Applications and skills

1.1

- Using SI units in the correct format for all required measurements, final answers to calculations and presentation of raw and processed data
- Using scientific notation and metric multipliers
- Quoting and comparing ratios, values and approximations to the nearest order of magnitude
- Estimating quantities to an appropriate number of significant figures

1.2

- Explaining how random and systematic errors can be identified and reduced
- Collecting data that include absolute and/or fractional uncertainties and stating these as an uncertainty range (expressed as: best estimate ± uncertainty range)
- Propagating uncertainties through calculations involving addition, subtraction, multiplication, division and raising to a power
- Determining the uncertainty in gradients and intercepts

1.3

- Solving vector problems graphically and algebraically

2.1

- Determining instantaneous and average values for velocity, speed and acceleration
- Solving problems using equations of motion for uniform acceleration
- Sketching and interpreting motion graphs
- Determining the acceleration of free-fall experimentally
- Analysing projectile motion, including the resolution of vertical and horizontal components of acceleration, velocity and displacement
- Qualitatively describing the effect of fluid resistance on falling objects or projectiles, including reaching terminal speed

2.2

- Representing forces as vectors
- Sketching and interpreting free-body diagrams
- Describing the consequences of Newton's first law for translational equilibrium
- Using Newton's second law quantitatively and qualitatively
- Identifying force pairs in the context of Newton's third law
- Solving problems involving forces and determining resultant force
- Describing solid friction (static and dynamic) by coefficients of friction

2.3

- Discussing the conservation of total energy within energy transformations
- Sketching and interpreting force–distance graphs
- Determining work done including cases where a resistive force acts
- Solving problems involving power
- Quantitatively describing efficiency in energy transfers

2.4

- Applying conservation of momentum in simple isolated systems including (but not limited to) collisions, explosions, or water jets
- Using Newton's second law quantitatively and qualitatively in cases where mass is not constant
- Sketching and interpreting force–time graphs
- Determining impulse in various contexts including (but not limited to) car safety and sports
- Qualitatively and quantitatively comparing situations involving elastic collisions, inelastic collisions and explosions

3.1

- Describing temperature change in terms of internal energy
- Using Kelvin and Celsius temperature scales and converting between them
- Applying the calorimetric techniques of specific heat capacity or specific latent heat experimentally
- Describing phase change in terms of molecular behaviour
- Sketching and interpreting phase change graphs
- Calculating energy changes involving specific heat capacity and specific latent heat of fusion and vaporization

3.2

- Solving problems using the equation of state for an ideal gas and gas laws
- Sketching and interpreting changes of state of an ideal gas on pressure–volume, pressure–temperature and volume–temperature diagrams
- Investigating at least one gas law experimentally

4.1

- Qualitatively describing the energy changes taking place during one cycle of an oscillation
- Sketching and interpreting graphs of simple harmonic motion examples

4.2

- Explaining the motion of particles of a medium when a wave passes through it for both transverse and longitudinal cases
- Sketching and interpreting displacement–distance graphs and displacement–time graphs for transverse and longitudinal waves
- Solving problems involving wave speed, frequency and wavelength
- Investigating the speed of sound experimentally

4.3

- Sketching and interpreting diagrams involving wavefronts and rays
- Solving problems involving amplitude, intensity and the inverse square law
- Sketching and interpreting the superposition of pulses and waves
- Describing methods of polarization
- Sketching and interpreting diagrams illustrating polarized, reflected and transmitted beams
- Solving problems involving Malus's law

4.4

- Sketching and interpreting incident, reflected and transmitted waves at boundaries between media
- Solving problems involving reflection at a plane interface
- Solving problems involving Snell's law, critical angle and total internal reflection
- Determining refractive index experimentally
- Qualitatively describing the diffraction pattern formed when plane waves are incident normally on a single-slit
- Quantitatively describing double-slit interference intensity patterns

4.5

- Describing the nature and formation of standing waves in terms of superposition
- Distinguishing between standing and travelling waves
- Observing, sketching and interpreting standing wave patterns in strings and pipes
- Solving problems involving the frequency of a harmonic, length of the standing wave and the speed of the wave

5.1

- Identifying two forms of charge and the direction of the forces between them
- Solving problems involving electric fields and Coulomb's law
- Calculating work done in an electric field in both joules and electronvolts
- Identifying sign and nature of charge carriers in a metal
- Identifying drift speed of charge carriers
- Solving problems using the drift speed equation
- Solving problems involving current, potential difference and charge

5.2

- Drawing and interpreting circuit diagrams
- Identifying ohmic and non-ohmic conductors through a consideration of the *V/I* characteristic graph
- Solving problems involving potential difference, current, charge, Kirchhoff's circuit laws, power, resistance and resistivity
- Investigating combinations of resistors in parallel and series circuits
- Describing ideal and non-ideal ammeters and voltmeters
- Describing practical uses of potential divider circuits, including the advantages of a potential divider over a series resistor in controlling a simple circuit
- Investigating one or more of the factors that affect resistance experimentally

5.3

- Investigating practical electric cells (both primary and secondary)
- Describing the discharge characteristic of a simple cell (variation of terminal potential difference with time)
- Identifying the direction of current flow required to recharge a cell
- Determining internal resistance experimentally
- Solving problems involving emf, internal resistance and other electrical quantities

5.4

- Determining the direction of force on a charge moving in a magnetic field
- Determining the direction of force on a current-carrying conductor in a magnetic field
- Sketching and interpreting magnetic field patterns
- Determining the direction of the magnetic field based on current direction
- Solving problems involving magnetic forces, fields, current and charges

6.1

- Identifying the forces providing the centripetal forces such as tension, friction, gravitational, electrical, or magnetic
- Solving problems involving centripetal force, centripetal acceleration, period, frequency, angular displacement, linear speed and angular velocity
- Qualitatively and quantitatively describing examples of circular motion including cases of vertical and horizontal circular motion

6.2

- Describing the relationship between gravitational force and centripetal force
- Applying Newton's law of gravitation to the motion of an object in circular orbit around a point mass
- Solving problems involving gravitational force, gravitational field strength, orbital speed and orbital period
- Determining the resultant gravitational field strength due to two bodies

7.1

- Describing the emission and absorption spectrum of common gases
- Solving problems involving atomic spectra, including calculating the wavelength of photons emitted during atomic transitions
- Completing decay equations for alpha and beta decay
- Determining the half-life of a nuclide from a decay curve
- Investigating half-life experimentally (or by simulation)

7.2

- Solving problems involving mass defect and binding energy
- Solving problems involving the energy released in radioactive decay, nuclear fission and nuclear fusion
- Sketching and interpreting the general shape of the curve of average binding energy per nucleon against nucleon number

7.3

- Describing the Rutherford-Geiger-Marsden experiment that led to the discovery of the nucleus
- Applying conservation laws in particle reactions
- Describing protons and neutrons in terms of quarks
- Comparing the interaction strengths of the fundamental forces, including gravity
- Describing the mediation of the fundamental forces through exchange particles
- Sketching and interpreting simple Feynman diagrams
- Describing why free quarks are not observed

8.1

- Solving specific energy and energy density problems
- Sketching and interpreting Sankey diagrams
- Describing the basic features of fossil fuel power stations, nuclear power stations, wind generators, pumped storage hydroelectric systems and solar power cells
- Solving problems relevant to energy transformations in the context of these generating systems
- Discussing safety issues and risks associated with the production of nuclear power
- Describing the differences between photovoltaic cells and solar heating panels

8.2

- Sketching and interpreting graphs showing the variation of intensity with wavelength for bodies emitting thermal radiation at different temperatures
- Solving problems involving the Stefan–Boltzmann law and Wien's displacement law
- Describing the effects of the Earth's atmosphere on the mean surface temperature
- Solving problems involving albedo, emissivity, solar constant and the Earth's average temperature

9.1

- Solving problems involving acceleration, velocity and displacement during simple harmonic motion, both graphically and algebraically
- Describing the interchange of kinetic and potential energy during simple harmonic motion
- Solving problems involving energy transfer during simple harmonic motion, both graphically and algebraically

9.2

- Describing the effect of slit width on the diffraction pattern
- Determining the position of first interference minimum
- Qualitatively describing single-slit diffraction patterns produced from white light and from a range of monochromatic light frequencies

9.3

- Qualitatively describing two-slit interference patterns, including modulation by one-slit diffraction effect
- Investigating Young's double-slit experimentally
- Sketching and interpreting intensity graphs of double-slit interference patterns
- Solving problems involving the diffraction grating equation
- Describing conditions necessary for constructive and destructive interference from thin films, including phase change at interface and effect of refractive index
- Solving problems involving interference from thin films

9.4

- Solving problems involving the Rayleigh criterion for light emitted by two sources diffracted at a single slit
- Resolvance of diffraction gratings

9.5

- Sketching and interpreting the Doppler effect when there is relative motion between source and observer
- Describing situations where the Doppler effect can be utilized
- Solving problems involving the change in frequency or wavelength observed due to the Doppler effect to determine the velocity of the source/observer

10.1

- Representing sources of mass and charge, lines of electric and gravitational force, and field patterns using an appropriate symbolism
- Mapping fields using potential
- Describing the connection between equipotential surfaces and field lines

10.2

- Determining the potential energy of a point mass and the potential energy of a point charge
- Solving problems involving potential energy
- Determining the potential inside a charged sphere
- Solving problems involving the speed required for an object to go into orbit around a planet and for an object to escape the gravitational field of a planet
- Solving problems involving orbital energy of charged particles in circular orbital motion and masses in circular orbital motion
- Solving problems involving forces on charges and masses in radial and uniform fields

11.1

- Describing the production of an induced emf by a changing magnetic flux and within a uniform magnetic field
- Solving problems involving magnetic flux, magnetic flux linkage and Faraday's law
- Explaining Lenz's law through the conservation of energy

11.2

- Explaining the operation of a basic ac generator, including the effect of changing the generator frequency
- Solving problems involving the average power in an ac circuit
- Solving problems involving step-up and step-down transformers
- Describing the use of transformers in ac electrical power distribution
- Investigating a diode bridge rectification circuit experimentally
- Qualitatively describing the effect of adding a capacitor to a diode bridge rectification circuit

11.3

- Describing the effect of different dielectric materials on capacitance
- Solving problems involving parallel-plate capacitors
- Investigating combinations of capacitors in series or parallel circuits
- Determining the energy stored in a charged capacitor
- Describing the nature of the exponential discharge of a capacitor
- Solving problems involving the discharge of a capacitor through a fixed resistor
- Solving problems involving the time constant of an RC circuit for charge, voltage and current

12.1

- Discussing the photoelectric effect experiment and explaining which features of the experiment cannot be explained by the classical wave theory of light
- Solving photoelectric problems both graphically and algebraically
- Discussing experimental evidence for matter waves, including an experiment in which the wave nature of electrons is evident
- Stating order of magnitude estimates from the uncertainty principle

12.2

- Describing a scattering experiment including location of minimum intensity for the diffracted particles based on their de Broglie wavelength
- Explaining deviations from Rutherford scattering in high energy experiments
- Describing experimental evidence for nuclear energy levels
- Solving problems involving the radioactive decay law for arbitrary time intervals
- Explaining the methods for measuring short and long half-lives