a changing velocity?
2. What happens to the direction of velocity during circular motion?
3. Does the speed of an object moving in a circle at constant speed change?
4. Explain why velocity is a vector quantity.
5. Give an example of an object moving with constant speed in a circle.
6. Explain why an object moving in a circle is accelerating even when its speed remains constant.

## P2.3 Forces in Action

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

1. What must happen to stretch an object?
2. What must happen to compress an object?
3. Why can't a single force acting alone stretch a spring?
4. Describe the forces acting when a rubber band is stretched.
5. Explain why bending an object requires more than one force.
6. Give an everyday example where two or more forces stretch, bend or compress an object.

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

1. What is elastic deformation?
2. What is plastic deformation?
3. What happens to an object after elastic deformation when the force is removed?
4. What happens to an object after plastic deformation when the force is removed?
5. Give an example of a material that shows elastic deformation.
6. Compare elastic deformation with plastic deformation.

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

1. What happens to the extension of a spring as the force increases?
2. What is meant by the extension of a spring?
3. State the relationship between force and extension before the limit of proportionality.
4. How is the relationship between force and extension shown on a graph?
5. Describe what happens to the spring when the force is removed before the elastic limit.
6. Explain the relationship between force and extension for a spring.

## P2.3d Describe the difference between linear and non-linear relationships between force and extension

1. What is a linear relationship?
2. What is a non-linear relationship?
3. What does a straight-line force-extension graph show?
4. What does a curved force-extension graph show?
5. Explain why the graph becomes non-linear after the limit of proportionality.
6. Compare linear and non-linear force-extension graphs.

## P2.3e Calculate a spring constant in linear cases

1. State the equation linking force, spring constant and extension.
2. What are the units of spring constant?
3. A spring extends 0.20 m when a force of 10 N is applied. Calculate the spring constant.
4. A spring has a spring constant of 400 N/m and extends by 0.05 m. Calculate the force applied.
5. A force of 15 N stretches a spring with a spring constant of 300 N/m. Calculate the extension.
6. Explain what a large spring constant tells you about a spring.

## P2.3f Calculate the work done in stretching

1. What is meant by work done?
2. State the equation used to calculate the work done in stretching a spring.
3. Calculate the work done when a 12 N force stretches a spring by 0.30 m.
4. A spring stores 8 J of energy when stretched. State the work done.
5. Explain where the energy is stored when a spring is stretched.
6. Describe the relationship between work done and elastic potential energy.

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

1. What is a gravitational field?
2. Why do all objects attract each other gravitationally?
3. Which objects produce the strongest gravitational fields?
4. Why does the Earth have a much stronger gravitational field than the Moon?
5. Explain how mass affects gravitational field strength.
6. Describe the relationship between mass and gravitational attraction.

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

1. What is weight?
2. What instrument is used to measure weight?
3. What are the units of weight?
4. State the equation linking weight, mass and gravitational field strength.
5. What is the value of gravitational field strength on Earth?
6. Explain how the weight of an object changes on different planets.

## P2.3i Recall the acceleration in free fall

1. What is meant by free fall?
2. What is the acceleration due to gravity on Earth?
3. Why do objects accelerate during free fall?
4. What force causes free fall?
5. Explain why objects in free fall accelerate at the same rate when air resistance is negligible.
6. Describe what happens to the speed of an object during free fall.

## P2.3j Apply formulae relating force, mass and relevant physical constants, including gravitational field strength, g, to explore how changes in these are inter-related

1. State the equation linking weight, mass and gravitational field strength.
2. Calculate the weight of a 5 kg object on Earth.
3. Calculate the mass of an object with a weight of 120 N on Earth.
4. Explain how weight changes if gravitational field strength increases.
5. Explain why an object's mass remains constant when it is taken to another planet.
6. Compare the weight of the same object on Earth and the Moon.

## P2.3k Describe examples in which forces cause rotation

1. What is meant by rotation?
2. What is a pivot?
3. Give an example of a force causing rotation.
4. What determines whether an object rotates clockwise or anticlockwise?
5. Explain why pushing a door near its handle makes it easier to open.
6. Describe how forces produce a turning effect.

## P2.3l Define and calculate the moment of a force

1. What is meant by the moment of a force?
2. State the equation used to calculate a moment.
3. What are the units of moment?
4. Calculate the moment produced by a 20 N force acting 0.5 m from a pivot.
5. Calculate the force needed to produce a moment of 15 Nm at a distance of 0.3 m.
6. Explain the principle of moments for a balanced object.

## P2.3m Explain how levers and gears transmit the rotational effects of forces

1. What is a lever?
2. What is the purpose of a gear?
3. How can a lever act as a force multiplier?
4. Why are gears of different sizes used together?
5. Explain how gears change rotational speed.
6. Describe how levers and gears make work easier.

## P2.3n Recall that the pressure in fluids (gases and liquids) causes a net force at right angles to any surface

1. In which direction does fluid pressure act on a surface?
2. Do gases exert pressure?
3. Do liquids exert pressure?
4. Why does pressure produce a force on the walls of a container?
5. Explain why fluid pressure acts in all directions.
6. Describe how pressure in a fluid produces a net force on a surface.

## P2.3o Use the relationship between the force, the pressure and the area in contact

1. State the equation linking pressure, force and area.
2. What are the units of pressure?

3. Calculate the pressure produced by a force of 100 N acting on an area of 0.5 $m^2$.
4. Calculate the force produced by a pressure of 5000 Pa acting over an area of 0.2 $m^2$.
5. Explain why increasing the contact area reduces pressure.
6. Describe how a simple hydraulic system works using pressure.

# P3: Electricity

## P3.1 Static and Charge

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

1. What is meant by electric charge?
2. State the two types of electric charge.
3. What type of charge does a proton have?
4. What type of charge does an electron have?
5. Explain why most bodies have zero net charge.
6. A body contains equal numbers of positive and negative charges. State its overall charge.

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

1. Describe how rubbing two insulating surfaces can produce static electricity.
2. State the type of material on which static charge can build up.
3. What happens when two objects with like charges are brought close together?
4. What happens when two objects with opposite charges are brought close together?
5. Explain how a spark can be produced between a charged object and another object.

6. Describe one experiment that provides evidence that charged objects exert forces when they are not touching.

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

1. Which subatomic particles are transferred when objects become statically charged?
2. What charge does an object gain when it gains electrons?
3. What charge does an object gain when it loses electrons?
4. Explain why positive charge does not move between objects during static charging.
5. Two insulating materials are rubbed together. Explain how they become oppositely charged.
6. Explain static electricity in terms of the transfer of electrons between objects.

## P3.1d Explain the concept of an electric field and how it helps to explain the phenomena of static electricity

1. What is an electric field?
2. Where is an electric field found?
3. Explain how an electric field can exert a force on a charged object.
4. How do electric fields help to explain attraction between opposite charges?
5. How do electric fields help to explain repulsion between like charges?
6. Explain how two charged objects can exert forces on each other without being in contact.

## P3.1e Recall that current is a rate of flow of charge (electrons) and the conditions needed for charge to flow

1. What is electric current?
2. Which particles carry charge through a metal wire?
3. State the two conditions needed for charge to flow through a circuit.
4. Why is a source of potential difference needed for charge to flow?
5. Why must a circuit be closed for current to flow?
6. Explain why no current flows when a switch in a circuit is open.

## P3.1f Recall that current has the same value at any point in a single closed loop

1. State how the current changes around a single closed loop.

2. A current of 0.4 A enters a lamp in a single closed loop. What current leaves the lamp?
3. Two ammeters are placed at different points in a single closed loop. Compare their readings.
4. Explain why charge does not become used up as it passes through a component.
5. A current of 2.5 A passes through a battery in a single closed loop. State the current through every other point in the loop.
6. Describe the current at different points in a series circuit containing a cell and two resistors.

### P3.1g Recall and use the relationship between quantity of charge, current and time

1. State the equation linking quantity of charge, current and time.
2. State the unit used to measure quantity of charge.
3. Calculate the charge transferred when a current of 3 A flows for 20 s.
4. Calculate the current when 240 C of charge flows in 80 s.
5. Calculate the time taken for 500 C of charge to flow at a current of 4 A.
6. A current increases while the time remains constant. Explain how this affects the quantity of charge transferred.

## P3.2 Simple Circuits

### P3.2a Describe the differences between series and parallel circuits

1. What is meant by a series circuit?
2. What is meant by a parallel circuit?
3. Compare the current in series and parallel circuits.
4. Compare the potential difference in series and parallel circuits.
5. Where should an ammeter be positioned in a circuit?
6. Where should a voltmeter be positioned in a circuit?

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

1. Draw the circuit symbol for a cell.
2. Draw the circuit symbol for an ammeter.
3. Draw the circuit symbol for a voltmeter.
4. Draw the circuit symbols for a fixed resistor and a variable resistor.
5. Draw the circuit symbols for a diode, filament lamp, LDR and NTC thermistor.

6. Draw a circuit diagram containing a cell, switch, resistor and ammeter, showing the positive and negative terminals correctly.

## P3.2c Recall that current, I, depends on both resistance, R, and potential difference, V, and the units in which these are measured

1. What is the symbol used for current?
2. State the unit used to measure current.
3. State the unit used to measure resistance.
4. State the unit used to measure potential difference.
5. Define potential difference.
6. Describe how changing resistance or potential difference can affect the current in a circuit.

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

1. State the equation linking potential difference, current and resistance.
2. Calculate the potential difference across a 6 Ω resistor carrying a current of 2 A.
3. Calculate the current through a 20 Ω resistor connected across 10 V.
4. Calculate the resistance of a component when the potential difference is 12 V and the current is 0.4 A.
5. What is meant by a resistor having a constant resistance?
6. Explain why the resistance of some components changes as the current changes.

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

1. What happens to the resistance of an ohmic conductor when its current changes at constant temperature?
2. Give an example of a component whose resistance changes as the current changes.
3. Explain why the resistance of a filament lamp changes as the current increases.
4. Compare the resistance behaviour of a fixed resistor and a filament lamp.
5. Explain why not all electrical components have a constant resistance.
6. Describe how measurements of current and potential difference can be used to determine whether resistance is constant.

## P3.2f Explain the design and use of circuits to explore such effects

1. Describe a circuit that could be used to investigate the resistance of a component.
2. Where should the ammeter be connected when investigating a component?
3. Where should the voltmeter be connected when investigating a component?
4. Explain how a variable resistor can be used to change the current in an investigation.
5. Describe how you could investigate the current and potential difference for a filament lamp.
6. Explain how circuits can be used to investigate wires, diodes, NTC thermistors and LDRs.

## P3.2g Use graphs to explore whether circuit elements are linear or non-linear

1. What is meant by a linear circuit element?
2. What is meant by a non-linear circuit element?
3. What shape of current-potential difference graph would indicate a linear relationship?
4. How can a graph be used to identify a non-linear circuit element?
5. A resistor produces a straight-line current-potential difference graph through the origin. What does this show?
6. Compare the current-potential difference graphs of linear and non-linear components.

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

1. Describe the shape of the current-potential difference graph for a fixed resistor at constant temperature.
2. Describe the shape of the current-potential difference graph for a filament lamp.
3. Describe the current-potential difference graph for a diode.
4. Explain what the graph for a filament lamp shows about its resistance.
5. Explain what the graph for a diode shows about the direction in which it conducts current.
6. Use the shape of a current-potential difference graph to identify whether a component could be a resistor, filament lamp or diode.

## P3.2i Explain why, if two resistors are in series the net resistance is increased, whereas with two in parallel the net resistance is decreased (qualitative explanation only)

1. What happens to the total resistance when another resistor is added in series?
2. What happens to the total resistance when another resistor is added in parallel?
3. Explain why two resistors in series have a greater net resistance than either resistor alone.
4. Explain why adding another parallel branch decreases the net resistance.
5. Compare the net resistance of two resistors connected in series with the same resistors connected in parallel.
6. Explain qualitatively how the number of available paths for current affects the net resistance.

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

1. Two resistors of 4 Ω and 6 Ω are connected in series. Calculate their total resistance.
2. A 12 V supply is connected to a series circuit with a total resistance of 6 Ω. Calculate the current.
3. Two identical parallel branches each carry a current of 0.5 A. Calculate the total current from the supply.
4. A resistor has a potential difference of 8 V and carries a current of 2 A. Calculate its resistance.
5. Calculate the potential difference across a 10 Ω resistor carrying a current of 0.3 A.
6. Explain how current and potential difference are distributed in series and parallel circuits.

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

1. Explain how an ammeter should be connected to measure the current through a component.
2. Explain how a voltmeter should be connected to measure the potential difference across a component.
3. Describe how a circuit could be designed to measure the resistance of a resistor.
4. Explain how a variable resistor can be used when testing an electrical component.
5. Describe how a d.c. circuit could be used to test the behaviour of an LDR.
6. Describe how a d.c. circuit could be used to test the behaviour of an NTC thermistor.

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

1. State the equation linking power, potential difference and current.
2. What is meant by electrical power?
3. Calculate the power of a device operating at 12 V with a current of 3 A.
4. A device transfers 600 J of energy in 20 s. Calculate its power.
5. Explain how increasing the potential difference can affect the power transferred by a device.
6. Explain the relationship between power, energy transferred and time.

### P3.2m Apply the equations relating potential difference, current, quantity of charge, resistance, power, energy, and time, and solve problems for circuits which include resistors in series, using the concept of equivalent resistance

1. A current of 2 A flows for 40 s. Calculate the charge transferred.
2. A 12 V supply produces a current of 3 A through a resistor. Calculate the resistance.
3. A device operates at 6 V and draws a current of 4 A. Calculate its power.
4. A 50 W device operates for 30 s. Calculate the energy transferred.
5. Two resistors of 5 Ω and 7 Ω are connected in series. Calculate their equivalent resistance and the current when connected to a 24 V supply.
6. A charge of 120 C passes through a component with a potential difference of 10 V. Calculate the energy transferred.

# P4: Magnetism and Magnetic Fields

## P4.1 Magnets and Magnetic Fields

### P4.1a Describe the attraction and repulsion between unlike and like poles for permanent magnets

1. What happens when two north poles are brought close together?
2. What happens when two south poles are brought close together?
3. What happens when a north pole is brought close to a south pole?
4. State the rule for the interaction between like magnetic poles.
5. State the rule for the interaction between unlike magnetic poles.

6. Sketch the magnetic field pattern between two bar magnets positioned so that they attract each other.

## P4.1b Describe the difference between permanent and induced magnets

1. What is a permanent magnet?
2. What is an induced magnet?
3. What happens to an induced magnet when it is removed from a magnetic field?
4. Compare the magnetic properties of permanent and induced magnets.
5. Explain how an unmagnetised magnetic material can become an induced magnet.
6. Describe one situation in which induced magnetism occurs.

## P4.1c Describe the characteristics of the magnetic field of a magnet, showing how strength and direction change from one point to another

1. What is meant by a magnetic field?
2. In which direction do magnetic field lines point outside a bar magnet?
3. Where is the magnetic field around a bar magnet strongest?
4. How does the spacing of magnetic field lines indicate the strength of the field?
5. Describe how a plotting compass can be used to determine the direction of a magnetic field.
6. Sketch the magnetic field pattern around a bar magnet and indicate its direction.

## P4.1d Explain how the behaviour of a magnetic (dipping) compass is related to evidence that the core of the Earth must be magnetic

1. What happens to a compass needle when it is free to rotate?
2. Why does a compass needle point approximately north-south?
3. What does the behaviour of a compass show about the Earth?
4. What is a dipping compass?
5. Explain how a dipping compass provides evidence for the Earth's magnetic field.
6. Explain why the behaviour of magnetic compasses provides evidence that the core of the Earth must be magnetic.

## P4.1e Describe how to show that a current can create a magnetic effect and describe the directions of the magnetic field around a conducting wire

1. Describe an experiment that shows a current-carrying wire produces a magnetic field.
2. What happens to a plotting compass placed near a wire when current flows through the wire?
3. Describe the shape of the magnetic field around a straight current-carrying wire.
4. How can the direction of the magnetic field around a conducting wire be determined?
5. What happens to the direction of the magnetic field if the direction of the current is reversed?
6. Describe how plotting compasses can be used to map the magnetic field around a current-carrying wire.

## P4.1f Recall that the strength of the field depends on the current and the distance from the conductor

1. What happens to the magnetic field strength when the current in a conductor increases?
2. What happens to the magnetic field strength as the distance from the conductor increases?
3. A current through a wire is doubled. State how this affects the magnetic field around the wire.
4. Compare the magnetic field strength at a point close to a conducting wire with a point further away.
5. State the two factors that affect the strength of the magnetic field around a current-carrying conductor.
6. Explain how you could increase the magnetic field strength at a fixed distance from a conducting wire.

## P4.1g Explain how solenoid arrangements can enhance the magnetic effect

1. What is a solenoid?
2. Describe the magnetic field produced by a current-carrying solenoid.
3. How does increasing the current through a solenoid affect its magnetic effect?
4. How can increasing the number of turns in a solenoid affect its magnetic field?

5. Explain why coiling a wire into a solenoid produces a stronger magnetic effect than a single straight wire.
6. Describe how the magnetic effect of a solenoid can be increased.

# P4.2 Uses of Magnetism

## P4.2a Describe how a magnet and a current-carrying conductor exert a force on one another

1. What happens when a current-carrying conductor is placed in a magnetic field?
2. What two fields interact to produce a force on a current-carrying conductor?
3. What happens to the force if the direction of the current is reversed?
4. What happens to the force if the direction of the magnetic field is reversed?
5. Describe the force exerted between a magnet and a current-carrying conductor.
6. Describe an experiment that demonstrates the force acting on a current-carrying conductor in a magnetic field.

## P4.2b Show that Fleming's left-hand rule represents the relative orientations of the force, the current and the magnetic field

1. What is Fleming's left-hand rule used to determine?
2. Which finger represents the magnetic field in Fleming's left-hand rule?
3. Which finger represents the current in Fleming's left-hand rule?
4. Which finger represents the force in Fleming's left-hand rule?
5. What is the angle between the force, current and magnetic field when Fleming's left-hand rule is applied?
6. Use Fleming's left-hand rule to determine the direction of the force when the directions of the current and magnetic field are given.

## P4.2c Apply the equation that links the force on a conductor to the magnetic flux density, the current and the length of conductor to calculate the forces involved

1. State the equation linking force, magnetic flux density, current and length of conductor.
2. State the unit of magnetic flux density.
3. Calculate the force on a 0.5 m conductor carrying a current of 4 A at right angles to a magnetic field of flux density 0.2 T.

4. Calculate the magnetic flux density when a 0.4 m conductor carrying 5 A experiences a force of 0.6 N.
5. Calculate the current required for a 0.25 m conductor in a 0.8 T magnetic field to experience a force of 1 N.
6. Explain how increasing the current or length of conductor in the magnetic field affects the force.

## P4.2d Explain how the force exerted from a magnet and a current-carrying conductor is used to cause rotation in electric motors

1. What causes a force to act on a current-carrying coil in an electric motor?
2. Why do the forces on opposite sides of a current-carrying coil act in opposite directions?
3. How do these forces cause the coil to rotate?
4. What happens to the direction of rotation if the current is reversed?
5. What happens to the direction of rotation if the magnetic field is reversed?
6. Explain how the interaction between a magnetic field and a current-carrying conductor causes rotation in an electric motor.

## P4.2e Recall that a change in the magnetic field around a conductor can give rise to an induced potential difference across its ends, which could drive a current, generating a magnetic field that would oppose the original change

1. What can be induced across a conductor when the magnetic field around it changes?
2. What can an induced potential difference cause if the conductor forms part of a complete circuit?
3. How can a magnet and conductor be moved to produce an induced potential difference?
4. What happens to the induced potential difference if the magnetic field changes more rapidly?
5. What magnetic field is produced when an induced current flows?
6. Explain how the magnetic field produced by an induced current opposes the original change that produced it.

## P4.2f Explain how this effect is used in an alternator to generate a.c., and in a dynamo to generate d.c.

1. What type of current is generated by an alternator?
2. What type of current is generated by a dynamo?

3. How does electromagnetic induction allow an alternator to generate a potential difference?
4. Why does an alternator produce an alternating current?
5. How does a dynamo produce a direct current?
6. Compare the electrical outputs of an alternator and a dynamo.

## P4.2g Explain how the effect of an alternating current in one circuit, in inducing a current in another, is used in transformers

1. What type of current must flow in the primary coil of a transformer?
2. What happens to the magnetic field around the primary coil when an alternating current flows?
3. How does the changing magnetic field induce a potential difference in the secondary coil?
4. Why would a steady direct current not continuously induce a potential difference in the secondary coil?
5. What is the purpose of the iron core in a transformer?
6. Explain how an alternating current in the primary circuit can induce a current in a separate secondary circuit.

## P4.2h Explain how the ratio of the potential differences across the two coils in a transformer depends on the ratio of the numbers of turns in each

1. What determines whether a transformer increases or decreases potential difference?
2. What is a step-up transformer?
3. What is a step-down transformer?
4. What happens to the potential difference if the secondary coil has more turns than the primary coil?
5. What happens to the potential difference if the secondary coil has fewer turns than the primary coil?
6. Explain the relationship between the ratio of potential differences and the ratio of the numbers of turns in a transformer.

## P4.2i Apply the equations linking the potential differences and numbers of turns in the two coils of a transformer

1. State the equation linking primary potential difference, secondary potential difference, primary turns and secondary turns.
2. A transformer has 100 turns on the primary coil and 500 turns on the secondary coil. The primary potential difference is 12 V. Calculate the secondary potential difference.

3. A transformer has a primary potential difference of 230 V and a secondary potential difference of 23 V. The primary coil has 1000 turns. Calculate the number of turns on the secondary coil.
4. A transformer has 200 turns on its primary coil and 50 turns on its secondary coil. Calculate the secondary potential difference when the primary potential difference is 240 V.
5. A transformer produces 24 V from a 240 V supply. Calculate the ratio of secondary turns to primary turns.
6. Determine whether a transformer is step-up or step-down from given values of potential difference and number of turns.

### P4.2j 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. What causes the diaphragm of a dynamic microphone to vibrate?
2. How does movement of the coil in a dynamic microphone produce an electrical signal?
3. How do variations in sound pressure produce variations in current in a microphone circuit?
4. What happens when a varying current passes through the coil of a loudspeaker?
5. How does the movement of a loudspeaker cone produce sound waves?
6. Compare the energy transfers and processes occurring in a dynamic microphone and a loudspeaker.

# Paper 2:

# P5: Waves in Matter

## P5.1 Wave Behaviour

### P5.1a Describe wave motion in terms of amplitude, wavelength, frequency and period

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

4. What is the period of a wave?
5. How does increasing the amplitude change the appearance of a wave?
6. Identify the amplitude and wavelength on a diagram of a wave.

## P5.1b Define wavelength and frequency

1. Define wavelength.
2. What is the unit of wavelength?
3. Define frequency.
4. What is the unit of frequency?
5. What does a frequency of 50 Hz mean?
6. Explain the difference between wavelength and frequency.

## P5.1c Describe and apply the relationship between wavelength, frequency and wave velocity

1. State the relationship between wave velocity, frequency and wavelength.
2. What happens to wavelength if frequency increases while wave velocity remains constant?
3. What happens to frequency if wavelength increases while wave velocity remains constant?
4. A wave has a frequency of 10 Hz and a wavelength of 2 m. Calculate its velocity.
5. A wave travels at 300 m/s and has a frequency of 100 Hz. Calculate its wavelength.
6. Explain the relationship between wavelength and frequency for waves travelling at constant velocity.

## P5.1d Apply formulae relating velocity, frequency and wavelength

1. State the equation linking wave velocity, frequency and wavelength.
2. Calculate the velocity of a wave with a frequency of 25 Hz and a wavelength of 4 m.
3. Calculate the frequency of a wave travelling at 600 m/s with a wavelength of 3 m.
4. Calculate the wavelength of a wave travelling at 340 m/s with a frequency of 170 Hz.
5. A wave has a wavelength of 0.5 m and travels at 20 m/s. Calculate its frequency.
6. A wave has a frequency of 2.5 kHz and a wavelength of 0.12 m. Calculate its velocity in m/s.

## P5.1e Describe differences between transverse and longitudinal waves

1. What is a transverse wave?
2. What is a longitudinal wave?
3. In which direction do particles vibrate in a transverse wave compared with the direction of wave travel?
4. In which direction do particles vibrate in a longitudinal wave compared with the direction of wave travel?
5. Give one example of a transverse wave and one example of a longitudinal wave.
6. Compare the direction of vibration and direction of travel in transverse and longitudinal waves.

## P5.1f Show how changes, in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related

1. What can happen to the velocity of a sound wave when it enters a different medium?
2. What happens to the frequency of a sound wave when it passes from one medium into another?
3. What happens to the wavelength if the velocity changes but the frequency remains constant?
4. A sound wave slows down as it enters a different medium. Explain what happens to its wavelength.
5. A sound wave enters a medium in which it travels faster. Explain what happens to its wavelength.
6. Use the wave equation to explain how velocity, frequency and wavelength are related when sound passes from one medium to another.

## P5.1g Describe the effects of reflection, transmission, and absorption of waves at material interfaces

1. What is meant by reflection of a wave?
2. What is meant by transmission of a wave?
3. What is meant by absorption of a wave?
4. What can happen when a wave reaches the boundary between two materials?
5. Explain how reflected ultrasound waves can be used to produce an image.
6. Explain how reflection of sound waves is used in sonar.

## P5.1h Describe, with examples, processes which convert wave disturbances between sound waves and vibrations in solids

1. How can vibrations in a solid produce sound waves in air?

2. How can sound waves in air cause a solid object to vibrate?
3. What happens to the eardrum when sound waves enter the ear?
4. How are vibrations transferred through the structures of the ear?
5. Explain how a loudspeaker converts vibrations of a solid into sound waves.
6. Describe one process in which sound waves are converted into vibrations in a solid and one in which vibrations in a solid are converted into sound waves.

## P5.1i Explain why such processes only work over a limited frequency range, and the relevance of this to human hearing

1. What is meant by the frequency range of human hearing?
2. Why can humans not hear every possible sound frequency?
3. What is the approximate frequency range of normal human hearing?
4. Why are very high-frequency sounds inaudible to humans?
5. How can ageing affect the range of frequencies a person can hear?
6. Explain why the conversion of sound waves into vibrations in the ear only works over a limited frequency range.

## P5.1j Describe how ripples on water surfaces are used to model transverse waves whilst sound waves in air are longitudinal waves, and how the speed of each may be measured

1. Why can ripples on a water surface be used to model transverse waves?
2. Why are sound waves in air described as longitudinal waves?
3. Describe how the speed of water waves can be measured using a ripple tank.
4. Describe how the speed of sound in air can be measured.
5. What measurements are needed to calculate the speed of ripples on water?
6. Compare the particle vibrations in water surface waves with those in sound waves in air.

## P5.1k Describe evidence for the cases of ripples on water surfaces and for sound waves in air that it is the wave that travels and not the water or the air

1. What travels through a medium when a wave passes through it?
2. Does the water itself travel across a ripple tank with the wave?
3. How can a floating object provide evidence that water particles do not travel with a water wave?
4. Do air particles travel from a sound source all the way to the listener?
5. Describe how air particles move as a sound wave passes through the air.

6. Explain the evidence that waves transfer energy while the particles of the medium only oscillate about their positions.

# P5.2 The Electromagnetic Spectrum

## P5.2a Recall that electromagnetic waves are transverse and are transmitted through space where all have the same velocity

1. What type of waves are electromagnetic waves?
2. Can electromagnetic waves travel through a vacuum?
3. What is the velocity of electromagnetic waves in a vacuum?
4. Compare the velocities of radio waves and gamma rays in a vacuum.
5. Explain why electromagnetic waves can travel through space.
6. State two properties that all electromagnetic waves have in common.

## P5.2b Explain that electromagnetic waves transfer energy from source to absorber

1. What do electromagnetic waves transfer?
2. Where does the energy carried by an electromagnetic wave originate?
3. What happens to the energy when an electromagnetic wave is absorbed?
4. Give an example of an electromagnetic wave transferring energy to an absorber.
5. Explain how infrared radiation can transfer energy from a source to an object.
6. Describe the energy transfer that occurs when electromagnetic radiation is absorbed by matter.

## P5.2c Apply the relationships between frequency and wavelength across the electromagnetic spectrum

1. What happens to wavelength as frequency increases across the electromagnetic spectrum?
2. Which electromagnetic waves have the longest wavelengths?
3. Which electromagnetic waves have the highest frequencies?
4. Compare the wavelength and frequency of radio waves with gamma rays.
5. Explain the relationship between frequency and wavelength for electromagnetic waves travelling at the same velocity.
6. Use the wave equation to explain why a shorter wavelength corresponds to a higher frequency.

## P5.2d Describe the main groupings of the electromagnetic spectrum and that these groupings range from long to short wavelengths and from low to high frequencies

1. List the seven main regions of the electromagnetic spectrum in order of increasing frequency.
2. Which region of the electromagnetic spectrum has the longest wavelength?
3. Which region of the electromagnetic spectrum has the shortest wavelength?
4. State the order of the colours of visible light from lowest to highest frequency.
5. Place microwaves, ultraviolet and infrared in order of increasing frequency.
6. Describe how wavelength and frequency change from radio waves to gamma rays across the electromagnetic spectrum.

## P5.2e Describe that our eyes can only detect a limited range of the electromagnetic spectrum

1. Which part of the electromagnetic spectrum can the human eye detect?
2. Which colour of visible light has the longest wavelength?
3. Which colour of visible light has the shortest wavelength?
4. Can the human eye directly detect infrared radiation?
5. Can the human eye directly detect ultraviolet radiation?
6. Explain what is meant by saying that visible light is only a limited range of the electromagnetic spectrum.

## P5.2f Recall that light is an electromagnetic wave

1. What type of wave is visible light?
2. Is light a transverse or longitudinal wave?
3. Can light travel through a vacuum?
4. What is the approximate speed of light in a vacuum?
5. State where visible light is found within the electromagnetic spectrum.
6. State two properties that visible light shares with all other electromagnetic waves.

## P5.2g Give examples of some practical uses of electromagnetic waves in the radio, microwave, infrared, visible, ultraviolet, X-ray and gamma ray regions

1. Give two practical uses of radio waves.
2. Give two practical uses of microwaves.
3. Give one practical use of infrared radiation and one use of visible light.

4. Give two practical uses of ultraviolet radiation.
5. Give two practical uses of X-rays.
6. Give two practical uses of gamma rays.

## P5.2h Describe how ultraviolet waves, X-rays and gamma rays can have hazardous effects, notably on human bodily tissues

1. Why can ultraviolet radiation be hazardous to human tissue?
2. State one harmful effect of excessive exposure to ultraviolet radiation.
3. Why can X-rays damage living cells?
4. Why can gamma rays damage living tissue?
5. Explain why exposure to ionising electromagnetic radiation should be limited.
6. Compare the potential hazards of ultraviolet, X-ray and gamma radiation to human bodily tissues.

## P5.2i Explain, in qualitative terms, how the differences in velocity, absorption and reflection between different types of waves in solids and liquids can be used both for detection and for exploration of structures which are hidden from direct observation, notably in our bodies

1. How can differences in the absorption of waves by different tissues be used in medical imaging?
2. Why are X-rays useful for producing images of bones?
3. How can reflected ultrasound waves be used to produce an image of structures inside the body?
4. Give one medical use of infrared radiation.
5. Give one medical use of gamma radiation in imaging.
6. Explain how differences in velocity, absorption and reflection allow waves to be used to investigate structures hidden inside the human body.

## P5.2j Recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits

1. How can radio waves be produced by an electrical circuit?
2. What type of electrical motion is needed to produce radio waves?
3. What can happen when radio waves reach a suitable electrical circuit?
4. What type of electrical effect can radio waves induce in a receiving circuit?
5. Explain how an oscillating electrical circuit can act as a source of radio waves.
6. Explain how radio waves can produce oscillations in a receiving electrical circuit.

# P5.3 Wave Interactions

## P5.3a Recall that different substances may absorb, transmit, refract, or reflect electromagnetic waves in ways that vary with wavelength

1. What is meant by absorption of an electromagnetic wave?
2. What is meant by transmission of an electromagnetic wave?
3. What is meant by reflection of an electromagnetic wave?
4. What is meant by refraction of an electromagnetic wave?
5. Explain why a substance may transmit some wavelengths of electromagnetic radiation but absorb others.
6. Describe the different ways electromagnetic waves can interact with a substance.

## P5.3b Explain how some effects are related to differences in the velocity of electromagnetic waves in different substances

1. What happens to the velocity of an electromagnetic wave when it passes from one substance into another?
2. What is refraction?
3. Why can a light ray change direction when it enters a different substance?
4. What happens to the speed of light when it passes from air into glass?
5. Explain why a light ray may bend when travelling from air into glass.
6. Explain how differences in wave velocity in different substances can cause refraction.

## P5.3c Use ray diagrams to illustrate reflection, refraction and the similarities and differences between convex and concave lenses (qualitative only)

1. Draw a ray diagram showing the reflection of a ray of light from a plane surface.
2. Draw a ray diagram showing a ray of light refracting as it enters a glass block.
3. Describe what happens to parallel rays of light passing through a convex lens.
4. Describe what happens to parallel rays of light passing through a concave lens.
5. Compare the effects of convex and concave lenses on parallel rays of light.
6. Explain how convex and concave lenses can be used to correct different vision problems.

### P5.3d Construct two-dimensional ray diagrams to illustrate reflection and refraction (qualitative only – equations not needed)

1. Draw a ray diagram showing an incident ray, reflected ray and normal.
2. Label the angle of incidence and angle of reflection on a ray diagram.
3. Draw a ray diagram showing light passing from air into glass.
4. Draw a ray diagram showing light passing from glass into air.
5. Describe how a ray bends when it enters a substance in which it travels more slowly.
6. Construct a ray diagram showing both refraction as light enters a glass block and refraction as it leaves the block.

### P5.3e Explain how colour is related to differential absorption, transmission and reflection

1. Why does an object appear a particular colour?
2. Why does a red object appear red when illuminated with white light?
3. What happens to the other wavelengths of visible light that are not reflected by a coloured object?
4. Explain how a coloured filter produces coloured light.
5. What is the difference between specular reflection and scattering?
6. Explain how absorption, transmission and reflection determine the colour that we see.

# P6: Radioactivity

## P6.1 Radioactive Emissions

### P6.1a Recall that atomic nuclei are composed of both protons and neutrons, that the nucleus of each element has a characteristic positive charge

1. Which two types of particle are found in an atomic nucleus?
2. What charge does a proton have?
3. What charge does a neutron have?
4. Why does an atomic nucleus have an overall positive charge?
5. What determines the characteristic positive charge of the nucleus of an element?
6. Compare the charges of protons and neutrons within an atomic nucleus.

## P6.1b Recall that atoms of the same elements can differ in nuclear mass by having different numbers of neutrons

1. What is an isotope?
2. What is the same about the nuclei of isotopes of the same element?
3. What is different about the nuclei of isotopes of the same element?
4. Why do isotopes of the same element have different nuclear masses?
5. Two atoms have the same number of protons but different numbers of neutrons. What is their relationship?
6. Explain why changing the number of neutrons does not change the identity of an element.

## P6.1c Use the conventional representation for nuclei to relate the differences between isotopes

1. What does the atomic number in nuclear notation represent?
2. What does the mass number in nuclear notation represent?
3. How can the number of neutrons in a nucleus be calculated from its nuclear notation?
4. An atom has a mass number of 23 and an atomic number of 11. Calculate its number of neutrons.
5. Compare the nuclear notation of two isotopes of the same element.
6. Use nuclear notation to explain how two isotopes can have the same identity and charge but different masses.

## P6.1d Recall that some nuclei are unstable and may emit alpha particles, beta particles, or neutrons, and electromagnetic radiation as gamma rays

1. What is meant by an unstable nucleus?
2. Name the four types of radiation or particles that may be emitted by an unstable nucleus.
3. What type of electromagnetic radiation can be emitted by an unstable nucleus?
4. Which radioactive emission consists of a helium nucleus?
5. Which radioactive emission is a high-speed electron?
6. Describe what can happen when an unstable atomic nucleus undergoes radioactive decay.

## P6.1e Relate the emission of alpha particles, beta particles, gamma radiation and neutrons to possible changes in the mass or the charge of the nucleus, or both

1. How does alpha emission change the mass number of a nucleus?
2. How does alpha emission change the atomic number of a nucleus?
3. How does beta-minus emission change the atomic number of a nucleus?
4. How does gamma emission affect the mass number and atomic number of a nucleus?
5. How does neutron emission affect the mass number and atomic number of a nucleus?
6. Compare the changes in nuclear mass and charge caused by alpha, beta, gamma and neutron emissions.

## P6.1f Use names and symbols of common nuclei and particles to write balanced equations that represent radioactive decay

1. State the nuclear symbol used to represent an alpha particle.
2. State the nuclear symbol used to represent a beta particle.
3. Complete a nuclear equation for the alpha decay of uranium-238.
4. Complete a nuclear equation for the beta decay of carbon-14.
5. What must be conserved on both sides of a balanced radioactive decay equation?
6. Write a balanced nuclear equation for a named radioactive isotope undergoing alpha or beta decay.

## P6.1g Balance equations representing the emission of alpha, beta or gamma radiation in terms of the masses, and charges of the atoms involved

1. What happens to the mass number when an alpha particle is emitted?
2. What happens to the atomic number when an alpha particle is emitted?
3. What happens to the mass number and atomic number during beta-minus decay?
4. What happens to the mass number and atomic number during gamma emission?
5. An unknown nucleus is produced by alpha decay. Explain how its mass number and atomic number can be determined.
6. Complete and balance nuclear equations involving alpha, beta and gamma emission using conservation of mass number and charge.

## P6.1h Recall that in each atom its electrons are arranged at different distances from the nucleus, that such arrangements may change with absorption or emission of electromagnetic radiation and that atoms can become ions by loss of outer electrons

1. How are electrons arranged around the nucleus of an atom?

2. What can happen to an inner electron when it absorbs energy from electromagnetic radiation?
3. What happens when an excited electron loses energy and returns to a lower energy level?
4. What is emitted when an electron loses energy and moves to a lower energy level?
5. What is ionisation?
6. Explain how an atom can become an ion through the loss of an outer electron.

## P6.1i Recall that changes in atoms and nuclei can also generate and absorb radiations over a wide frequency range

1. What can changes within atoms and nuclei generate?
2. What can atoms and nuclei do to electromagnetic radiation?
3. From which part of the electromagnetic spectrum can radiation generated by changes in atoms and nuclei come?
4. Which high-frequency electromagnetic radiation can be produced by changes in atomic nuclei?
5. Explain how changes in atoms can involve the absorption or emission of electromagnetic radiation.
6. Describe the range of electromagnetic radiation that may be generated or absorbed by changes in atoms and nuclei.

## P6.1j Explain the concept of half-life and how this is related to the random nature of radioactive decay

1. What is meant by the half-life of a radioactive isotope?
2. What happens to the number of undecayed radioactive nuclei after one half-life?
3. Why is radioactive decay described as a random process?
4. Why is it impossible to predict exactly when an individual radioactive nucleus will decay?
5. Explain how dice can be used to model the random nature of radioactive decay and half-life.
6. Explain how half-life can be used in radioactive dating.

## P6.1k Calculate the net decline, expressed as a ratio, during radioactive emission after a given (integral) number of half-lives

1. What fraction of the original radioactive nuclei remains after one half-life?
2. What fraction of the original radioactive nuclei remains after three half-lives?
3. A sample initially contains 8000 radioactive nuclei. Calculate the number remaining after four half-lives.
4. The activity of a radioactive source is initially 640 Bq. Calculate its activity after three half-lives.
5. A radioactive sample has a half-life of 5 days. Calculate the fraction of the original radioactive nuclei remaining after 20 days.
6. A source has an initial activity of 1600 Bq and a half-life of 10 years. Calculate its activity after 40 years.

### P6.1l Recall the differences in the penetration properties of alpha particles, beta particles and gamma rays

1. Which type of nuclear radiation has the lowest penetrating power?
2. Which type of nuclear radiation has the greatest penetrating power?
3. What material can be used to stop alpha particles?
4. What material can be used to stop beta particles?
5. What materials can be used to reduce the penetration of gamma rays?
6. Compare the penetrating properties of alpha particles, beta particles and gamma rays.

## P6.2 Uses and Hazards

### P6.2a Recall the differences between contamination and irradiation effects and compare the hazards associated with these two

1. What is meant by radioactive contamination?
2. What is meant by irradiation?
3. State the difference between contamination and irradiation.
4. Why can contamination continue to expose a person to radiation after the original source has been removed?
5. Why does irradiation not necessarily make an object radioactive?
6. Compare the hazards associated with contamination and irradiation.

### P6.2b Explain why the hazards associated with radioactive material differ according to the half-life involved

1. What does a short half-life indicate about the rate at which a radioactive material decays?
2. Why can a radioactive source with a short half-life have a high activity?
3. Why can a radioactive material with a long half-life remain hazardous for a long time?
4. Explain why half-life must be considered when choosing a radioactive isotope for a particular use.
5. Explain why an isotope used in a smoke detector needs a suitable half-life.
6. Compare the hazards presented by radioactive materials with short and long half-lives.

## P6.2c Describe the different uses of nuclear radiations for exploration of internal organs, and for control or destruction of unwanted tissue

1. What is a radioactive tracer?
2. How can a radioactive tracer be used to explore the function of an internal organ?
3. How can radiation emitted by a tracer be detected from outside the body?
4. What is radiotherapy?
5. Explain how nuclear radiation can be used to destroy unwanted tissue.
6. Compare the use of nuclear radiation for exploring internal organs with its use for controlling or destroying unwanted tissue.

## P6.2d Recall that some nuclei are unstable and may split, and relate such effects to radiation which might emerge, to transfer of energy to other particles and to the possibility of chain reactions

1. What is nuclear fission?
2. What must an unstable nucleus usually absorb before nuclear fission occurs?
3. What happens to an unstable nucleus during nuclear fission?
4. What particles and radiation may be released during nuclear fission?
5. Explain how neutrons released during fission can cause a chain reaction.
6. Describe how nuclear fission results in energy transfer and the possibility of a chain reaction.

## P6.2e Describe the process of nuclear fusion

1. What is nuclear fusion?
2. What happens to small atomic nuclei during nuclear fusion?
3. What type of nucleus is formed during nuclear fusion?
4. What happens to mass during a nuclear fusion reaction?

5. How is energy released during nuclear fusion?
6. Describe the process of nuclear fusion and explain how mass may be converted into the energy of radiation.

# P7: Energy

## P7.1 Work Done

### P7.1a Describe for situations where there are energy transfers in a system, that there is no net change to the total energy of a closed system (qualitative only)

1. State the law of conservation of energy.
2. What is meant by a closed system?
3. What happens to the total energy of a closed system when energy transfers occur?
4. Can energy be created or destroyed in a closed system?
5. Explain why the total energy remains constant even when energy is transferred between different stores.
6. Describe the energy changes in a closed system and explain why there is no net change in total energy.

### P7.1b Describe all the changes involved in the way energy is stored when a system changes for common situations

1. Describe the energy store changes when an object is projected upwards.
2. Describe the energy store changes when a moving object hits an obstacle.
3. Describe the energy store changes when an object is accelerated by a constant force.
4. Describe the energy store changes when a vehicle slows down.
5. Describe the energy store changes when water is brought to the boil in an electric kettle.
6. Describe the energy store changes when an object moves up a slope and then comes to rest.

### P7.1c Describe the changes in energy involved when a system is changed by heating (in terms of temperature change and specific heat capacity), by work done by forces, and by work done when a current flows

1. What happens to the thermal energy store of an object when it is heated?
2. How does the specific heat capacity of a substance affect the energy needed to increase its temperature?
3. Describe an energy transfer that occurs when a force does work on an object.
4. Describe the energy changes when a current flows through a heating element.
5. Explain how work done by a force can change the energy stored in a system.
6. Compare energy transfers caused by heating, forces doing work and an electric current doing work.

## P7.1d Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system

1. State the equation linking work done, force and distance moved in the direction of the force.
2. State the equation linking energy transferred, charge and potential difference.
3. State the equation linking change in thermal energy, mass, specific heat capacity and temperature change.
4. Calculate the work done when a force of 50 N moves an object 4 m in the direction of the force.
5. An appliance transfers 3.6 MJ of energy. Express this energy in kWh.
6. A television transfers 7.2 MJ of energy. Express this energy in kWh.

## P7.1e Calculate the amounts of energy associated with a moving body, a stretched spring and an object raised above ground level

1. State the equation used to calculate the kinetic energy of a moving object.
2. State the equation used to calculate the elastic potential energy stored in a stretched spring.
3. State the equation used to calculate the gravitational potential energy gained by an object raised above the ground.
4. Calculate the kinetic energy of a 5 kg object travelling at 4 m/s.
5. Calculate the elastic potential energy stored in a spring with a spring constant of 200 N/m stretched by 0.10 m.
6. Calculate the gravitational potential energy gained by a 10 kg object raised through a height of 5 m.

# P7: Energy

## P7.2 Power and Efficiency

### P7.2a Describe, with examples, the process by which energy is dissipated, so that it is stored in less useful ways

1. What is meant by energy being dissipated?
2. Does dissipated energy disappear from a system?
3. Give an example of energy being dissipated due to friction.
4. What usually happens to the thermal energy store of the surroundings when energy is dissipated?
5. Explain why dissipated energy is described as being stored in less useful ways.
6. Describe the energy dissipation that occurs when a moving vehicle slows down.

### P7.2b Describe how, in different domestic devices, energy is transferred from batteries or the a.c. from the mains

1. What energy store provides energy in a battery-powered device?
2. How is energy transferred to a domestic appliance connected to the mains?
3. Describe the useful energy transfer in an electric kettle.
4. Describe the useful energy transfer in an electric motor.
5. Give an example of how energy can be wasted within a motor.
6. Explain how energy supplied electrically to a domestic device can be transferred into both useful and wasted energy stores.

### P7.2c Describe, with examples, the relationship between the power ratings for domestic electrical appliances and how this is linked to the changes in stored energy when they are in use

1. What is meant by the power rating of an electrical appliance?
2. What is the unit of power?
3. What does it mean if an appliance has a power rating of 2000 W?
4. Which transfers more energy each second: a 500 W appliance or a 1500 W appliance?
5. Explain why a high-power kettle can transfer energy to water more quickly than a low-power kettle.
6. Describe the relationship between the power rating of an appliance and the rate at which energy stores change.

## P7.2d Calculate energy efficiency for any energy transfer

1. State the equation used to calculate energy efficiency.
2. A device receives 500 J of energy and transfers 400 J usefully. Calculate its efficiency.
3. A motor receives 2000 J of energy and transfers 1500 J usefully. Calculate its efficiency as a percentage.
4. A machine is 80% efficient and receives 1000 J of energy. Calculate the useful energy transferred.
5. A device transfers 600 J usefully and is 75% efficient. Calculate the total input energy.
6. Calculate the wasted energy when a device receives 2500 J and has an efficiency of 60%.

## P7.2e Describe ways to increase efficiency

1. What is meant by increasing the efficiency of a device?
2. How can reducing friction increase the efficiency of a machine?
3. How can thermal insulation increase the efficiency of a heating system?
4. Why can reducing unwanted sound increase the efficiency of some devices?
5. Give two ways in which the efficiency of a machine could be increased.
6. Explain why reducing unwanted energy transfers increases efficiency.

## P7.2f Explain ways of reducing unwanted energy transfer

1. How does lubrication reduce unwanted energy transfer in moving machinery?
2. How does thermal insulation reduce unwanted energy transfer?
3. Why can cavity wall insulation reduce energy transfer from a house?
4. How can loft insulation reduce unwanted energy transfer from a building?
5. Explain how reducing friction can reduce energy dissipation.
6. Explain two ways unwanted energy transfer from a building can be reduced.

## P7.2g Describe how the rate of cooling of a building is affected by the thickness and thermal conductivity of its walls (qualitative only)

1. What is meant by thermal conductivity?
2. How does increasing the thickness of a wall affect the rate of cooling of a building?
3. How does decreasing the thermal conductivity of a wall affect the rate of cooling?

4. Which is a better thermal insulator: a material with high or low thermal conductivity?
5. Explain why thick walls made from materials with low thermal conductivity reduce energy transfer.
6. Compare the rate of cooling of two identical buildings when one has thicker, better-insulated walls.

# P8: Global Challenges

## P8.1 Physics on the Move

### P8.1a Recall typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems

1. What is a typical walking speed for a person?
2. What is a typical running speed for a person?
3. What is a typical cycling speed?
4. What is the approximate speed of sound in air?
5. Give a typical speed for a car travelling on a road.
6. Compare typical speeds for walking, running, cycling, road transport, wind and sound.

### P8.1b Estimate the magnitudes of everyday accelerations

1. What is meant by acceleration?
2. State the unit used to measure acceleration.
3. Estimate a reasonable acceleration for a car pulling away from traffic lights.
4. Estimate a reasonable deceleration for a bicycle coming to a stop.
5. Which would usually have the greater acceleration: a person beginning to walk or a car accelerating rapidly?
6. Estimate the magnitude of the acceleration in a given everyday situation and explain whether your estimate is reasonable.

### P8.1c Make calculations using ratios and proportional reasoning to convert units and to compute rates

1. Convert 72 km/h into m/s.
2. Convert 15 m/s into km/h.
3. A car travels 150 km in 2.5 hours. Calculate its average speed in km/h.

4. A cyclist travels 6000 m in 20 minutes. Calculate the average speed in m/s.
5. A vehicle travels at 25 m/s for 40 s. Calculate the distance travelled.
6. A car increases its speed from 10 m/s to 30 m/s in 5 s. Calculate its acceleration.

## P8.1d Explain methods of measuring human reaction times and recall typical results

1. What is meant by reaction time?
2. Describe how a ruler-drop experiment can be used to measure human reaction time.
3. What is a typical human reaction time?
4. Why should a reaction-time experiment be repeated several times?
5. How can the reliability of a reaction-time investigation be improved?
6. Explain how the distance a ruler falls can be used to determine a person's reaction time.

## P8.1e Explain the factors which affect the distance required for road transport vehicles to come to rest in emergencies and the implications for safety

1. What is thinking distance?
2. What is braking distance?
3. State the relationship between thinking distance, braking distance and overall stopping distance.
4. Give three factors that can increase thinking distance.
5. Give three factors that can increase braking distance.
6. Explain how speed, tiredness, alcohol, road conditions and tyre condition can affect stopping distance and road safety.

## P8.1f Estimate how the distances required for road vehicles to stop in an emergency varies over a range of typical speeds

1. What happens to thinking distance as the speed of a vehicle increases?
2. What happens to braking distance as the speed of a vehicle increases?
3. Why does doubling the speed of a vehicle more than double its overall stopping distance?
4. Estimate whether a car travelling at 60 mph would require a greater or smaller stopping distance than one travelling at 30 mph.
5. Explain why braking distance increases rapidly as vehicle speed increases.
6. Use stopping-distance data for a range of speeds to estimate the stopping distance at a given speed.

### P8.1g Explain the dangers caused by large decelerations

1. What is meant by deceleration?
2. Why can a large deceleration be dangerous to passengers in a vehicle?
3. How do seat belts reduce the dangers caused by large decelerations?
4. How do airbags reduce the forces acting on passengers during a collision?
5. How do crumple zones reduce the forces experienced during a collision?
6. Explain why increasing the time taken for a vehicle or passenger to stop can reduce the force experienced.

### P8.1h Estimate the forces involved in typical situations on a public road

1. State the equation linking resultant force, mass and acceleration.
2. Calculate the force required to accelerate a 1000 kg car at 2 $m/s^2$.
3. Calculate the force acting on a 1500 kg vehicle decelerating at 4 $m/s^2$.
4. Estimate a reasonable force needed to accelerate a typical car on a public road.
5. Explain why a heavier vehicle requires a larger force to produce the same acceleration as a lighter vehicle.
6. Estimate the force acting on a vehicle in a given road situation using its approximate mass and acceleration.

### P8.1i Estimate, for everyday road transport, the speed, accelerations and forces involved in large accelerations

1. Give a reasonable estimate for the speed of a car travelling on a fast road.
2. Give a reasonable estimate for the acceleration of a car accelerating rapidly.
3. State the equation used to calculate force from mass and acceleration.
4. A 1200 kg car accelerates at 5 $m/s^2$. Calculate the resultant force.
5. Explain why large accelerations can result in large forces.
6. Estimate the speed, acceleration and force involved when a typical road vehicle undergoes a large acceleration.

## P8.2 Powering Earth

## P8.2a Describe the main energy sources available for use on Earth, compare the ways in which they are used and distinguish between renewable and non-renewable sources

1. What is meant by a renewable energy source?
2. What is meant by a non-renewable energy source?
3. Classify fossil fuels, nuclear fuel, biofuel, wind, hydroelectricity, tides and the Sun as renewable or non-renewable energy sources.
4. Describe how fossil fuels are used to generate electricity.
5. Describe how wind, hydroelectricity and tidal energy can be used to generate electricity.
6. Compare renewable and non-renewable energy sources in terms of their availability, reliability and environmental impact.

## P8.2b Explain patterns and trends in the use of energy resources

1. What is meant by a trend in the use of an energy resource?
2. How has the use of different energy resources changed over time?
3. Give two reasons why the use of fossil fuels may decrease over time.
4. Give two reasons why the use of renewable energy resources may increase over time.
5. Explain how environmental concerns can affect the choice of energy resources.
6. Interpret data showing the changing use of different energy resources over time and describe the main trends.

## P8.2c Recall that, in the national grid, electrical power is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic use

1. What is the National Grid?
2. At what type of potential difference is electrical power transferred over long distances in the National Grid?
3. Why is electrical power transferred at high potential differences over long distances?
4. What happens to the potential difference before electricity enters homes?
5. Where is electrical power generated before being transferred through the National Grid?
6. Describe how electrical power is transferred from a power station to a domestic property using the National Grid.

## P8.2d Recall that step-up and step-down transformers are used to change the potential difference as power is transferred from power stations

1. What is the purpose of a step-up transformer?
2. What is the purpose of a step-down transformer?
3. Where are step-up transformers used in the National Grid?
4. Where are step-down transformers used in the National Grid?
5. Why must the potential difference be reduced before electricity is supplied to homes?
6. Describe how step-up and step-down transformers are used as electrical power is transferred from power stations to consumers.

## P8.2e Explain how the national grid is an efficient way to transfer energy

1. Why is some energy wasted when electrical power is transferred through cables?
2. In what form is energy usually dissipated from transmission cables?
3. How does increasing the potential difference affect the current for the same power transfer?
4. Why does reducing the current reduce energy losses from transmission cables?
5. Why are high potential differences used to transfer electrical power over long distances?
6. Explain how the National Grid reduces unwanted energy transfers and transfers energy efficiently.

## P8.2f Link the potential differences and numbers of turns of a transformer to the power transfer involved; relate this to the advantages of power transmission at high voltages

1. State the relationship between the potential differences and numbers of turns in the primary and secondary coils of a transformer.
2. What happens to the potential difference when a transformer has more turns on the secondary coil than on the primary coil?
3. State the equation linking primary potential difference and current to secondary potential difference and current for a transformer.
4. A transformer has a primary potential difference of 230 V and a primary current of 4 A. The secondary potential difference is 920 V. Calculate the secondary current.
5. Explain why increasing the transmission potential difference reduces the current for the same power transfer.

6. Explain why transmitting electrical power at high potential differences reduces energy losses in the National Grid.

## P8.2g Recall that the domestic supply in the UK is a.c. at 50 Hz and about 230 volts

1. Is the UK domestic electricity supply a.c. or d.c.?
2. What is the frequency of the UK domestic electricity supply?
3. What is the potential difference of the UK domestic electricity supply?
4. What does a frequency of 50 Hz mean?
5. State the two key numerical values used to describe the UK domestic electricity supply.
6. Describe the domestic electricity supply used in the UK.

## P8.2h Explain the difference between direct and alternating voltage

1. What is meant by direct voltage?
2. What is meant by alternating voltage?
3. How does the polarity of a direct voltage change with time?
4. How does the polarity of an alternating voltage change with time?
5. Compare the voltage-time traces for a.c. and d.c. supplies.
6. Explain the difference between the potential difference supplied by a battery and that supplied by the UK mains.

## P8.2i Recall the differences in function between the live, neutral and earth mains wires, and the potential differences between these wires

1. What is the function of the live wire in a mains circuit?
2. What is the function of the neutral wire in a mains circuit?
3. What is the function of the earth wire in a mains circuit?
4. What is the potential difference between the live and neutral wires in the UK mains supply?
5. What is the approximate potential difference between the neutral wire and earth?
6. Compare the functions and potential differences of the live, neutral and earth wires in a mains circuit.

## P8.2j Explain that a live wire may be dangerous even when a switch in a mains circuit is open, and explain the dangers of providing any connection between the live wire and earth

1. Why can the live wire still be dangerous when a switch is open?

2. Why should a switch be connected in the live wire rather than the neutral wire?
3. What could happen if a person provides a connection between the live wire and earth?
4. Why can touching a live wire result in an electric shock?
5. How does insulation help protect a user from the live parts of an electrical device?
6. Explain why contact between the live wire and an earthed metal case can be dangerous and how insulation reduces this risk.

# P8: Global Challenges

## P8.3 Beyond Earth

### P8.3a Explain the red-shift of light as seen from galaxies which are receding (qualitative only). The change with distance of each galaxy's speed is evidence of an expanding universe

1. What is meant by red-shift?
2. What happens to the wavelength of light from a galaxy that is moving away from Earth?
3. What happens to the frequency of light when it is red-shifted?
4. What does red-shift tell us about the motion of distant galaxies?
5. What relationship is observed between the distance of a galaxy and the speed at which it is receding?
6. Explain how observations of red-shift provide evidence that the universe is expanding.

### P8.3b Explain how red shift and other evidence can be linked to the Big-Bang model

1. What is the Big Bang model?
2. How does red-shift provide evidence for the Big Bang model?
3. What is cosmic microwave background radiation?
4. Why is cosmic microwave background radiation evidence for the Big Bang model?
5. Explain how an expanding universe supports the idea that the universe was once much smaller and denser.
6. Explain how red-shift and cosmic microwave background radiation together provide evidence for the Big Bang model.

## P8.3c Recall that our Sun was formed from dust and gas drawn together by gravity and explain how this caused fusion reactions, leading to equilibrium between gravitational collapse and expansion due to the energy released during fusion

1. What material was the Sun originally formed from?
2. What force caused dust and gas to be drawn together during the formation of the Sun?
3. Why did the temperature increase as the material forming the Sun collapsed together?
4. What nuclear process began when the temperature became sufficiently high?
5. What two effects are balanced when a star such as the Sun is stable?
6. Explain how gravitational collapse led to fusion reactions and eventually to a stable equilibrium in the Sun.

## P8.3d Explain that all bodies emit radiation, and that the intensity and wavelength distribution of any emission depends on their temperatures

1. What type of radiation is emitted by all bodies?
2. How does the intensity of radiation emitted by an object change as its temperature increases?
3. How does the wavelength distribution of emitted radiation change as temperature increases?
4. Why can hot objects emit a continuous range of electromagnetic radiation?
5. Compare the radiation emitted by a hot object with that emitted by a cooler object.
6. Explain how the temperature of a body affects both the intensity and wavelength distribution of the radiation it emits.

## P8.3e Recall the main features of our solar system, including the similarities and distinctions between the planets, their moons, and artificial satellites

1. Name the eight planets of the Solar System in order from the Sun.
2. What is meant by a natural satellite?
3. What is an artificial satellite?
4. What is a minor planet?
5. Compare geostationary and polar orbits used by artificial satellites.
6. Compare planets, natural satellites and artificial satellites in terms of their features and orbits.

## P8.3f Explain for circular orbits, how the force of gravity can lead to changing velocity of a planet but unchanged speed (qualitative only)

1. What force keeps a planet moving in orbit around the Sun?
2. Why does a planet moving in a circular orbit have a changing velocity?
3. Why can the speed of a planet remain constant even though its velocity changes?
4. In which direction does the gravitational force act on an orbiting planet?
5. Explain why velocity changes when the direction of motion changes.
6. Explain how gravity can continuously change the velocity of an orbiting planet without changing its speed.

## P8.3g Explain how, for a stable orbit, the radius must change if this speed changes (qualitative only)

1. What is meant by the radius of an orbit?
2. What is meant by a stable orbit?
3. What must happen to the orbital radius if the speed of an orbiting object changes?
4. How are orbital speed and orbital radius related for a stable orbit?
5. Explain why changing the speed of a satellite can cause it to move into a different orbit.
6. Explain qualitatively why a change in orbital speed requires a change in orbital radius for the orbit to remain stable.

## P8.3h Explain how the temperature of a body is related to the balance between incoming radiation absorbed and radiation emitted; illustrate this balance using everyday examples and the example of the factors which determine the temperature of the Earth

1. What happens to the temperature of a body when it absorbs radiation faster than it emits radiation?
2. What happens to the temperature of a body when it emits radiation faster than it absorbs radiation?
3. When will the temperature of a body remain constant?
4. Explain how a hot drink cools in terms of radiation absorbed and emitted.
5. How does the Earth's atmosphere affect electromagnetic radiation travelling to and from the Earth's surface?
6. Explain how the balance between incoming radiation absorbed and outgoing radiation emitted affects the temperature of the Earth.

## P8.3i Explain, in qualitative terms, how the differences in velocity, absorption and reflection between different types of waves in solids and liquids can be used both for detection and for exploration of structures which are hidden from direct observation, notably in the Earth's core and in deep water

1. What are P waves and S waves?
2. How can seismic waves provide information about the internal structure of the Earth?
3. Why can the behaviour of P and S waves provide evidence about whether parts of the Earth's interior are solid or liquid?
4. How can reflection of seismic waves help scientists investigate structures inside the Earth?
5. How does sonar use reflected sound waves to investigate objects or structures in deep water?
6. Explain how differences in the velocity, absorption and reflection of waves can be used to investigate the Earth's core and structures in deep water.