1. Energy

Weeks 1–5

Energy

They should be able to

1. A system is an object or group of objects; when a system changes, the way energy is stored changes.
2. Describe all the changes in the way energy is stored for: an object projected upwards; a moving object hitting an obstacle; an object accelerated by a constant force; a vehicle slowing down; bringing water to the boil in an electric kettle.
3. Calculate changes in energy when a system is changed by heating, by work done by forces, and by work done when a current flows.
4. Use calculations to show on a common scale how the overall energy in a system is redistributed when the system is changed.
5. Calculate the kinetic energy of a moving object using Ek = 0.5 m v^2.
6. Calculate the elastic potential energy stored in a stretched spring using Ee = 0.5 k e^2, assuming the limit of proportionality has not been exceeded.
7. Calculate the gravitational potential energy gained by an object raised above ground level using Ep = m g h, with the value of g given.
8. Chain these equations to find a transferred quantity (for example spring energy to speed, or cord energy to height).
9. Calculate the amount of energy stored in or released from a system as its temperature changes using dE = m c d(theta).
10. State the definition of specific heat capacity and use its unit, J/kg C.
11. Rearrange the equation to find mass, specific heat capacity or temperature change, converting kJ to J first.
12. Required practical 1: describe the investigation to determine the specific heat capacity of one or more materials, including measuring energy supplied, insulating the block and evaluating errors.
13. Define power as the rate at which energy is transferred or the rate at which work is done.
14. Use power = energy transferred / time and power = work done / time.
15. State that an energy transfer of 1 joule per second is equal to a power of 1 watt.
16. Give examples that illustrate the definition of power, such as comparing two electric motors that both lift the same weight through the same height but one does it faster.
17. State that energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed.
18. Describe, with examples, energy transfers in a closed system showing there is no net change to the total energy.
19. Describe how energy is dissipated in system changes so that it is stored in less useful ways.
20. Explain ways of reducing unwanted energy transfers, including lubrication and thermal insulation.
21. Use the idea that the higher the thermal conductivity of a material, the higher the rate of energy transfer by conduction across it, and describe how the rate of cooling of a building depends on the thickness and thermal conductivity of its walls.
22. Required practical 2 (physics only): investigate the effectiveness of different materials as thermal insulators and the factors that affect the thermal insulation properties of a material.
23. Calculate energy efficiency using efficiency = useful output energy transfer / total input energy transfer.
24. Calculate efficiency using efficiency = useful power output / total power input.
25. Use efficiency values as a decimal or as a percentage.
26. (HT only) Describe ways to increase the efficiency of an intended energy transfer.
27. Describe the main energy sources available for use on Earth: fossil fuels (coal, oil and gas), nuclear fuel, bio-fuel, wind, hydroelectricity, geothermal, the tides, the Sun and water waves.
28. Distinguish between renewable and non-renewable energy resources, using the definition that a renewable resource is one that is being (or can be) replenished as it is used.
29. Compare ways that different energy resources are used: transport, electricity generation and heating.
30. Understand why some energy resources are more reliable than others.

31. Describe the environmental impact arising from the use of different energy resources.
32. Explain patterns and trends in the use of energy resources.
33. Consider environmental issues arising from the use of energy resources and discuss why dealing with them involves political, social, ethical or economic considerations.

Stage	Use	Your notes
Starter 10 min · retrieval practice	*nothing in the Library for this stage yet*	
Teach the new content	Handout 01 Slide deck 01	
Practice guided then independent	Exercise sheets 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7 Past-paper sheets 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7	
Check before they leave	*nothing in the Library for this stage yet*	
Homework set from the Library	Any unused exercise sheet above	

2. Electricity

Weeks 6–10

They should be able to

1. Draw and interpret circuit diagrams using standard symbols.
2. State that electric charge flows only when a circuit is closed and includes a source of potential difference.
3. Use charge flow = current x time (Q = It), with time in seconds.
4. Recall that electric current is a flow of charge and that the current is the same at every point in a single closed loop.
5. State that the current through a component depends on its resistance and the potential difference across it.
6. Use potential difference = current x resistance (V = IR) in all directions.
7. Recall that the greater the resistance, the smaller the current for a given potential difference.
8. Required practical 3: investigate how the resistance of a wire depends on its length at constant temperature, including meter placement, R = V/I, the proportional graph, zero error and keeping the wire cool.
9. Explain that for some resistors resistance stays constant while in others it changes as the current changes.
10. Describe the I-V graph of an ohmic conductor at constant temperature, a filament lamp and a diode.
11. Explain the filament lamp graph: current heats the filament, resistance increases.
12. State that thermistor resistance decreases as temperature increases and give the thermostat application.
13. State that LDR resistance decreases as light intensity increases and give the switching-on-lights application.
14. Required practical 4: investigate the I-V characteristics of circuit elements, including varying the potential difference, reversing the supply, and protecting the diode.
15. For series components: state that the current is the same, the supply potential difference is shared, and the total resistance is the sum of the resistances.
16. For parallel components: state that the potential difference is the same across each, the total current is the sum of the branch currents, and the total resistance of two resistors is less than the smallest individual resistance.
17. Explain qualitatively why adding resistors in series increases total resistance while adding resistors in parallel decreases it.
18. Calculate currents, potential differences and resistances in dc series circuits, using equivalent resistance.
19. State that mains electricity is an ac supply with frequency 50 Hz and potential difference about 230 V in the UK.
20. Explain the difference between direct and alternating potential difference.
21. Identify the live, neutral and earth wires by insulation colour and state the job of each.
22. Explain why a live wire may be dangerous even when a switch in the mains circuit is open.
23. Explain the dangers of providing any connection between the live wire and earth.
24. Use power = potential difference x current (P = VI) and power = current squared x resistance (P = I^2 R).
25. Explain how the power transfer in a device relates to the potential difference across it, the current through it, and the energy transferred over time.
26. Use energy transferred = power x time (E = Pt) and energy transferred = charge flow x potential difference (E = QV), with time in seconds.
27. Describe how domestic appliances transfer energy to kinetic energy, heating or light, and relate power ratings to changes in stored energy in use.
28. Describe the National Grid as a system of cables and transformers linking power stations to consumers.
29. State that step-up transformers increase the transmission potential difference and step-down transformers decrease it for domestic use.
30. Explain why the National Grid is an efficient way to transfer energy, using P = VI and the cable power loss P = I^2 R.
31. Explain that rubbing insulating materials transfers electrons, leaving equal and opposite charges.
32. Describe the forces between charged objects: like charges repel, unlike charges attract, as a non-contact force.

33. Describe the production of static electricity and sparking by rubbing surfaces.
34. Draw the electric field pattern for an isolated charged sphere.
35. Explain the concept of an electric field and how it explains the non-contact force between charges and sparking.

Stage	Use	Your notes
Starter 10 min · retrieval practice	*nothing in the Library for this stage yet*	
Teach the new content	Handout 02 Slide deck 02	
Practice guided then independent	Exercise sheets 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8 Past-paper sheets 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8	
Check before they leave	*nothing in the Library for this stage yet*	
Homework set from the Library	Any unused exercise sheet above	

3. Particle model of matter

Weeks 11–13

They should be able to

1. Use density = mass / volume with the units kg/m3 and g/cm3, converting between them.
2. Use the particle model to explain the different states of matter and the differences in density between them.
3. Recognise and draw simple diagrams that model solids, liquids and gases.
4. Required practical 5: determine the densities of regular and irregular solid objects and liquids, using dimensions, a balance and a displacement technique.
5. Describe melting, freezing, boiling, evaporating, condensing and sublimating, and state that mass is conserved.
6. Explain that changes of state are physical changes which recover the original properties when reversed.
7. Define internal energy as the total kinetic and potential energy of all the particles in a system.
8. Explain that heating either raises the temperature or produces a change of state.
9. Use dE = m c d(theta) for temperature changes, with the value of c interpreted per kilogram per degree Celsius.
10. Interpret the specific heat capacity in particle terms.
11. Solve for energy, mass, specific heat capacity or temperature change with unit conversions.
12. Use energy for a change of state = mass x specific latent heat (E = mL).
13. Define specific latent heat and distinguish fusion from vaporisation.
14. Interpret heating and cooling graphs that include changes of state.
15. Distinguish specific heat capacity from specific latent heat.
16. Describe gas molecules as in constant random motion.
17. Relate the temperature of a gas to the average kinetic energy of its molecules.
18. Explain gas pressure in terms of molecular collisions with the container walls.
19. Explain qualitatively how the pressure of a fixed volume of gas changes with temperature.
20. Use pressure x volume = constant for a fixed mass of gas at constant temperature.
21. Calculate the new pressure or volume when either changes.
22. Use the particle model to explain how increasing the volume of a gas decreases its pressure.
23. (HT only) Explain how doing work on a gas increases its internal energy and can raise its temperature, for example in a bicycle pump.

Stage	Use	Your notes
Starter 10 min · retrieval practice	*nothing in the Library for this stage yet*	
Teach the new content	Handout 03 Slide deck 03	
Practice guided then independent	Exercise sheets 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 Past-paper sheets 3.1, 3.2, 3.3, 3.4, 3.5, 3.6	
Check before they leave	*nothing in the Library for this stage yet*	
Homework set from the Library	Any unused exercise sheet above	

4. Atomic structure

Weeks 14–16

They should be able to

1. Describe the structure of the atom as a positive nucleus of protons and neutrons surrounded by electrons at different energy levels.
2. Recall the order of magnitude of the atom's radius and that the nucleus is less than 1/10 000 of it, holding most of the mass.
3. Use atomic number and mass number to find protons, neutrons and electrons.
4. Define isotopes as atoms of the same element with different neutrons, and explain positive ions as atoms that have lost outer electrons.
5. Describe the sequence: indivisible spheres, plum pudding model, nuclear model, Bohr orbits, protons, neutrons.
6. Explain why the alpha scattering evidence led to the nuclear model.
7. Describe the difference between the plum pudding model and the nuclear model.
8. Describe radioactive decay as a random process in which unstable nuclei give out radiation.
9. Define activity (becquerel) and count-rate.
10. State the nature of alpha, beta, gamma and neutron radiation, with penetration, range in air and ionising power.
11. Apply the properties to choose the best source for a given use.
12. Write balanced nuclear equations for single alpha and beta decay, balancing atomic and mass numbers.
13. Define half-life as the time for the number of nuclei or the count rate to halve.
14. Determine half-life from given information or a graph.
15. (HT only) Calculate the net decline, expressed as a ratio, after a given number of half-lives.
16. Define radioactive contamination and irradiation, and state that irradiated objects do not become radioactive.
17. Compare the hazards of contamination and irradiation.
18. Describe suitable precautions against hazards from radioactive sources.
19. Explain the importance of publishing and peer-reviewing studies of radiation effects.
20. Describe natural and man-made sources of background radiation.
21. State that dose depends on occupation and location, and subtract background from measurements.
22. Explain how hazards differ according to half-life.
23. Describe and evaluate uses of nuclear radiation in medicine for exploration of internal organs and destruction of unwanted tissue.
24. Describe nuclear fission: a neutron absorbed by a large unstable nucleus, the products, and the released energy.
25. Explain chain reactions and the difference between controlled (reactor) and uncontrolled (weapon) versions.
26. Draw and interpret diagrams representing fission and chain reactions.
27. Describe nuclear fusion as the joining of two light nuclei with mass converting to radiation energy.

Stage	Use	Your notes
Starter 10 min · retrieval practice	*nothing in the Library for this stage yet*	
Teach the new content	Handout 04 Slide deck 04	

Stage	Use	Your notes
Practice guided then independent	Exercise sheets 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7 Past-paper sheets 4.1, 4.2, 4.3, 4.4, 4.5	
Check before they leave	*nothing in the Library for this stage yet*	
Homework set from the Library	Any unused exercise sheet above	

5. Forces

Weeks 17–22

They should be able to

1. Distinguish scalar and vector quantities, with examples of each.
2. Represent vectors as arrows with length for magnitude.
3. Classify contact and non-contact forces with examples.
4. Use weight = mass x gravitational field strength, recall the centre of mass and the newtonmeter.
5. Calculate the resultant of collinear forces; (HT) use free-body diagrams, resolve forces and find resultants by scale drawing.
6. Use work done = force x distance moved along the line of action of the force.
7. Recall 1 joule = 1 newton-metre and convert between them.
8. Describe the energy transfer when work is done, including the temperature rise from work against friction.
9. Explain why more than one force is needed to stretch, bend or compress a stationary object.
10. Distinguish elastic and inelastic deformation.
11. Use force = spring constant x extension and E = 0.5 k e squared below the limit of proportionality.
12. Interpret force-extension data and graphs; calculate a spring constant as the gradient.
13. Required practical 6: investigate the relationship between force and extension for a spring.
14. Use moment of a force = force x perpendicular distance from the pivot.
15. Apply the balance of clockwise and anticlockwise moments.
16. Explain how levers and gears transmit the rotational effects of forces.
17. Use pressure = force normal to a surface / area of the surface.
18. (HT) Use pressure = height x density x g for a column of liquid.
19. Explain upthrust and the factors for floating and sinking.
20. Explain why atmospheric pressure decreases with height.
21. Distinguish distance from displacement and speed from velocity.
22. Recall typical speeds for walking, running, cycling and sound in air.
23. Use s = vt and average speed; read distance-time graphs by gradient with (HT) tangents.
24. Use a = change in velocity / time; velocity-time gradients and (HT) areas; v squared minus u squared = 2as.
25. Describe motion in a fluid reaching terminal velocity.
26. State and apply Newton's first law, including (HT) inertia.
27. Use resultant force = mass x acceleration; (HT) inertial mass.
28. State and apply Newton's third law to equilibrium situations.
29. Required practical 7: investigate the effect of force on acceleration at constant mass, and mass at constant force.
30. Define stopping distance as thinking distance plus braking distance.
31. Explain reaction-time factors; measure human reaction times.
32. Explain how speed, road/weather and vehicle condition affect braking distance.
33. Explain braking as frictional work on the kinetic store and the dangers of large decelerations.
34. Use momentum = mass x velocity.
35. Apply conservation of momentum to collisions in a closed system.
36. Use force = change in momentum / time.
37. Explain safety features by the longer impact time reducing the force.

Stage	Use	Your notes
Starter 10 min · retrieval practice	*nothing in the Library for this stage yet*	
Teach the new content	Handout 05 Slide deck 05	
Practice guided then independent	Exercise sheets 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9 Past-paper sheets 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9	
Check before they leave	*nothing in the Library for this stage yet*	
Homework set from the Library	Any unused exercise sheet above	

6. Waves

Weeks 23–25

They should be able to

1. Describe the difference between transverse and longitudinal waves with examples.
2. Describe evidence that the wave, not the material, travels.
3. Use amplitude, wavelength, frequency and period; apply period = 1/frequency and wave speed = frequency x wavelength.
4. Describe methods to measure the speed of sound in air and of ripples on water.
5. Required practical 8: measure frequency, wavelength and speed in a ripple tank and in a solid.
6. (Physics only) Relate velocity, frequency and wavelength changes when sound passes between media.
7. Construct ray diagrams for reflection at a surface; describe absorption and transmission at interfaces.
8. Required practical 9: investigate reflection by different surfaces and refraction by different substances.
9. (HT) Describe sound conversion to vibrations of solids, the ear, and the 20 Hz to 20 kHz human hearing range.
10. (HT) Explain ultrasound imaging by partial reflection at boundaries, and seismic P-wave/S-wave exploration.
11. Describe EM waves as transverse, forming a continuous spectrum, all at the same speed in vacuum or air.
12. Recite the order of the spectrum from radio to gamma in wavelength and frequency.
13. Give uses of each band and (HT) explain their suitability.
14. State the hazards of ultraviolet, X-rays and gamma rays; interpret radiation dose data.
15. (HT) Explain how substances absorb, transmit, refract or reflect EM waves differently with wavelength; construct refraction ray and wavefront diagrams.
16. Construct ray diagrams for convex and concave lenses; distinguish real and virtual images.
17. Use magnification = image height / object height as a unitless ratio.
18. Explain colour by differential reflection and absorption; filters by transmission; specular vs diffuse reflection.
19. State that all bodies emit and absorb infrared radiation, more when hotter.
20. Define a perfect black body as complete absorber and best emitter.
21. Relate intensity and wavelength distribution of emission to temperature.
22. (HT) Explain constant temperature as balanced absorption and emission, and apply to the Earth's temperature factors.

Stage	Use	Your notes
Starter 10 min · retrieval practice	*nothing in the Library for this stage yet*	
Teach the new content	Handout 06 Slide deck 06	
Practice guided then independent	Exercise sheets 6.1, 6.2, 6.3, 6.4, 6.5 Past-paper sheets 6.1, 6.2, 6.3, 6.4, 6.5	
Check before they leave	*nothing in the Library for this stage yet*	
Homework set from the Library	Any unused exercise sheet above	

7. Magnetism and electromagnetism

Weeks 26–28

They should be able to

1. Describe attraction and repulsion between permanent magnet poles as a non-contact force.
2. Distinguish permanent from induced magnets, and recall that induced magnetism always causes attraction.
3. Describe the magnetic field and its direction; recall the four magnetic materials.
4. Explain how a plotting compass shows field directions, and the compass evidence for the Earth's field.
5. Describe the magnetic field around a current-carrying wire and the strong uniform field inside a solenoid; explain electromagnets.
6. Draw the field patterns for a straight wire and a solenoid with directions.
7. Apply Fleming's left-hand rule and $F = BIl$ to conductors at right angles to a field.
8. Explain the rotation of a motor coil and the role of the split-ring commutator.
9. (Physics only) Explain how loudspeakers and headphones convert current variations to sound pressure variations.
10. State the conditions for the generator effect and the factors affecting the size and direction of the induced pd.
11. Explain alternators (ac) and dynamos (dc) and interpret their pd-time graphs.
12. Explain how moving-coil microphones convert sound to current variations.
13. Use the transformer turns and power equations; explain induction between coils and the advantage of high-pd transmission.

Stage	Use	Your notes
Starter 10 min · retrieval practice	*nothing in the Library for this stage yet*	
Teach the new content	Handout 07 Slide deck 07	
Practice guided then independent	Exercise sheets 7.1, 7.2, 7.3 Past-paper sheets 7.1, 7.2, 7.3	
Check before they leave	*nothing in the Library for this stage yet*	
Homework set from the Library	Any unused exercise sheet above	

8. Space physics – physics only (4.8)

Weeks 29–30

– (4.8)

They should be able to

1. Describe the solar system: one star, eight planets, dwarf planets and natural satellites; part of the Milky Way.
2. Explain the Sun's formation from a nebula pulled together by gravity, and the fusion equilibrium of a main-sequence star.
3. Describe the life cycles of a Sun-sized star and of a much more massive star.
4. Explain how fusion processes produce the naturally occurring elements and how a supernova forms and distributes elements heavier than iron.
5. Describe gravity as the force maintaining circular orbits of planets and satellites.
6. Describe the similarities and distinctions between planets, their moons and artificial satellites.
7. (HT only) Explain qualitatively how circular orbits involve changing velocity but unchanged speed.
8. (HT only) Explain how a stable orbit must change radius when the speed changes.
9. Describe red-shift as an observed increase in wavelength of light from most distant galaxies.
10. State the link between distance, recession speed and the size of the red-shift.
11. Explain how red-shift is evidence for an expanding universe and the Big Bang theory.
12. Describe how observations, including the 1998 supernova results, lead to theories, and name current unknowns such as dark matter and dark energy.

Stage	Use	Your notes
Starter 10 min · retrieval practice	*nothing in the Library for this stage yet*	
Teach the new content	Handout 08 Slide deck 08	
Practice guided then independent	Exercise sheets 8.1, 8.2, 8.3 Past-paper sheets 8.1, 8.2, 8.3	
Check before they leave	*nothing in the Library for this stage yet*	
Homework set from the Library	Any unused exercise sheet above	