Paper 1:

Topic 1 – Energy Retrieval Starters

6.1.1.1 Energy stores and systems

1. A system is an object or group of objects being studied and the energy transfers that happen within it.
2. Energy stores are transferred between different stores when a system changes.
3. A projected object transfers energy from the chemical store of the person/device into the kinetic store of the object. As it rises, kinetic energy decreases and gravitational potential energy increases.
4. A moving object hitting an obstacle transfers energy from the kinetic store to thermal energy stores of the object and surroundings, and possibly elastic potential energy if the object deforms.
5. Water heated in an electric kettle transfers energy electrically from the kettle to the thermal energy store of the water.
6. Energy cannot be created or destroyed because of the law of conservation of energy. It can only be transferred between stores.

6.1.1.2 Changes in energy

1. $E_p = mgh$
   $720 = 12 \times 10 \times h$
   $h = 720 \div 120$
   $h = 6$ m
2. $E_k = \frac{1}{2}mv^2$
   m = mass in kg
   v = velocity in m/s
3. $E_k = \frac{1}{2} \times 1000 \times 20^2$
   $E_k = 500 \times 400$
   $E_k = 200\,000$ J
4. $E_e = \frac{1}{2}ke^2$
   $0.5 = \frac{1}{2} \times k \times 0.1^2$
   $0.5 = 0.005k$
   $k = 100$ N/m

5. Ep = mgh
   Ep = 5 × 10 × 3
   Ep = 150 J
6. Ep = mgh
   Ep = 2 × 10 × 5
   Ep = 100 J

6.1.1.3 Energy changes in systems

1. Specific heat capacity is the energy needed to raise the temperature of 1 kg of a substance by 1°C.
2. J/kg°C (joules per kilogram per degree Celsius).
3. $E = mc\Delta T$
   $E = 2 \times 500 \times 10$
   $E = 10\ 000$ J
4. Heating transfers energy to the thermal energy store of the particles, increasing their kinetic energy and temperature.
5. $c = E \div (m\Delta T)$
   $c = 12\ 000 \div (4 \times 15)$
   $c = 200$ J/kg°C
6. Heat a known mass of the material using an electric heater. Measure the energy supplied and the temperature change. Calculate specific heat capacity using $c = E \div (m\Delta T)$.

6.1.1.4 Power

1. Power is the rate at which energy is transferred.
2. Power = energy transferred ÷ time
   600 = 18 000 ÷ t
   t = 30 s
3. Watt (W).
4. Power = 600 ÷ 30
   Power = 20 W
5. A more powerful device transfers energy at a faster rate because it transfers more energy each second.
6. The device with higher power transfers the same amount of energy in a shorter time.

6.1.2.1 Energy transfers in a system

1. Energy cannot be created or destroyed; it can only be transferred between stores.
2. Energy that is not transferred usefully is dissipated to the surroundings.

3. Wasted energy is energy transferred to unwanted stores, usually thermal energy in the surroundings.
4. Friction causing a moving object to heat up.
5. Lubrication reduces friction, so less energy is wasted as thermal energy.
6. Thermal insulation reduces energy transfer by reducing conduction and convection.

6.1.2.2 Efficiency

1. No. Efficiency cannot be greater than 100% because useful output energy cannot exceed total input energy.
2. Efficiency = useful output ÷ total input × 100
   Efficiency = 400 ÷ 800 × 100
   Efficiency = 50%
3. Efficiency = 900 ÷ 1500 × 100
   Efficiency = 60%
4. Efficiency = 80 ÷ 200 × 100
   Efficiency = 40%
5. Increasing efficiency reduces wasted energy and saves energy resources.
6. Reduce friction using lubrication; improve insulation to reduce thermal energy losses.

6.1.3 National and global energy resources

1. A renewable energy resource is one that is naturally replaced and will not run out.
2. A non-renewable energy resource is one that is finite and will eventually run out.
3. Wind, solar, hydroelectric.
4. Coal, oil, natural gas.
5. Fossil fuels release carbon dioxide when burned, contributing to climate change and pollution.
6. Some renewable resources are unreliable because they depend on weather conditions, such as wind speed and sunlight.

Topic 1 Review

1. Energy stores change by transferring energy between stores. Heating increases thermal energy stores, lifting increases gravitational potential energy, and movement increases kinetic energy.

2. Kinetic energy: $E_k = \frac{1}{2}mv^2$.
   Gravitational potential energy: $E_p = mgh$.
   Elastic potential energy: $E_e = \frac{1}{2}ke^2$.
3. Specific heat capacity shows how much energy is needed to increase the temperature of a material. Higher specific heat capacity means more energy is needed for the same temperature rise.
4. Energy transferred is the amount of energy moved, while power is the rate of energy transfer.
5. Efficiency can be improved by reducing wasted energy, for example through insulation and reducing friction.
6. Renewable resources are replaced naturally but may be unreliable. Non-renewable resources are reliable but limited and can cause environmental damage.

Topic 2 – Electricity Retrieval Starters

6.2.1.1 Standard circuit diagram symbols

1. Cell: a long line and a short line.
2. Variable resistor: resistor symbol with a diagonal arrow through it.
3. Diode: triangle/arrow-like symbol with a line showing the direction of current flow.
4. Voltmeter: a circle with a V inside.
5. Thermistor: resistor symbol with a diagonal line through it.
6. Ammeter: a circle with an A inside.

6.2.1.2 Electrical charge and current

1. Electric current is the rate of flow of electric charge.
2. $Q = It$
   $Q = 3 \times 20$
   $Q = 60$ C
3. 5 minutes = 300 seconds
   $I = Q \div t$
   $I = 900 \div 300$
   $I = 3$ A
4. $t = Q \div I$
   $t = 240 \div 0.8$
   $t = 300$ s

5. A potential difference provides energy to charges, causing them to flow through a circuit.
6. In a single closed loop circuit, the current is the same at all points.

6.2.1.3 Current, resistance and potential difference

1. V = IR
   V = 15 × 2
   V = 30 V
2. I = V ÷ R
   I = 12 ÷ 4
   I = 3 A
3. R = V ÷ I
   R = 9 ÷ 0.3
   R = 30 Ω
4. I = V ÷ R
   I = 240 ÷ 60
   I = 4 A
5. Increasing resistance decreases the current if the potential difference stays the same.
6. Use wires of different lengths, measure the resistance of each wire while keeping other variables the same, and compare results.

6.2.1.4 Resistors

1. An ohmic conductor is a component where current is directly proportional to potential difference at constant temperature.
2. The resistance of a filament lamp increases as it gets hotter because the metal ions vibrate more and make it harder for electrons to flow.
3. A thermistor's resistance decreases as temperature increases.
4. An LDR's resistance decreases as light intensity increases.
5. A diode only allows current to flow in one direction because it has low resistance in one direction and high resistance in the other.
6. I–V graphs show whether current is proportional to potential difference. Straight lines show linear components; curved lines show non-linear components.

6.2.2 Series and parallel circuits

1. A series circuit has components in one loop, while a parallel circuit has components connected across different branches.
2. Total resistance = 5 + 12
   Total resistance = 17 Ω

3. Total resistance = 8 + 6 + 4
   Total resistance = 18 Ω
4. Current is the same everywhere in a series circuit.
5. Potential difference is shared between components in parallel circuits, with the same voltage across each branch.
6. Adding resistors in parallel gives more pathways for current, reducing the total resistance.

6.2.3.1 Direct and alternating potential difference

1. Direct potential difference provides a constant direction of current flow. Alternating potential difference repeatedly changes direction.
2. 50 Hz.
3. Approximately 230 V.
4. Charges flow in one direction only in a direct current circuit.
5. Mains electricity is alternating because the direction of current changes repeatedly.
6. Battery supply: mobile phone. Mains electricity: kettle.

6.2.3.2 Mains electricity

1. Live wire, neutral wire and earth wire.
2. The earth wire provides a safe path for current during a fault.
3. Brown.
4. The live wire remains at a high potential difference and can give an electric shock.
5. Connecting live and earth creates a large current, which can cause overheating and danger.
6. The earth wire carries the fault current, causing the fuse to melt or circuit breaker to switch off.

6.2.4.1 Power

1. $P = VI$
   $P = 12 \times 3$
   $P = 36$ W
2. $P = I^2R$
   $P = 5^2 \times 8$
   $P = 200$ W
3. $I = P \div V$
   $I = 1500 \div 230$
   $I = 6.5$ A

4. $R = P \div I^2$
   $R = 60 \div 2^2$
   $R = 15\ \Omega$
5. Increasing current increases power because more energy is transferred each second.
6. Power is the rate of energy transfer:
   Power = energy transferred ÷ time.

6.2.4.2 Energy transfers in everyday appliances

1. $E = Pt$
   $E = 1000 \times 180$
   $E = 180\ 000\ J$
2. $P = E \div t$
   $P = 7200 \div 120$
   $P = 60\ W$
3. $V = E \div Q$
   $V = 5000 \div 25$
   $V = 200\ V$
4. $Q = E \div V$
   $Q = 240 \div 6$
   $Q = 40\ C$
5. Appliances transfer electrical energy into useful energy stores, such as thermal, kinetic or light energy stores.
6. Higher power appliances transfer more energy every second.

6.2.4.3 The National Grid

1. The National Grid is a system of cables and transformers used to transfer electrical energy around the country.
2. A step-up transformer increases potential difference for efficient transmission.
3. A step-down transformer decreases potential difference for safe use in homes.
4. Higher potential difference reduces current, reducing energy losses in cables.
5. Electricity travels from power stations through transmission cables, then through transformers to homes.
6. The National Grid is efficient because it transfers energy at high potential differences, reducing wasted energy.

Topic 2 Review

1. Charge, current and time are related by Q = It.
2. Q = 480 C, t = 120 s
   I = Q ÷ t
   I = 480 ÷ 120
   I = 4 A
3. Series circuits have one pathway and the same current. Parallel circuits have multiple pathways and the same potential difference across branches.
4. E = Pt
   E = 2000 × 300
   E = 600 000 J
5. Thermistors change resistance with temperature and LDRs change resistance with light intensity, allowing circuits to respond to changes.
6. The National Grid uses high potential differences and transformers to transfer electrical energy efficiently from power stations to consumers.

Topic 3 – Particle Model of Matter Retrieval Starters

6.3.1.1 Density of materials

1. Density is the mass per unit volume of a substance.
2. Density = mass ÷ volume
   Density = 2 ÷ 0.0005
   Density = 4000 kg/m³
3. Mass = density × volume
   Mass = 800 × 0.002
   Mass = 1.6 kg
4. Volume = mass ÷ density
   Volume = 5 ÷ 2500
   Volume = 0.002 m³
5. Solids usually have higher density than gases because their particles are packed closely together, while gas particles are spread out.
6. Solid particles are closely packed and vibrate around fixed positions. Liquid particles are close together but can move around each other. Gas particles are far apart and move randomly at high speeds.

Required practical activity: Measuring density

1. Measure the mass using a balance. Measure the dimensions using a ruler or callipers. Calculate volume and use density = mass ÷ volume.
2. Use water displacement in a measuring cylinder to find the volume of an irregular object.
3. Volume = length × width × height
   Volume = 5 × 5 × 5
   Volume = 125 cm^3
4. Density = mass ÷ volume
   Density = 0.75 ÷ 0.0003
   Density = 2500 kg/m^3
5. Vernier callipers or a micrometer.
6. Displacement is used because irregular objects do not have simple shapes, so their volume cannot be calculated using dimensions.

6.3.1.2 Changes of state

1. Solid to liquid: melting. Liquid to gas: boiling or evaporation.
2. Mass is conserved because no particles are created or destroyed.
3. Melting is physical because the substance remains the same and no new substance is formed.
4. Particles gain energy, vibrate more and become able to move around each other.
5. Evaporation occurs at the surface and can happen below boiling point. Boiling occurs throughout a liquid at a fixed temperature.
6. Energy is transferred to particles, increasing their potential energy during a change of state.

6.3.2.1 Internal energy

1. Internal energy is the total energy stored by particles in a system.
2. Kinetic energy and potential energy.
3. Heating increases the kinetic energy of particles and may increase potential energy during changes of state.
4. Higher temperature means particles have greater kinetic energy, increasing internal energy.
5. Kinetic energy is energy due to particle movement. Potential energy is stored due to particle positions and forces between particles.
6. A change of state can occur without temperature change because energy changes the arrangement of particles rather than increasing kinetic energy.

6.3.2.2 Temperature changes in a system and specific heat capacity

1. $E = mc\Delta T$
   $E = 2 \times 500 \times 20$
   $E = 20\ 000$ J
2. $\Delta T = E \div mc$
   $\Delta T = 12\ 000 \div (3 \times 400)$
   $\Delta T = 10°C$
3. $c = E \div (m\Delta T)$
   $c = 20\ 000 \div (5 \times 10)$
   $c = 400$ J/kg°C
4. Specific heat capacity is the energy required to raise the temperature of 1 kg of a substance by 1°C.
5. Different materials have different particle structures and require different amounts of energy to increase particle kinetic energy.
6. A larger mass requires more energy, so the temperature change is smaller when the same energy is supplied.

6.3.2.3 Changes of state and specific latent heat

1. Latent heat is energy transferred to change the state of a substance without changing its temperature.
2. Temperature stays constant because energy is used to overcome forces between particles rather than increase kinetic energy.
3. $E = mL$
   $680\ 000 = 2 \times L$
   $L = 340\ 000$ J/kg
4. $E = mL$
   $E = 0.5 \times 2\ 000\ 000$
   $E = 1\ 000\ 000$ J
5. Specific latent heat of fusion is energy needed to melt 1 kg of a substance. Specific latent heat of vaporisation is energy needed to boil 1 kg of a substance.
6. During melting, particles gain potential energy as forces between particles are overcome.

6.3.3.1 Particle motion in gases

1. Gas particles move randomly at high speeds in all directions.
2. Increasing temperature increases the kinetic energy of gas particles.
3. Hotter particles move faster and collide more frequently and with greater force with the container walls, increasing pressure.

4. The particles gain kinetic energy, move faster and collide more often with the container walls.
5. Gas particles collide with the walls of the container, creating pressure.
6. Higher temperature causes faster particle movement, leading to more frequent and forceful collisions and increased pressure.

Topic 3 Review

1. Density = mass ÷ volume
   Density = 4 ÷ 0.002
   Density = 2000 kg/m³
2. Solids have particles closely packed and vibrating. Liquids have particles close together that can move. Gases have particles spread out and moving randomly.
3. Heating transfers energy to particles, increasing kinetic energy or changing particle arrangement during changes of state.
4. $E = mc\Delta T$.
5. $E = mL$.
6. Increasing gas temperature increases particle kinetic energy, causing more frequent and forceful collisions with container walls, increasing pressure.

Topic 4 – Atomic Structure Retrieval Starters

6.4.1.3 The development of the model of the atom

1. Before electrons were discovered, atoms were thought to be solid spheres with no internal structure.
2. The discovery of electrons showed that atoms contained smaller negatively charged particles, changing the model of the atom.
3. The plum pudding model described atoms as a sphere of positive charge with negative electrons embedded inside.
4. The alpha particle scattering experiment showed that atoms contain a small, dense, positively charged nucleus and that most of the atom is empty space.
5. The plum pudding model had electrons spread throughout the atom, while the nuclear model had electrons orbiting a small central nucleus.

6. Scientific models change when new experimental evidence provides information that cannot be explained by the current model.

6.4.2.1 Radioactive decay and nuclear radiation

1. Radioactive decay is the random process where an unstable nucleus emits radiation and changes into a more stable nucleus.
2. Some nuclei undergo radioactive decay because they are unstable due to an imbalance of protons and neutrons.
3. Activity is the rate at which unstable nuclei decay.
4. Becquerel (Bq).
5. Alpha: two protons and two neutrons. Beta: a high-energy electron. Gamma: electromagnetic radiation.
6. Alpha has the lowest penetration but highest ionising power. Beta has medium penetration and ionising power. Gamma has the highest penetration but lowest ionising power.

6.4.2.2 Nuclear equations

1. During alpha decay, the mass number decreases by 4 and the atomic number decreases by 2.
2. During beta decay, the mass number stays the same and the atomic number increases by 1.
3. ${}^{238}_{92}U \rightarrow {}^{4}_{2}He + {}^{234}_{90}Th$
4. ${}^{14}_{6}C \rightarrow {}^{0}_{-1}e + {}^{14}_{7}N$
5. Gamma radiation is energy released from the nucleus and does not contain mass or charge, so the mass number and atomic number remain unchanged.
6. The nucleus loses two protons and two neutrons, so the mass number decreases by 4 and the atomic number decreases by 2.

6.4.2.3 Half-lives and the random nature of radioactive decay

1. Half-life is the time taken for the number of undecayed nuclei or activity of a radioactive sample to halve.
2. Radioactive decay is random because it is impossible to predict when a particular nucleus will decay.
3. After one half-life:
   800 ÷ 2 = 400 counts per minute

4. 15 years = 3 half-lives
   1600 → 800 → 400 → 200
   Activity = 200 Bq
5. The number of undecayed nuclei decreases by half during each half-life.
6. A shorter half-life means a radioactive isotope is less stable and decays more quickly.

6.4.2.4 Radioactive contamination

1. Radioactive contamination is when radioactive material gets onto or inside an object.
2. It is dangerous because radioactive materials can emit ionising radiation that damages cells.
3. Irradiation is exposure to radiation from a radioactive source.
4. Contamination involves radioactive material being present on or inside something. Irradiation is only exposure to radiation.
5. An irradiated object does not become radioactive because it has not gained radioactive material.
6. Scientific research should be shared and checked to ensure results are reliable and accurate.

Topic 4 Review

1. Evidence from experiments changed the atomic model from a solid sphere to models containing electrons and a nucleus.
2. Alpha radiation has high ionising power and low penetration. Beta has medium ionising power and penetration. Gamma has low ionising power and high penetration.
3. Alpha decay: mass number decreases by 4 and atomic number decreases by 2. Beta decay: atomic number increases by 1 while mass number stays the same.
4. Each half-life halves the activity of a radioactive source.
5. Contamination is radioactive material on or inside an object. Irradiation is exposure to radiation without radioactive material being transferred.
6. Radioactive sources must be controlled because ionising radiation can damage living cells and cause harm if not used safely.

Paper 2:

Topic 5 – Forces Retrieval Starters

6.5.1.1 Scalar and vector quantities

1. Distance is a scalar quantity.
2. Displacement is a vector quantity.
3. Speed is a scalar quantity.
4. Velocity is a vector quantity.
5. Force is a vector quantity.
6. A scalar quantity has magnitude only. A vector quantity has magnitude and direction.

6.5.1.2 Contact and non-contact forces

1. Friction and air resistance.
2. Gravity and magnetic forces.
3. Contact forces require objects to touch. Non-contact forces act over a distance.
4. Friction acts between surfaces in contact and opposes motion.
5. Two magnets with the same poles repel because their magnetic fields interact.
6. Force is a vector quantity because it has both size and direction.

6.5.1.3 Gravity

1. Weight = mass × gravitational field strength
   Weight = 8 × 10
   Weight = 80 N
2. Mass = weight ÷ gravitational field strength
   Mass = 180 ÷ 9
   Mass = 20 kg
3. Mass is the amount of matter in an object and stays constant. Weight is the force caused by gravity and can change depending on the gravitational field strength.
4. Weight acts from the centre of mass of an object.

5. An astronaut's mass stays the same because the amount of matter does not change, but their weight changes because the Moon has a weaker gravitational field.
6. A Newton meter (spring balance).

6.5.1.4 Resultant forces

1. Resultant force = 18 + 7
   Resultant force = 25 N
2. Resultant force = 25 − 9
   Resultant force = 16 N
3. A resultant force is the overall force acting on an object after combining all forces.
4. If the resultant force is zero, the object remains at rest or continues at constant velocity.
5. Free-body diagram: upward reaction force from the table and downward weight force.
6. A vector diagram uses arrows representing forces. The combined length and direction show the resultant force.

6.5.2 Work done and energy transfer

1. Work done = force × distance
   Work done = 45 × 6
   Work done = 270 J
2. Distance = work done ÷ force
   Distance = 720 ÷ 90
   Distance = 8 m
3. Work done = 15 × 12
   Work done = 180 J
4. Work done transfers energy from one energy store to another.
5. Work done against friction transfers energy to thermal energy stores, increasing temperature.
6. 650 N m = 650 J

6.5.3 Forces and elasticity

1. Force = spring constant × extension
   Force = 300 × 0.08
   Force = 24 N
2. Spring constant = force ÷ extension
   k = 100 ÷ 0.25
   k = 400 N/m

3. $E_e = \frac{1}{2}ke^2$
   $E_e = \frac{1}{2} \times 180 \times 0.20^2$
   $E_e = 3.6$ J
4. Elastic deformation is reversible. Inelastic deformation is permanent.
5. The spring will no longer return to its original shape and becomes permanently stretched.
6. Apply different forces to a spring, measure the extension each time, and plot a graph of force against extension.

6.5.4.1.1 Distance and displacement

1. Distance is the total path travelled. Displacement is the straight-line distance in a stated direction from the starting point.
2. Distance = 400 m. Displacement = 0 m.
3. Velocity.
4. Speed.
5. Displacement should include both size and direction.
6. Displacement is the shortest distance between two points, so it cannot be greater than distance travelled.

6.5.4.1.2 Speed

1. Speed = distance ÷ time
   Speed = 5400 ÷ 300
   Speed = 18 m/s
2. Distance = speed × time
   Distance = 20 × 45
   Distance = 900 m
3. Time = distance ÷ speed
   Time = 600 ÷ 5
   Time = 120 s
4. Typical walking speed = 1.5 m/s.
5. Speed of sound in air = approximately 340 m/s.
6. Average speed is used because most journeys involve changing speeds.

6.5.4.1.3 Velocity

1. Speed has magnitude only. Velocity has magnitude and direction.
2. An object travelling around a circular path has constant speed but changing velocity because direction changes.
3. Velocity is a vector because it includes direction.
4. Velocity includes direction.
5. The car has a velocity of 15 m/s north.

6. Travelling in a circle involves changing direction, so velocity changes.

6.5.4.1.4 The distance–time relationship

1. The gradient represents speed.
2. A stationary object has a horizontal line.
3. A constant speed object has a straight line with constant gradient.
4. A steeper gradient shows a greater speed.
5. Speed = 6 m/s.
6. A tangent shows the gradient at a specific point to calculate instantaneous speed.

6.5.4.1.5 Acceleration

1. Acceleration = change in velocity ÷ time
   Acceleration = (28 − 8) ÷ 5
   Acceleration = 4 m/s^2
2. Final velocity = acceleration × time
   Final velocity = 4 × 7
   Final velocity = 28 m/s
3. $v^2 = u^2 + 2as$
   $28^2 = 12^2 + 2 \times a \times 80$
   $784 = 144 + 160a$
   $a = 4\ m/s^2$
4. The gradient of a velocity–time graph represents acceleration.
5. The area under a velocity–time graph represents distance travelled.
6. Terminal velocity is when the resultant force becomes zero and an object falls at a constant velocity.

6.5.4.2.1 Newton's First Law

1. An object remains stationary or continues moving at constant velocity if the resultant force is zero.
2. Constant speed means forces are balanced and resultant force is zero.
3. A resultant force causes acceleration, changing velocity.
4. Inertia is the tendency of an object to resist changes in motion.
5. Passengers move forward when a car brakes because their bodies continue moving due to inertia.
6. Passengers move forward because their bodies continue moving while the car slows down.

6.5.4.2.2 Newton's Second Law

1. Force = mass × acceleration
   Force = 12 × 3.6
   Force = 43.2 N
2. Force = 5 × 3.6
   Force = 18 N
3. Mass = force ÷ acceleration
   Mass = 48 ÷ 6
   Mass = 8 kg
4. Increasing mass decreases acceleration if the force stays constant.
5. Investigate how changing force or mass affects acceleration using a trolley system and measure acceleration with light gates or motion sensors.
6. Inertial mass is a measure of how difficult it is to change an object's velocity.

6.5.4.2.3 Newton's Third Law

1. When two objects interact, they exert equal and opposite forces on each other.
2. A rocket pushes gases down and the gases push the rocket upwards.
3. Action and reaction forces act on different objects, so they do not cancel.
4. The person pushes the wall and the wall pushes back with an equal force.
5. A rocket moves upwards because gases are pushed down, creating an upward reaction force.
6. Recoil occurs because the object pushing a projectile experiences an equal and opposite force.

6.5.4.3.1 Stopping distance

1. Stopping distance is the total distance travelled before a vehicle stops.
2. Thinking distance and braking distance.
3. Higher speed increases kinetic energy, so more distance is needed to stop.
4. Thinking distance is travelled before braking begins. Braking distance is travelled while slowing down.
5. Braking distance increases more than proportionally because kinetic energy increases with speed squared.
6. Understanding stopping distance helps drivers maintain safe distances.

6.5.4.3.2 Reaction time

1. Typical reaction time is about 0.2–0.9 seconds.
2. Use a ruler drop test or computer reaction timer.

3. Alcohol, tiredness and distractions increase reaction time.
4. Distractions delay the response, increasing thinking distance.
5. Alcohol slows the nervous system, increasing reaction time.
6. Measure reaction times under different conditions and compare results.

6.5.4.3.3 Factors affecting braking distance

1. Wet roads reduce friction, increasing braking distance.
2. Icy roads greatly reduce friction, increasing braking distance.
3. Worn tyres provide less grip, increasing braking distance.
4. Worn brakes produce less braking force, increasing stopping distance.
5. Higher speed increases kinetic energy, requiring more distance to stop.
6. Reduce speed and maintain tyres and brakes properly.

6.5.4.3.4 Factors affecting braking distance

1. Brakes become hot because kinetic energy is transferred to thermal energy through friction.
2. A larger braking force causes a greater deceleration.
3. Excessive braking can cause tyres to lose grip and the vehicle to skid.
4. Repeated braking transfers large amounts of energy to thermal energy stores, causing overheating.
5. Braking force = mass × deceleration.
6. Kinetic energy increases rapidly because $E_k = \frac{1}{2}mv^2$.

6.5.5.1 Momentum (HT only)

1. Momentum = mass × velocity
   Momentum = 1200 × 18
   Momentum = 21 600 kg m/s
2. Velocity = momentum ÷ mass
   Velocity = 16 ÷ 0.8
   Velocity = 20 m/s
3. Velocity = momentum ÷ mass
   Velocity = 450 ÷ 75
   Velocity = 6 m/s
4. Momentum is the product of mass and velocity.
5. kg m/s.
6. A faster object has greater momentum because velocity increases.

6.5.5.2 Conservation of momentum (HT only)

1. Total momentum before collision = 2 × 4 = 8 kg m/s
   Combined mass = 2 + 2 = 4 kg
   Velocity = 8 ÷ 4
   Velocity = 2 m/s
2. Conservation of momentum means total momentum before and after an event remains constant.
3. The system must be closed with no external forces acting.
4. Momentum is conserved because forces inside the system are equal and opposite.
5. Use trolleys on a track, measure masses and velocities before and after collision, and compare momentum.
6. Momentum helps analyse collisions by showing how motion changes during interactions.

Topic 6 – Waves Retrieval Starters

6.6.1.1 Transverse and longitudinal waves

1. Transverse waves vibrate perpendicular to the direction of energy transfer. Longitudinal waves vibrate parallel to the direction of energy transfer.
2. Light waves.
3. Sound waves.
4. High-pressure regions are compressions and low-pressure regions are rarefactions.
5. Sound cannot travel through a vacuum because there are no particles to transfer the vibrations.
6. Water ripples transfer energy across the surface but the water particles only move up and down.

6.6.1.2 Properties of waves

1. Amplitude is the maximum displacement of a point on a wave from its rest position.
2. Wavelength is the distance between two corresponding points on consecutive waves.
3. Frequency is the number of waves passing a point each second.

4. Period = 1 ÷ frequency
   Period = 1 ÷ 8
   Period = 0.125 s
5. Wave speed = frequency × wavelength
   Frequency = speed ÷ wavelength
   Frequency = 24 ÷ 6
   Frequency = 4 Hz
6. Measure the distance travelled by sound and measure the time taken. Calculate speed using speed = distance ÷ time.

6.6.2.1 Types of electromagnetic waves

1. Radio waves → microwaves → infrared → visible light → ultraviolet → X-rays → gamma rays.
2. Visible light.
3. All electromagnetic waves transfer energy and travel at the same speed in a vacuum.
4. Infrared transferring thermal energy.
5. Gamma rays.
6. Higher frequency electromagnetic waves have shorter wavelengths.

6.6.2.2 Properties of electromagnetic waves 1

1. Electromagnetic waves can be reflected, refracted, absorbed or transmitted.
2. Light changes direction because its speed changes when it enters a different medium.
3. Refraction is the change in direction of a wave caused by a change in speed when it enters a different material.
4. Waves slow down because they interact with particles in the material.
5. A ray diagram shows the incident ray, normal line and refracted ray.
6. The variable changed is the distance from the infrared source. The variable measured is the temperature increase.

6.6.2.3 Properties of electromagnetic waves 2

1. Ultraviolet, X-rays and gamma rays are ionising.
2. Gamma rays.
3. Skin damage or increased risk of skin cancer.
4. Cell damage or increased risk of cancer.
5. Ionising radiation has enough energy to remove electrons and damage cells.

6. A higher radiation dose increases the amount of ionising radiation absorbed and increases risk.

6.6.2.4 Uses and applications of electromagnetic waves

1. Microwaves.
2. Visible light.
3. X-rays and gamma rays.
4. Infrared detects heat differences because warm objects emit more infrared radiation.
5. Microwaves can travel through the atmosphere and carry information over long distances.
6. X-rays pass through soft tissue but are absorbed by bones, allowing images to be produced. They must be controlled because they are ionising.

Topic 6 Review

1. Transverse waves vibrate perpendicular to energy transfer. Longitudinal waves vibrate parallel to energy transfer.
2. Wave equation:
   $v = f\lambda$
   $340 = 170 \times \lambda$
   $\lambda = 2$ m
3. Frequency = 1 ÷ period
   Frequency = 1 ÷ 0.02
   Frequency = 50 Hz
4. Electromagnetic waves can travel through space because they do not need particles. Sound waves require particles to transfer vibrations.
5. Ultraviolet, X-rays and gamma rays are ionising. UV can damage skin, X-rays can damage cells, and gamma rays have the highest penetration and can cause serious cell damage.
6. Different electromagnetic waves have different wavelengths and frequencies, making them suitable for different uses such as communication, heating and medical imaging.

Topic 7 – Magnetism and Electromagnetism

6.7.1.1 Poles of a magnet

1. Two north poles repel each other.
2. A north pole and a south pole attract each other.
3. A non-contact force is a force that acts between objects without them touching.
4. A permanent magnet produces its own magnetic field. An induced magnet only becomes magnetic when placed in a magnetic field.
5. An induced magnet loses its magnetism when removed from the magnetic field because its magnetic domains return to random arrangements.
6. An induced magnet is always attracted to a permanent magnet because the induced pole closest to the permanent magnet is always opposite.

6.7.1.2 Magnetic fields

1. A magnetic field is the region around a magnet where magnetic forces act.
2. Magnetic materials include iron, steel, nickel and cobalt.
3. The magnetic field is strongest at the poles of a bar magnet.
4. Magnetic field lines point from the north pole to the south pole outside a magnet.
5. Use a plotting compass to show the direction of the field at different points around the magnet, then join the points to draw field lines.
6. A compass needle points north because the Earth produces a magnetic field that interacts with the magnet in the compass.

6.7.2.1 Electromagnetism

1. A magnetic field is produced around a wire when an electric current flows through it.
2. Increasing the current increases the strength of the magnetic field around the wire.
3. A solenoid produces a stronger magnetic field because the magnetic fields from each loop of wire combine.
4. Adding an iron core increases the strength of an electromagnet because iron becomes magnetised and strengthens the magnetic field.
5. A solenoid has a magnetic field pattern similar to a bar magnet, with field lines passing through the centre of the coil and looping around the outside.

6. Place a current-carrying wire near a plotting compass and observe the compass needle deflect. Increasing the current increases the deflection.

6.7.2.2 Fleming's left-hand rule (HT only)

1. The motor effect is the force experienced by a current-carrying wire placed in a magnetic field.
2. Fleming's left-hand rule predicts the direction of the force on a current-carrying wire in a magnetic field.
3. Force = magnetic flux density × current × length
   F = BIL
   = 0.5 × 4 × 0.30
   = 0.6 N
4. Magnetic flux density = force ÷ (current × length)
   B = 2 ÷ (5 × 0.40)
   = 1 T
5. Increasing the current and increasing the magnetic field strength increase the force.
6. There is no motor effect when the current is parallel to the magnetic field because the wire does not cut through the magnetic field lines.

6.7.2.3 Electric motors (HT only)

1. A current-carrying coil rotates in a magnetic field because the forces on opposite sides of the coil act in opposite directions, creating a turning force.
2. The split-ring commutator reverses the current in the coil every half turn so the coil continues rotating in the same direction.
3. Carbon brushes transfer electrical current to the rotating coil.
4. The current must reverse every half turn so the forces continue acting in the same direction and the coil keeps rotating.
5. Electrical energy is transferred into kinetic energy, with some energy dissipated as thermal energy and sound.
6. Increasing the current or magnetic field strength increases the force on the coil, increasing the turning effect and making the motor rotate faster.

Topic 7 Review

1. Permanent magnets produce their own magnetic field. Induced magnets only become magnetic when placed in a magnetic field and lose their magnetism when removed.
2. A magnetic field around a bar magnet can be plotted using a plotting compass. The compass is moved around the magnet and the direction of the field lines is recorded.
3. A solenoid becomes an electromagnet when a current flows through the coil. Adding an iron core increases the magnetic field strength.
4. Force = BIL
   $= 0.6 \times 8 \times 0.25$
   $= 1.2$ N
5. Fleming's left-hand rule shows the direction of the force by using the thumb for force, first finger for magnetic field direction and second finger for current direction.
6. An electric motor converts electrical energy into kinetic energy by using the motor effect to create a turning force on a current-carrying coil.