Physics Year 13	**Working towards expected outcomes** Your child is not yet making the expected progress within this course.	**Working at expected outcomes** Your child is achieving the expected progress for this point within the course.	**Working beyond expected outcomes** Your child is exceeding the expected progress.
Further Mechanics	Students working **towards** expected outcomes in Y12 can: • Use the idea that impulse is linked to the change in momentum in straightforward examples. • Describe momentum as a quantity that is conserved in collisions, applying this in one dimension. • Identify if a collision is elastic or inelastic by checking whether kinetic energy is conserved. • Recall that the kinetic energy of a moving object can be calculated using momentum and mass. • Convert between degrees and radians with support and identify angular quantities like displacement and velocity. • Use the terms angular velocity and time period in simple circular motion problems. • Recognise that a resultant force is needed to keep an object moving in a circle.	Students working **at** expected in Y12 can: • Explain how impulse causes a change in momentum and link this to Newton's second law. • Apply momentum conservation to two-dimensional collisions, using vector diagrams and clear reasoning. • Identify whether a collision is elastic or inelastic using both momentum and energy considerations. • Calculate the kinetic energy of a moving object using information about its momentum and mass. • Convert confidently between angular and linear quantities, such as angular velocity and displacement. • Apply knowledge of circular motion to solve problems involving frequency, time period, radius and speed. • Use vector diagrams to explain why circular motion involves acceleration towards the centre. • Calculate the size of the force needed to keep an object moving in a circle based on its speed and radius.	Students working **beyond** expected in Y12 can: **In addition to all the skills listed under 'Working At' for this topic, students working beyond expected outcomes can:** • Justify how impulse relates to changes in momentum across a range of unfamiliar contexts. • Solve multi-step problems involving momentum in two dimensions using components and advanced vector reasoning. • Analyse energy transfers in collisions and assess the validity of elasticity assumptions. • Explore the relationship between momentum and kinetic energy to compare physical systems. • Evaluate complex problems involving angular quantities, confidently switching between units and using reasoning to support answers. • Derive expressions for circular motion using vector or energy-based arguments. • Apply circular motion concepts in unfamiliar contexts such as orbits, rides, or rotating arms. • Lead practical work independently, refining methods, identifying error sources and

	• Use the idea that faster motion or smaller radius increases centripetal force. • Carry out practical tasks with support, using step-by-step instructions and recording basic observations.	• Complete practical work with care, collecting valid data and identifying ways to reduce uncertainty.	explaining how their choices meet CPAC requirements.
Nuclear and Particle Physics	• Define nucleon number and proton number and identify them in nuclear symbols. • Describe how alpha particle scattering led to a new atomic model. • State that electrons can be released from heated materials and can be accelerated using electric and magnetic fields. • Recognise the function of electric and magnetic fields in accelerating or deflecting charged particles. • Use simple relationships involving charge, velocity, and magnetic field with support. • Use basic rules of charge or energy conservation in simple particle reactions.	• Explain how alpha particle scattering provided evidence for the nuclear model of the atom. • Describe how thermionic emission works and explain how charged particles are accelerated in fields. • Explain how electric and magnetic fields are used in particle accelerators and detectors. • Explain how the motion of charged particles is affected by magnetic fields and use this to predict circular paths. • Apply conservation of charge, energy and momentum to particle interactions and identify particles from tracks. • Explain why high-energy collisions are needed to probe nuclear structure. • Describe how energy and mass are equivalent and apply this concept to explain annihilation and pair production.	**In addition to all the skills listed under 'Working At' for this topic, students working beyond expected outcomes can:** • Evaluate historical experiments such as Rutherford's alpha scattering and link them to scientific theory development. • Apply concepts of acceleration and magnetic deflection in detailed analysis of circular paths and field interactions. • Derive and manipulate relationships for particle motion in fields and explain how radius depends on charge, velocity, and field strength. • Analyse complex collision and decay scenarios using full conservation of energy, charge, momentum, and baryon/lepton numbers. • Justify why particle lifetime appears to increase at high speeds using qualitative understanding of relativistic effects.

	• Recognise common units like MeV and convert between these and standard SI units when guided. • Identify baryons, mesons, and leptons as different types of particles and give examples. • Match a particle to its antiparticle based on charge or mass. • Read and interpret straightforward particle equations using common particle symbols.	• Convert confidently between energy and mass using MeV/c^2 and between MeV and SI units. • Describe the classification of particles into baryons, mesons and leptons, and state the basic quark composition. • Use conservation laws and baryon/lepton numbers to determine whether a particle interaction is allowed. • Write and interpret balanced particle equations using symbols, charge and mass numbers.	• Explain the need for high collision energies in terms of resolving power and the strong nuclear force. • Evaluate particle classification systems, discussing the standard model and evidence for the top quark. • Apply quark content to predict particle outcomes and rearrange reactions based on interaction rules. • Construct and explain unfamiliar particle equations using accurate notation and correct conservation principles.
Electric and Magnetic Fields	• Describe what an electric field is and how it affects charged particles. • Recognise that electric field strength relates to the force on a charge. • Use basic examples to describe the idea of attraction and repulsion between charges. • Understand that capacitors store charge and energy. • Describe a magnetic field as a region where a magnetic force acts. • State that current-carrying wires and magnets produce magnetic fields.	• Apply the concept of electric fields to explain the motion of charges near charged objects. • Use uniform and radial field diagrams to explain field strength and potential. • Solve problems using field strength and potential difference for parallel plates and point charges. • Explain the relationship between field lines and equipotentials. • Use capacitance equations to calculate charge, voltage, and energy stored.	**In addition to all the skills listed under 'Working At' for this topic, students working beyond expected outcomes can:** • Compare and analyse uniform and non-uniform electric fields in quantitative contexts. • Evaluate the relationship between field strength and potential, using energy and work concepts. • Interpret and sketch charge/discharge curves using both logarithmic and exponential forms. • Explain and derive energy storage equations graphically and mathematically. • Apply knowledge of field strength and capacitance in unfamiliar multi-step problems.

	• Recognise that changing magnetic fields can induce a current. • Describe the idea of alternating current and simple peak values. • Identify simple features of charge and discharge graphs. • State the purpose of a capacitor and give an example of where it is used.	• Interpret and explain exponential charge and discharge graphs. • Analyse how time constant affects capacitor behaviour in circuits. • Use Fleming's left-hand rule to predict force on charges or wires in magnetic fields. • Apply magnetic force equations for moving charges and current-carrying conductors. • Explain how flux and flux linkage change in dynamic systems (e.g. moving coils). • Use Faraday's and Lenz's laws to explain how induced emf is generated. • Use the terms frequency, period, and root-mean-square (rms) values correctly in AC contexts. • Solve problems involving rms values for alternating voltage and current. • Carry out and interpret the capacitor discharge core practical, analysing the impact of RC.	• Analyse how field concepts apply to deflection of particles in mass spectrometers or CRTs. • Evaluate the efficiency and behaviour of capacitors in real circuits. • Solve complex problems involving flux, induced emf and Lenz's law in dynamic systems. • Predict induced current direction and magnitude in transformers or rotating coil generators. • Critically apply rms and peak relationships in alternating current systems and justify energy usage patterns. • Use experimental results to support or challenge capacitor or induction models.
Thermodynamics	• Identify situations where energy is stored thermally and describe temperature as a measure of thermal energy.	• Accurately calculate thermal energy changes using the specific heat capacity and latent heat equations. • Describe internal energy in terms of both random kinetic and potential	**In addition to all the skills listed under 'Working At' for this topic, students working beyond expected outcomes can:** • Analyse complex thermal systems involving multiple energy transfers and use data to evaluate energy changes.

	• Recall and use the specific heat capacity and specific latent heat equations with given values. • Describe the concepts of internal energy as a combination of kinetic and potential energies of particles. • Define absolute zero as the lowest possible temperature and link it to the motion of particles. • Recognise that heating can change internal energy and cause temperature or state changes. • Describe a black body as an ideal emitter and absorber of radiation and interpret simple radiation curves. • State that as temperature increases, radiation intensity increases and peak wavelength decreases.	energies and explain how heating affects both. • Explain absolute zero in relation to the kinetic theory of gases. • Use the kinetic theory equation for pressure and volume and relate it to gas motion. • Apply the ideal gas equation to solve problems involving pressure, volume, and temperature. • Interpret data from gas investigations and describe how pressure varies with volume at constant temperature. • Explain and apply the kinetic energy equation for gas molecules and link this to temperature. • Analyse and interpret radiation curves for black body emitters and apply the Stefan-Boltzmann law and Wien's law qualitatively. • Complete and interpret the three core practicals: thermistor calibration, specific latent heat, and gas pressure-volume relationships.	• Solve multi-step problems using internal energy changes, applying specific heat capacity and latent heat accurately in unfamiliar contexts. • Use kinetic theory and the ideal gas law to derive and explain the relationships between pressure, volume, and temperature. • Evaluate assumptions made in the kinetic theory model and discuss its limitations. • Quantitatively compare energy distributions in gases at different temperatures. • Use Stefan-Boltzmann and Wien's laws to calculate radiated energy and peak wavelengths, and evaluate radiation efficiency. • Interpret radiation curves in detail and explain temperature effects using both graphical and algebraic reasoning. • Evaluate and improve the reliability and accuracy of the core practicals, identifying sources of error and suggesting refinements.
Space	• Describe what is meant by luminosity and intensity of light from a star.	• Use the intensity–distance relationship to calculate how light spreads from a point source.	**In addition to all the skills listed under Working At for this topic, students working beyond expected outcomes can:**

	• Recall that distant stars appear dimmer and describe the inverse square relationship between brightness and distance. • Identify basic features of a Hertzsprung-Russell diagram and describe how temperature and brightness vary across it. • Describe how light from distant galaxies is redshifted and explain that this suggests they are moving away. • State that the universe is expanding and that there is ongoing research into its age and fate.	• Explain how trigonometric parallax and standard candles are used to determine astronomical distances. • Sketch and interpret Hertzsprung-Russell diagrams, identifying the main sequence and different stages of stellar evolution. • Explain the Doppler effect and apply it to describe frequency shifts in light and sound. • Calculate redshift using appropriate relationships and explain what it tells us about galaxy motion. • Apply Hubble's law to estimate distances to galaxies and describe how this leads to an estimate for the age of the universe. • Describe the implications of redshift evidence for the expanding universe and outline the concept of dark matter in simple terms.	• Apply intensity and luminosity relationships to complex problems involving multiple star systems or unknown variables. • Evaluate the reliability and uncertainty of distance measurements using standard candles and trigonometric methods. • Analyse and explain patterns across the Hertzsprung-Russell diagram, including stellar classification and life cycles. • Derive and manipulate redshift and Doppler shift equations to solve unfamiliar problems. • Use Hubble's law in different forms and critique the assumptions made in its application. • Evaluate cosmological models based on current observational data, including discussion of the evidence for dark matter and the limitations of current theories. • Discuss how scientific understanding of the universe changes over time and how models evolve in response to new evidence
Nuclear Radiation	• State what is meant by nuclear radius and recognise typical orders of magnitude for atomic and nuclear sizes.	• Use the relationship between nuclear radius and mass number to estimate nuclear density.	**In addition to all the skills listed under Working At for this topic, students working beyond expected outcomes can:**

	• Describe what is meant by radioactive decay and identify alpha, beta and gamma radiation. • Recall that radioactive decay is random and that activity decreases over time. • Recognise and describe basic features of decay curves. • Define half-life and describe how it relates to the rate of radioactive decay.	• Apply the concept of half-life to solve problems involving exponential decay. • Use and manipulate decay equations to determine activity, remaining nuclei or time elapsed. • Plot and interpret decay curves, including calculations involving the exponential decay law. • Evaluate experimental methods used to determine the half-life of a sample and identify sources of uncertainty. • Explain how radioactive sources are used in industry and medicine, linking half-life and radiation type to suitability.	• Analyse experimental data to determine decay constants, including using logarithmic plots. • Apply exponential models to complex problems involving combinations of decay processes or mixed isotopes. • Explain and evaluate the assumptions behind decay equations and explore the impact of statistical variation in small samples. • Compare and critique the use of different isotopes for specific real-world applications based on decay type, energy, and half-life. • Discuss the implications of radioactive decay models for nuclear safety, waste disposal, and long-term risk assessment.
Gravitational Fields and Oscillations	• Define a gravitational field as a region where a mass experiences a force. • State that gravitational field strength is force per unit mass. • Recognise basic features of radial and uniform fields from diagrams. • State that gravitational force depends on the masses involved and distance between them. • Recognise simple examples of oscillations and identify basic	• Use gravitational field strength, potential, and Newton's law of gravitation to solve standard problems. • Compare electric and gravitational fields using similarities and differences. • Apply the principles of circular motion to orbital paths, linking motion to gravitational forces. • Use data and graphical methods to calculate time periods, amplitudes, and accelerations in oscillating systems.	**In addition to all the skills listed under Working At for this topic, students working beyond expected outcomes can:** • Solve multistep problems involving gravitational field strength and potential energy in radial fields. • Analyse orbital motion in unfamiliar contexts using Newton's law of gravitation and centripetal force concepts. • Evaluate and derive gravitational field expressions and apply them to escape velocity and planetary motion.

	features such as amplitude and time period. • Plot displacement-time and velocity-time graphs from given data. • Define resonance and damping in simple terms.	• Interpret displacement-time and velocity-time graphs for oscillations and relate gradients to velocity and acceleration. • Describe the features of simple harmonic motion and link them to relevant conditions. • Explain energy transfers in damped and undamped oscillations, using conservation of energy. • Describe how damping affects resonance and amplitude in forced oscillations. • Carry out practical work on oscillating systems, e.g. using resonance to determine mass, with awareness of key variables (CPAC).	• Derive and apply SHM equations from first principles and explain how each parameter affects the motion. • Link mathematical models of oscillations to physical systems, including pendulums and springs. • Apply advanced reasoning to damping and resonance, discussing how materials and design influence system response. • Use core practical results to assess uncertainty, linearise data, and validate theoretical predictions (e.g. mass vs. frequency^2).