| **Lesson** | **Lesson title** | **Lesson objectives** |
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| TOPIC 1 - ENERGY | | |
| 1.1 | Potential energy | * Consider what happens when a spring is stretched. * Describe what is meant by gravitational potential energy. * Calculate the energy stored by an object raised above ground level. |
| 1.2 | Investigating kinetic energy | * Describe how the kinetic energy store of an object changes as its speed changes. * Calculate kinetic energy. * Consider how energy is transferred. |
| 1.3 | Work done and energy transfer | * Understand what is meant by work done. * Explain the relationship between work done and force applied. * Identify the transfers between energy stores when work is done against friction. |
| 1.4 | Understanding power | * Define power. * Compare the rate of energy transfer by various machines and electrical appliances. * Calculate power. |
| 1.5 | Specific heat capacity | * Understand how things heat up. * Find out about heating water. * Find out about specific heat capacity. |
| 1.6 | Required practical: Investigating specific heat capacity | * Use theories to develop a hypothesis. * Evaluate a method and suggest improvements. * Perform calculations to support conclusions. |
| 1.7 | Dissipation of energy | * Explain ways of reducing unwanted energy transfer. * Describe what affects the rate of cooling of a building. * Understand that energy is dissipated. |
| 1.8 | Energy efficiency | * Explain what is meant by energy efficiency. * Calculate the efficiency of energy transfers. * Find out about conservation of energy. |
| 1.9 | Required practical: Investigating ways of reducing the unwanted energy transfers in a system | * Use scientific ideas to make predictions * Analyse data to identify trends. * Evaluate an experimental procedure. |
| 1.10 | Using energy resources | * Describe the main energy resources available for use on Earth. * Distinguish between renewable and non-renewable resources. * Explain the ways in which the energy resources are used. |
| 1.11 | Global energy supplies | * Analyse global trends in energy use. * Understand what the issues are when using energy resources. |
| 1.12 | Key concept: Energy transfer | * To be able to recognize objects with energy. * To be able to recognize the different types of energy. * To be able to describe energy transfers. * To be able to use and describe the law of conservation of energy. |
| 1.13 | Maths skills: Calculations using significant figures | * Substitute numerical values into equations and use appropriate units. * Change the subject of an equation. * Give an answer using an appropriate number of significant figures. |
| 1.14 | Maths skills: Handling data | * Recognise the difference between mean, mode and median. * Explain the use of tables and frequency tables. * Explain when to use scatter diagrams, bar charts and histograms. |
| TOPIC 2 - ELECTRICITY | | |
| 2.1 | Static electricity | * Describe how insulating materials can become charged. * Know that there are two kinds of electric charge. * Explain these observations in terms of electron transfer. |
| 2.2 | Electric fields | * Explain what an electric field is. * Draw an electric field pattern for a charged sphere. * Use the idea of an electric field to explain electrostatic attraction and sparking. |
| 2.3 | Electric current | * Know circuit symbols. * Recall that current is a rate of flow of electric charge. * Recall that current (*I*) depends on resistance (*R*) and potential difference (*V*) * Explain how an electric current passes round a circuit. |
| 2.4 | Series and parallel circuits | * Recognise series and parallel circuits. * Describe the changes in the current in series and parallel circuits. * Describe the changes in the potential difference in series and parallel circuits. |
| 2.5 | Investigating circuits | * Classify materials as either conducting or insulating. * Use series circuits to test components and make measurements. * Carry out calculations on series circuits. |
| 2.6 | Circuit components | * Set up a circuit to investigate resistance. * Investigate the changing resistance of a filament lamp. * Compare the properties of a resistor and a filament lamp. |
| 2.7 | Required practical: Investigate, using  circuit diagrams to construct circuits,  the *I–V* characteristics of a filament lamp, a diode and a resistor at constant temperature | * Understand how an experiment can be designed to test an idea. * Evaluate how an experimental procedure can yield more accurate data. * Interpret and explain graphs using scientific ideas. |
| 2.8 | Required practical: Use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits, including the length of a wire at a constant temperature and combinations of resistors in series and parallel | * Use a circuit to determine resistance. * Gather valid data for use in calculations. * Apply the circuit to determine the resistance of combinations of components. |
| 2.9 | Control circuits | * Use a thermistor and a light-dependent resistor (LDR). * Investigate the properties of thermistors, LDRs and diodes. |
| 2.10 | Electricity in the home | * Recall that the domestic supply in the UK is 230 V ac and 50 Hz. * Describe the main features of live, neutral and earth wires. |
| 2.11 | Transmitting electricity | * Describe how electricity is transmitted using the National Grid. * Explain why electrical power is transmitted at high potential differences. * Understand the role of transformers. |
| 2.12 | Power and energy transfers | * Describe the energy transfers in different domestic appliances. * Describe power as a rate of energy transfer. * Calculate the energy transferred. |
| 2.13 | Calculating power | * Calculate power. * Use power equations to solve problems. * Consider power ratings and changes in stored energy. |
| 2.14 | Key concept: What’s the difference between potential difference and current? | * Understand the concepts of current and potential difference. * Apply the concepts of current and potential difference. * Use these concepts to explain various situations. |
| 2.15 | Maths skills: Using formulae and understanding graphs | * Recognise how algebraic equations define the relationships between variables. * Solve simple algebraic equations by substituting numerical values. * Describe relationships expressed in graphical form. |
| TOPIC 3 – PARTICLE MODEL OF MATTER | | |
| 3.1 | Density | * Use the particle model to explain the different states of matter. * Describe differences in density for different states of matter. * Calculate density for the different states of matter. |
| 3.2 | Required practical: To investigate the densities of regular and irregular solid objects and liquids | * Interpret observations and data. * Use spatial models to solve problems. * Plan experiments and devise procedures. * Use an appropriate number of significant figures in measurements and calculations. |
| 3.3 | Changes of state | * Describe how, when substances change state, mass is conserved. * Describe energy transfer in changes of state. * Explain changes of state in terms of particles. |
| 3.4 | Internal energy | * Describe the particle model of matter. * Understand what is meant by the internal energy of a system. * Describe the effect of heating on the energy stored within a system. |
| 3.5 | Specific heat capacity | * Describe the effect of increasing the temperature of a system in terms of particles. * State the factors that are affected by an increase in temperature of a substance. * Explain specific heat capacity. |
| 3.6 | Latent heat | * Explain what is meant by latent heat. * Describe that when a change of state occurs it changes the energy stored but not the temperature. * Perform calculations involving specific latent heat. |
| 3.7 | Particle motion in gases | * Relate the temperature of a gas to the average kinetic energy of the particle. * Explain how gas has a pressure. * Explain that changing the temperature of a gas held at constant volume changes its pressure. |
| 3.8 | Increasing the pressure of a gas | * Describe the relationship between the pressure and volume of a gas at constant temperature. * Calculate the change in the pressure or volume of a gas held at constant temperature when either the pressure or volume is increased or decreased. * Explain how doing work on a gas can increase its temperature. |
| 3.9 | Key concept: Particle model and changes of state | * Use the particle model to explain states of matter. * Use ideas about energy and bonds to explain changes of state. * Explain the relationship between temperature and energy. |
| 3.10 | Maths skills: Drawing and interpreting graphs | * Plot a graph of temperature against time, choosing a suitable scale. * Draw a line of best fit (which may be a curve). * Interpret a graph of temperature against time. |
| TOPIC 4 – ATOMIC STRUCTURE | | |
| 4.1 | Atomic structure | * Describe the structure of the atom. * Use symbols to represent particles. * Describe ionisation. |
| 4.2 | Radioactive decay | * Describe radioactive decay. * Describe the types of nuclear radiation. * Understand the processes of alpha decay and beta decay. |
| 4.3 | Background radiation | * Recall sources of background radiation. * Describe how different types of radiation have differing ionising power. * Justify the selection of sources for particular applications. |
| 4.4 | Nuclear equations | * Understand nuclear equations. * Write balanced nuclear equations for alpha decay. * Write balanced nuclear equations for beta decay. |
| 4.5 | Radioactive half-life | * Explain what is meant by radioactive half-life. * Calculate half-life. * Choose the best radioisotope for a task. |
| 4.6 | Hazards and uses of radiation | * Describe radioactive contamination. * Give examples of how radioactive tracers can be used. * Explain how contaminated waste is disposed of. |
| 4.7 | Irradiation | * Explain what is meant by irradiation. * Understand the distinction between contamination and irradiation. * Appreciate the importance of communication between scientists. |
| 4.8 | Uses of radiation in medicine | * Compare gamma rays and X-rays. * Describe some uses of radiation for medical diagnosis and therapy. |
| 4.9 | Using nuclear radiation | * Explore the risks and benefits of using nuclear radiation. * Describe how internal organs can be explored. * Understand how nuclear radiation can control or destroy unwanted tissue. |
| 4.10 | Nuclear fission | * Describe nuclear fission. * Explain how a chain reaction occurs. * Explain how fission is used. |
| 4.11 | Nuclear fusion | * Explain nuclear fusion. * Describe the conditions needed for fusion. * Describe how nuclear fusion might be an attractive energy source. |
| 4.12 | Key concept: Developing ideas for the structure of the atom | * Understand how ideas about the structure of the atom have changed. * How evidence is used to test and improve models. |
| 4.13 | Maths skills: Using ratios and proportional reasoning | * Calculate radioactive half-life from a curve of best fit. * Calculate the net decline in radioactivity. |
| TOPIC 5 - FORCES | | |
| 5.1 | Forces | * Describe a force. * Recognise the difference between contact and non-contact forces. * State examples of scalar and vector quantities. |
| 5.2 | Speed | * Calculate speed using distance travelled divided by time taken. * Calculate speed from a distance–time graph. * Measure the gradient of a distance–time graph at any point. |
| 5.3 | Acceleration | * Describe acceleration. * Calculate acceleration. * [Higher tier] Explain motion in a circle. |
| 5.4 | Velocity–time graphs | * Draw velocity–time graphs. * Calculate acceleration using a velocity–time graph. * [Higher tier] Calculate displacement using a velocity–time graph. |
| 5.5 | Calculations of motion | * Describe uniform motion. * Use an equation for uniform motion. * Apply this equation to vertical motion. |
| 5.6 | Heavy or massive? | * Identify the correct units for mass and weight. * Explain the difference between mass and weight. * Understand how weight is an effect of gravitational fields. |
| 5.7 | Forces and motion | * Understand what a force does. * Explain what happens to an object if all the forces acting on it cancel each other out. * Analyse how this applies to everyday situations. |
| 5.8 | Resultant forces | * Calculate the resultant from opposing forces. * Draw free-body diagrams to find resultant forces. * [Higher tier] Understand that a force can be resolved into two components acting at right angles to each other. |
| 5.9 | Forces and acceleration | * Explain what happens to the motion of an object when the resultant force is not zero. * Analyse situations in which a non-zero resultant force is acting. * Explain what inertia is. |
| 5.10 | Required practical: Investigating the acceleration of an object | * Plan an investigation to explore an idea. * Analyse results to identify patterns and draw conclusions. * Compare results with scientific theory. |
| 5.11 | Newton’s third law | * Identify force pairs. * Understand and be able to apply Newton’s third law. |
| 5.12 | Momentum [higher tier] | * Explain what is meant by momentum. * Apply ideas about the rate of change of momentum to safety features in cars. * Use momentum calculations to predict what happens in a collision. |
| 5.13 | Keeping safe on the road | * Explain the factors that affect stopping distance. * Explain the dangers caused by large deceleration. * Estimate the forces involved in the deceleration of a road vehicle (higher tier). * Apply the idea of rate of change of momentum to explain safety features (higher tier). |
| 5.14 | Moments | * Describe the turning effect of a force about a pivot. * Explain and use the principle of moments. * Explain what is meant by the centre of mass of an object. |
| 5.15 | Levers and gears | * Describe how levers and gears can be used to transmit the rotational effect of a force. * Explain how levers and gears transmit forces. |
| 5.16 | Pressure in a fluid | * Explain how pressure acts in a fluid. * Calculate pressure at different depths in a liquid (higher tier). * Explain what causes upthrust (higher tier). |
| 5.17 | Atmospheric pressure | * Show that the atmosphere exerts a high pressure. * Explain variations in atmospheric pressure with height. * Describe a simple model of the Earth’s atmosphere and atmospheric pressure. |
| 5.18 | Forces and energy in springs | * Explain why you need two forces to stretch a spring. * Describe the difference between elastic and inelastic deformation. * Calculate extension, compression and elastic potential energy. |
| 5.19 | Required practical: Investigate the relationship between force and the extension of a spring | * Interpret readings to show patterns and trends. * Interpret graphs to form conclusions. * Apply the equation for a straight line to the graph. |
| 5.20 | Key concept: Forces and acceleration | * Recognise examples of balanced and unbalanced forces. * Apply ideas about speed and acceleration to explain   sensations of movement.   * Apply ideas about inertia and circular motion to explain   braking and cornering. |
| 5.21 | Maths skills: Making estimates of calculations | * Estimate the results of simple calculations. * Round numbers to make an estimate. * Calculate order of magnitude. |
| TOPIC 6 - WAVES | | |
| 6.1 | Describing waves | * Describe wave motion. * Define wavelength and frequency. * Apply the relationship between wavelength, frequency and wave velocity. |
| 6.2 | Transverse and longitudinal waves | * Compare the motion of transverse and longitudinal waves. * Explain why water waves are transverse waves. * Explain why sound waves are longitudinal waves. |
| 6.3 | Key concept: Transferring energy or information by waves | * To understand that all waves have common properties. * To understand how waves can be used to carry information. * To understand various applications of energy transfer by different types of electromagnetic waves. |
| 6.4 | Measuring wave speeds | * Explain how the speed of sound in air can be measured. * Explain how the speed of water ripples can be measured. * Describe the use of echo sounding. |
| 6.5 | Required practical: Measuring the wavelength, frequency and speed of waves in a ripple tank and waves in a solid | * Develop techniques for making observations of waves. * Select suitable apparatus to measure frequency and wavelength. * Use data to answer questions. |
| 6.6 | Reflection and refraction of waves | * Describe reflection, transmission and absorption of waves. * Construct ray diagrams to illustrate reflection. * Construct ray diagrams to illustrate refraction. |
| 6.7 | Required practical: Investigate the reflection of light by different types of surface and the refraction of light by different substances | * Make and record observations of how light is reflected and transmitted at different surfaces. * Measure angles and discuss the method, apparatus and uncertainty in measurements. * Draw conclusions from experimental results. |
| 6.8 | Sound waves | * Describe how we hear sound and state the range of frequencies we can hear. * Explain that sound travels faster in a denser medium. * Explain about reflection, absorption and transmission of sound. |
| 6.9 | Exploring ultrasound | * Explain what ultrasound is. * Describe how ultrasound can be used in industry to investigate or detect hidden or buried objects. * Explain how ultrasound is used in medicine. |
| 6.10 | Seismic waves | * Describe how earthquakes are detected. * Describe the properties of P waves and S waves. * Explain how the properties of seismic waves allow us to investigate the inside of the Earth. |
| 6.11 | The electromagnetic spectrum | * Recall the similarities and differences between transverse and longitudinal waves. * Recognise that electromagnetic waves are transverse waves. * Describe the main groupings and wavelength ranges of the electromagnetic spectrum. |
| 6.12 | Reflection, refraction and wave fronts | * Explain reflection and refraction and how these may vary with wavelength. * Construct ray diagrams to illustrate refraction. * Use wave front diagrams to explain refraction in terms of the difference in velocity of the waves in different substances. |
| 6.13 | Gamma rays and X-rays | * List the properties of gamma rays and X-rays. * Compare gamma rays and X-rays. |
| 6.14 | Ultraviolet and infrared radiation | * Describe the properties of ultraviolet and infrared radiation. * Describe some uses and hazards of ultraviolet radiation. * Describe some uses of infrared radiation. |
| 6.15 | Required practical: Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface | * Explain reasons for the equipment used to carry out an investigation. * Explain the rationale for carrying out an investigation. * Apply ideas from an investigation to a range of practical contexts. |
| 6.16 | Microwaves | * List some properties of microwaves. * Describe how microwaves are used for communications. |
| 6.17 | Radio and microwave communication | * Describe how radio waves are used for television and radio communications. * Describe how microwaves are used in satellite communications. * Describe the reflection and refraction of radio waves. |
| 6.18 | Colour | * Describe what happens when light of different wavelengths lands on an object. * Explain what determines the colour of an opaque object. * Explain the effect of coloured filters. |
| 6.19 | Lenses | * Understand what a lens does. * Draw ray diagrams to show the formation of images by lenses. * Describe the difference between a real and a virtual image. |
| 6.20 | Images and magnification | * Draw ray diagrams to show the formation of real and virtual images by lenses. * Calculate the magnification of an image. |
| 6.21 | Emission and absorption of infrared radiation | * Realise that all bodies emit and absorb infrared radiation. * Compare emission and absorption of radiation from different surfaces. * Define a perfect black body. * Explain that the intensity and distribution of wavelengths of any emission depend on the temperature of the body. |
| 6.22 | Temperature of the Earth | * Describe how the atmosphere absorbs radiation in a way that varies with wavelength. * List the factors affecting the temperature of the Earth. * Explain how the temperature of an object is related to the radiation absorbed and radiation emitted. |
| 6.23 | Maths skills: Using and rearranging equations | * Select and apply the equations *T* = 1/*f* and *v* = *f λ* * Substitute numerical values into equations using appropriate units. * Change the subject of an equation. |
| TOPIC 7 - ELECTROMAGNETS | | |
| 7.1 | Magnetism and magnetic forces | * Explain what is meant by the poles of a magnet. * Plot the magnetic field around a bar magnet. * Describe magnetic materials and induced magnetism. |
| 7.2 | Compasses and magnetic fields | * Describe the Earth’s magnetic field. * Describe the magnetic field of a current. * Explain the link between current and magnetic field. |
| 7.3 | The magnetic effect of a solenoid | * Draw the magnetic field around a conducting wire and a solenoid. * Describe the force on a wire in a magnetic field. * Apply the left-hand rule to work out the direction of a magnetic field, a current or a force around a wire. |
| 7.4 | Electromagnets in action | * Describe simple uses of electromagnets. * Explain how an electric bell and relay works. * Interpret diagrams of other devices that use electromagnets to explain how the devices work. |
| 7.5 | Calculating the force on a conductor | * Explain the meaning of magnetic flux density, *B*. * Know the factors that make a more powerful motor. * Calculate the force on a current-carrying conductor in a magnetic field. |
| 7.6 | Electric motors | * List equipment that uses motors. * Describe how motors work. * Describe how to change the speed and direction of rotation of a motor. |
| 7.7 | Loudspeakers | * Describe how a moving coil loudspeaker works. * Link the vibration on a loudspeaker to the properties of the waves it produces. * Compare loudspeakers and headphones. |
| 7.8 | The generator effect | * Describe how the current is induced in a wire when it moves in a magnetic field. * Identify apparatus needed to demonstrate induced current. * Identify the factors that affect the size and direction of the induced current or induced potential difference. |
| 7.9 | Key concept: The link between electricity and magnetism | * Explore how electricity and magnetism are connected. * Describe how electromagnetic induction occurs. * Describe the principle of the electric motor. |
| 7.10 | Using the generator effect | * Explain how moving coil microphones use the generator effect. * Explain how a dynamo generates direct current and an alternator generates alternating current. * For a dynamo and alternator, draw and interpret graphs of potential difference generated in the coil against time. |
| 7.11 | Transformers | * Explain how a transformer both uses and produces alternating current. * Explain the relationship between the number of turns in the primary coil and the number of turns in the secondary coil. * Calculate the current that needs to be provided to produce a particular power output. |
| 7.12 | Maths skills: Rearranging equations | * Know how to rearrange equations. * Know how to use the transformer equation. * Know how to calculate the force on a conductor. |
| TOPIC 8 - SPACE | | |
| 8.1 | The Solar System | * Describe the orbits of planets and moons in the Solar System. * Distinguish between planets, dwarf planets and moons. |
| 8.2 | Orbits of planets, moons and artificial satellites | * Compare the orbital motion of moons, artificial satellites and planets in the Solar System. * Describe what keeps bodies in orbit around planets and stars. * Explain how, for circular orbits, an object can have a changing velocity but unchanged speed. * Explain why bodies must move at a particular speed to stay in orbit at a particular distance. |
| 8.3 | The Sun and other stars | * Describe how the Sun and other stars formed. * Describe the nuclear fusion reactions in the Sun. |
| 8.4 | Main sequence of a star | * Describe the main sequence stage of a star’s life cycle. * Identify the forces that are in equilibrium in a stable star. |
| 8.5 | Life cycles of stars | * Describe the life cycles of a star like the Sun and a massive star. |
| 8.6 | How the elements are formed | * Understand how new elements are produced by nuclear fusion in stars. * Recognise that the heavier elements are made in a supernova. |
| 8.7 | Red-shift | * Describe red-shift. * Describe evidence for the expanding Universe. |
| 8.8 | Key concept: Gravity: the force that binds the Universe | * Understand that gravity provides the force that keeps planets and satellites in orbits. * Understand that gravity is necessary at the start of a star’s life cycle and to maintain equilibrium in a stable star. * Describe how the weight of an object depends on the gravitational field strength. * Recognise that that there is still much about the universe that is not understood, e.g. dark mass and dark energy. |
| 8.9 | Maths skills: Using scale and standard form | * Understand the scale of objects in the Universe. * Use standard form. |