Physics **Year 12**	**Working towards expected outcomes**	**Working at expected outcomes**	**Working beyond expected outcomes**
	Your child is not yet making the expected progress within this course.	Your child is achieving the expected progress for this point within the course.	Your child is exceeding the expected progress.
Materials	Students working **towards** expected outcomes in Y12 can: • Recall and use the equation for density: $\rho = m / V$, when all quantities are given. • Describe upthrust as the weight of fluid displaced and apply this idea in familiar contexts. • Recognise that viscosity is affected by temperature and apply Stokes' Law in structured problems. • Describe how to safely carry out a practical using a falling-ball method for viscosity, following instructions. • Use Hooke's law for linear relationships where data is straightforward. • Recall definitions of stress, strain, and Young modulus and substitute values into the equations when prompted. • Identify and sketch force-extension graphs for springs showing the limit of proportionality.	Students working **at** expected in Y12 can: • Apply the density formula to calculate mass or volume in a range of contexts, including irregular shapes. • Use the upthrust = weight of fluid displaced relationship in novel scenarios, recognising conditions for equilibrium. • Apply Stokes' Law whilst understanding its assumptions. • Carry out Core Practical 4 methodically, including repeating measurements, identifying anomalies and calculating viscosity using average values. • Use and rearrange Hooke's law, identify the spring constant from graphs and describe energy stored in a spring. • Use equations for stress, strain, and Young modulus to solve multi-step problems and interpret values meaningfully. • Plot and interpret force-extension and force-compression graphs, identifying	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:** • Solve multi-step problems involving density, combining with pressure or energy equations where appropriate. • Evaluate the limitations of Stokes' Law, discussing the effects of turbulence and conditions where the law no longer applies. • Explain the physical principles behind viscosity and upthrust using particle models and fluid mechanics. • Design improvements for Core Practical 4, analysing sources of uncertainty and suggesting better apparatus or techniques. • Analyse force-extension and stress-strain data, including non-linear regions, and relate these to material properties. • Use gradients and areas under graphs to determine energy stored and elastic strain energy, and discuss energy transformations.

	• Recognise key features of stress-strain graphs and define the breaking stress. • Follow a method for determining Young modulus in a practical, with support, recording basic data accurately.	regions such as elastic limit and plastic deformation. • Describe key features of stress-strain graphs including breaking point, elastic limit and Young modulus. • Accurately complete Core Practical 5, including determining Young modulus from the gradient of a graph, using appropriate equipment, and considering error sources.	• Distinguish between different materials based on their stress-strain curves and evaluate their suitability for real-world applications. • In Core Practical 5, evaluate systematic and random errors, justify use of digital equipment, and comment on reliability and validity using CPAC standards (e.g., repeatability, control of variables, clear identification of risks).
Waves	• Define and use key wave terms such as amplitude, frequency, period, wavelength, and wave speed. • Use the wave equation for basic calculations. • Describe differences between longitudinal and transverse waves using simple examples. • Recognise wavefronts and basic ideas of superposition and phase. • Identify nodes and antinodes in a stationary wave and describe their meaning. • Calculate simple values using intensity with given power and area. • Use Snell's Law to perform basic refraction calculations between two media.	• Accurately define and apply wave quantities and describe how they relate with confidence across contexts. • Explain and analyse longitudinal and transverse wave behaviour including pressure variation or displacement graphs. • Draw and interpret graphs for both progressive and stationary waves, identifying phase differences and path differences. • Use given values to calculate wave speed on a string and interpret its implications. • Analyse stationary waves formed by reflection or resonance, explaining the formation of nodes and antinodes.	**In addition to all the skills listed under 'Working At' for this topic, students working beyond expected outcomes can:** • Combine wave equations in unfamiliar contexts and justify their application. • Compare and evaluate wave behaviour quantitatively across different media or boundaries (e.g. water, air, string). • Analyse stationary wave patterns mathematically and derive relationships linking frequency, length, and harmonic number. • Use vector analysis or graphing techniques to explain intensity patterns, including central maxima and fringe spacing. • Justify use of diffraction gratings over other methods using resolving power and theoretical analysis.

	• Identify basic ray diagrams for converging and diverging lenses. • Carry out required practicals under direction, following a method but with support in collecting and processing data.	• Apply the intensity equation and discuss the relationship between intensity and amplitude. • Use Snell's Law to calculate refractive index, critical angle and total internal reflection conditions. • Draw and interpret accurate ray diagrams including real and virtual images for lenses. • Understand and apply the thin lens formula and magnification equations. • Describe and explain concepts of coherence, path difference, phase difference, polarisation and diffraction using examples. • Perform diffraction grating calculations. • Perform required practicals (CPAC 6, 7, 8) with confidence, making accurate measurements and discussing reliability, repeatability and valid conclusions.	• Evaluate the effect of lens combinations and calculate effective power for compound systems. • Discuss wave superposition and interference in complex contexts, including multi-source or non-coherent systems. • Explain and analyse polarisation in practical and theoretical contexts, linking to real-world applications. • Independently plan practical work (e.g. CPAC 6–8), select appropriate equipment, justify the procedure, and suggest improvements based on detailed evaluation of uncertainties and systematic error sources.

Mechanics	- Recall and use the SUVAT equations for uniform acceleration in 1D with support. - Draw basic motion graphs and give basic descriptions of motion. - Recognise scalars and vectors and give some examples. - Resolve vectors at right angles and find resultants in simple cases using drawing. - Use free-body diagrams to show simple forces. - Recall Newton's laws in words. - State definitions of momentum and kinetic energy and use equations with numbers provided. - Apply the principle of moments in basic symmetrical setups. - Perform calculations involving work, GPE and KE.	- Confidently apply all SUVAT equations in familiar contexts and rearrange as required. - Draw and interpret displacement–time, velocity–time and acceleration–time graphs and link them to physical motion. - Distinguish between scalars and vectors with consistent accuracy and apply the idea of vector addition, including components. - Resolve vectors at angles using trigonometry and find resultants using scale diagrams or calculation. - Draw accurate free-body diagrams for objects in equilibrium or undergoing acceleration. - Apply Newton’s laws to explain the motion of objects, including identifying third law pairs in examples. - Calculate momentum, force and impulse using correct equations and apply conservation of momentum in 1D collisions. - Apply the principle of moments to real-world examples, including finding unknown forces or distances. - Explain and calculate energy transfers involving work done, gravitational potential energy, and kinetic energy.	**In addition to all the skills listed under ‘Working At’ for this topic, students working beyond expected outcomes can:** - Apply SUVAT equations in multi-stage problems, justify assumptions (e.g. constant acceleration) and critique limitations of the model. - Explain subtleties in motion graphs (e.g. instantaneous vs average values, curved sections) and describe what changes indicate about forces acting. - Confidently analyse vector problems including oblique angles and non-right-angled triangles, showing clear understanding of the link between components and resultants. - Use Newton’s laws in a range of contexts including lifts, rockets, friction and terminal velocity, showing a full understanding of balanced/unbalanced forces. - Quantitatively apply conservation of momentum in more complex scenarios, including recoil, explosions or coupled systems. - Apply principles of equilibrium to extended bodies with non-standard geometries and justify reasoning. - Set up energy conservation equations for systems involving multiple transfers (e.g. springs, inclines, resistive forces) and justify energy paths.

		- Use and rearrange power and efficiency equations. - Carry out Core Practical 1: Determine the acceleration of a freely falling object safely and with minimal guidance. Analyse data and identify appropriate sources of error.	- Analyse limitations of experimental methods and suggest valid improvements, e.g. for minimising error in measuring acceleration due to gravity. - Evaluate sources of uncertainty in Core Practical 1 and explain how they impact the calculated value of g. Confidently justify conclusions and support them with repeat readings and graph interpretation.
Electricity	- Define current. - Use basic electricity equations with support and uses simple circuit symbols. - Describe series and parallel behaviour qualitatively. - State conservation of current/energy with support. - Identify I–V characteristics for resistors, filament bulbs, and diodes. - Explains meaning of resistivity simply and perform basic calculations.	- Apply electricity equations in unfamiliar contexts. - Explain resistance in terms of material, length and area. - Apply Kirchhoff's laws to solve series and parallel circuit problems. - Explain the behaviour of components using I–V graphs and real-world applications. - Interpret resistivity data, including graphs of resistance vs length or area. - Link resistivity to material structure.	**In addition to all the skills listed under 'Working At' for this topic, students working beyond expected outcomes can:** - Explain current using the microscopic model and compare current in different materials. - Justify how resistivity varies with temperature, using microscopic ideas and I–V graph interpretations. - Solve complex circuits combining Kirchhoff's laws and use reasoning to justify answers. - Justify non-ohmic behaviour using energy and particle models, comparing temperature effects.

	• States the meaning of emf and internal resistance. • Use the EMF equation when prompted. • Describe potential dividers in simple terms. • Use voltage ratios in structured tasks. • Record data with basic accuracy. Identifies one way to improve.	• Solve problems involving terminal pd, emf, and internal resistance. Apply concepts to real examples. • Analyse dividers including variable resistors, LDRs and thermistors in sensing circuits. • Collect repeatable data and identifies patterns. • Comment on sources of error and justifies one improvement.	• Compare conductors, semiconductors and insulators using the charge carrier model. • Explain internal resistance in terms of energy loss per charge. Evaluate assumptions in calculations. • Design sensing circuits for given conditions and justify choices using precise calculations. • Plan procedures independently. Evaluate accuracy, reliability and uncertainty using appropriate terminology.
Quantum	• States that electrons can behave as waves and quotes the de Broglie equation: λ = h / p. • Describes the photoelectric effect as the emission of electrons when light hits a metal surface. • Identifies that energy of a photon is linked to frequency using E = h × f. • Recalls the meaning of key terms: threshold frequency, work function, electronvolt. • Substitutes values into equations with support: hf = phi + 0.5 × m × v^2 and E = h × f.	• Explain the de Broglie equation and how diffraction shows wave-like properties of particles. • Apply energy equations fluently in different contexts. • Calculate work function, threshold frequency or kinetic energy. • Apply the photoelectric effect as evidence for particle nature of light. • Explain how atomic spectra support the idea of discrete energy levels and transitions. • Calculates frequency of emitted or absorbed photons during transitions.	**In addition to all the skills listed under 'Working At' for this topic, students working beyond expected outcomes can:** • Justify why the wave model fails to explain photoelectric observations and how the photon model resolves this. • Discuss duality using both wave and particle evidence, including comparisons of diffraction and photoelectric effect. • Evaluate assumptions in quantum calculations and comment on limitations (e.g. neglecting energy losses).

	• States that absorption or emission of photons causes electrons to change energy levels. • Identifies atomic line spectra as evidence for quantised energy levels.	• Interpret graphs and data involving photoelectrons and photon energies.	• Calculate or derive values from unfamiliar atomic transitions using E = h × f and energy level diagrams. • Apply knowledge of quantised energy to justify features in emission and absorption spectra. • Solve multi-step problems combining equations, units (eV to J) and interpretations of data.