2024 Units 3 and 4 Study Design Dot points and differences to 2023 version.

In the tables below, the left hand column has the dot points from the 2024 study design, the right hand column indicates changes, if any.

2024 Unit 3 Study Design	**Status**
Area of Study 1 **How do physicists explain motion in two dimensions?**	
Newton's laws of motion Investigate and apply theoretically and practically Newton's three laws of motion in situations where two or more coplanar forces act along a straight line and in two dimensions.	No change
Investigate and analyse theoretically and practically the uniform circular motion of an object moving in a horizontal plane: $F_{net} = \frac{mv^2}{r}$, including: a vehicle moving around a circular road. a vehicle moving around a banked track. an object on the end of a string.	No change
Model natural and artificial satellite motion as uniform circular motion	No change
Investigate and apply theoretically Newton's second law to circular motion in a vertical plane (forces at the highest and lowest positions only)	No change
Investigate and analyse theoretically and practically the motion of projectiles near Earth's surface, including a qualitative description of the effects of air resistance.	No change
Investigate and apply theoretically and practically the laws of energy and momentum conservation in isolated systems in one dimension.	No change

Relationships between force, energy and mass Investigate and apply theoretically and practically the concept of work done by a force using: work done = force × displacement work done = area under force vs distance graph (one dimensional only)	force replaces constant force. force replaces constant force. displacement replaces distance moved in direction of net force. (one dimensional only) has been included
Analyse transformations of energy between kinetic energy, elastic potential energy, gravitational potential energy and energy dissipated to the environment (considered as a combination of heat, sound and deformation of material):	Strain potential energy becomes elastic potential energy.
kinetic energy at low speeds: $E_k = \frac{1}{2}mv^2$ elastic and inelastic collisions with reference to conservation of kinetic energy	
elastic potential energy: area under force-distance graph including ideal springs obeying Hooke's Law: $E_S = \frac{1}{2}kx^2$	Strain potential energy becomes elastic potential energy.
gravitational potential energy: $E_g = mg\Delta h$ or from area under a force-distance graph and area under a field-distance graph multiplied by mass.	
Investigate and analyse theoretically and practically impulse in an isolated system for collisions between objects moving in a straight line: $F\Delta t = m\Delta v$	No change
	Relativity has moved to Unit 4

Area of Study 2 **How do things move without contact?**	
Fields and interactions Describe gravitation, magnetism and electricity using a field model.	No change
Investigate and compare theoretically and practically gravitational, magnetic and electric fields, including directions and shapes of fields, attractive and repulsive effects, and the existence of dipoles and monopoles.	repulsive 'fields' becomes repulsive effects.
Investigate and compare theoretically and practically gravitational fields and electrical fields about a point mass or charge (positive or negative) with reference to: the direction of the field. the shape of the field. the use of the inverse square law to determine the magnitude of the field. potential energy changes (qualitative) associated with a point mass or charge moving in the field.	the use of the inverse square law to determine the magnitude of the field potential energy changes (qualitative) associated with a point mass or charge moving in the field has been included.
Investigate and apply theoretically and practically a field model to magnetic phenomena, including shapes and directions of fields produced by bar magnets, and by current-carrying wires, loops and solenoids.	apply replaces 'compare' a field model to magnetic phenomena replaces 'magnetic fields'. produced by bar magnets, and by current-carrying wires, loops and solenoids replaces 'attractive and repulsive fields, and the existence of dipoles and monopoles'.
Identify fields as static or changing, and as uniform or non-uniform.	No change
Effects of fields Analyse the use of an electric field to accelerate a charge, including:	No change

electric field and electric force concepts: $E = k\frac{Q}{r^2}$ and $F = k\frac{Q_1Q_2}{r^2}$ potential energy changes in a uniform electric field: $W = qV$, $E = \frac{V}{d}$ the magnitude of the force on a charged particle due to a uniform electric field: $F = qE$. Analyse the use of a magnetic field to change the path of a charged particle, including: the magnitude and direction of the force applied to an electron beam by a magnetic field: $F = qvB$, in cases where the directions of v and B are perpendicular or parallel the radius of the path followed by an electron in a magnetic field: $qvB = \frac{mv^2}{r}$ where $v << c$ Analyse the use of gravitational fields to accelerate mass, including: gravitational field and gravitational force concepts: $g = \frac{GM}{r^2}$ and $F_g = \frac{Gm_1m_2}{r^2}$ potential energy changes in a uniform gravitational field: $E_g = mg\Delta h$ Analyse the change in gravitational potential energy from area under a force vs distance graph and area under a field vs distance graph multiplied by mass.	Include where $v << c$ $F_g = \frac{Gm_1m_2}{r^2}$ replaces $F = \frac{Gm_1m_2}{r^2}$ force vs distance replaces 'force-distance'. 'force-distance' is consistent with previous dot point in Relationships between force, energy and mass.
Application of field concepts Apply the concepts of force due to gravity and normal force including in relation to satellites in orbit where the orbits are assumed to be uniform and circular.	F_g deleted from after 'gravity' normal force replaces 'normal reaction force F_N' in relation to has been inserted.

Model satellite motion (artificial, Moon, planet) as uniform circular orbital motion: $a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$	No change
Describe the interaction of two fields, allowing that electric charges, magnetic poles and current carrying conductors can either attract or repel, whereas masses only attract each other.	No change
Investigate and analyse theoretically and practically the force on a current carrying conductor due to an external magnetic field, $F = nIlB$, where the directions of I and B are either perpendicular or parallel to each other.	No change
Investigate and analyse theoretically and practically the operation of simple DC motors consisting of one coil, containing a number of loops of wire, which is free to rotate about an axis in a uniform magnetic field and including the use of a split ring commutator.	No change
Investigate, qualitatively, the effect of current, external magnetic field and the number of loops of wire on the torque of a simple motor.	Has been included.
Model the acceleration of particles in a particle accelerator (including synchrotrons) as uniform circular motion (limited to linear acceleration by a uniform electric field and direction change by a uniform magnetic field).	No change

Area of Study 3 How are fields used in electricity generation?	
Generation of electricity	
Calculate magnetic flux when the magnetic field is perpendicular to the area, and describe the qualitative effect of differing angles between the area and the field: $\Phi_B = B_{\perp}A$	No change
Investigate and analyse theoretically and practically the generation of electromotive force (emf) including AC voltage and calculations using induced emf: $\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}$, with reference to: rate of change of magnetic flux number of loops through which the flux passes direction of induced emf in a coil	No change
Explain the production of DC voltage in DC generators and AC voltage in alternators, including the use of split ring commutators and slip rings respectively.	No change
Describe the production of electricity using photovoltaic cells and the need for an inverter to convert power from DC to AC for use in the home (not including details of semiconductors action or inverter circuitry)	Has been included.
Transmission of electricity	
Compare sinusoidal AC voltages produced as a result of the uniform rotation of a loop in a constant magnetic field with reference to frequency, period, amplitude, peak-to-peak voltage ($V_{p\text{–}p}$) and peak-to-peak current ($I_{p\text{–}p}$)	No change
Compare alternating voltage expressed as the root-mean-square (rms) to a constant DC voltage developing the same power in a resistive component.	No change Convert between rms, peak and peak-to-peak values of voltage and current has been deleted.

Analyse transformer action with reference to electromagnetic induction for an ideal transformer: $\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$	No change
Analyse the supply of power by considering transmission losses across transmission lines.	No change Identify the advantage of the use of AC power as domestic power supply, has been deleted.

2024 Unit 4 Study Design	**Status**
Area of Study 1 **How has understanding about the physical world changed?**	
Light as a wave	**Properties of mechanical waves** explain a wave as the transmission of energy through a medium without the net transfer of matter distinguish between transverse and longitudinal waves identify the amplitude, wavelength, period and frequency of waves calculate the wavelength, frequency, period and speed of travel of waves using: $v = f\lambda = \frac{\lambda}{t}$ explain qualitatively the Doppler effect explain polarisation of visible light and its relation to a transverse wave model has been deleted.
Describe light as a transverse electromagnetic wave which is produced by the acceleration of charges, which in turn produces changing electric fields and associated changing magnetic fields.	transverse has been inserted.
Identify that all electromagnetic waves travel at the same speed, *c*, in a vacuum.	No change
	compare the wavelength and frequencies of different regions of the electromagnetic spectrum, including radio, microwave, infrared, visible, ultraviolet, x-ray and gamma, and identify the distinct uses each has in society investigate and analyse theoretically and practically the behaviour of waves including:

	– refraction using Snell's Law: $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$ and $n_1 v_1 = n_2 v_2$ – total internal reflection and critical angle including applications: $n_1 \sin(\theta_c) = n_2 \sin(90°)$ investigate and explain theoretically and practically colour dispersion in prisms and lenses with reference to refraction of the components of white light as they pass from one medium to another **Production of light from matter** compare the production of light in lasers, synchrotrons, LEDs and incandescent lights. Has been deleted from Year 12.
Explain the formation of a standing wave resulting from the superposition of a travelling wave and its reflection	Replaces 'explain resonance as the superposition of a travelling wave and its reflection, and with reference to a forced oscillation matching the natural frequency of vibration.'
Analyse the formation of standing waves (only those with nodes at both ends is required)	(only those with nodes at both ends is required) replaces 'in strings fixed at one or both ends' explain resonance as the superposition of a travelling wave and its reflection, and with reference to a forced oscillation matching the natural frequency of vibration, has been deleted.
Investigate and explain theoretically and practically diffraction as the directional spread of various frequencies with reference to different gap width or obstacle size, including the qualitative effect of changing the $\frac{\lambda}{w}$ ratio, and apply this to limitations of imaging using electromagnetic waves.	explain has replaced 'describe'

Explain the results of Young's double slit experiment with reference to: evidence for the wave-like nature of light constructive and destructive interference of coherent waves in terms of path differences: $n\lambda$ and $(n + \frac{1}{2})\lambda$, respectively, where n = 0,1, 2,… effect of wavelength, distance of screen and slit separation on interference patterns: $\Delta x = \frac{\lambda L}{d}$, when $L>>d$	investigate and analyse theoretically and practically constructive and destructive interference from two sources with reference to coherent waves and path difference: nλ and (n - $\frac{1}{2}$)λ respectively. Has been deleted. $(n + \frac{1}{2})\lambda$, has replaced $(n - \frac{1}{2})\lambda$, respectively, where n = 0,1, 2,… has been included. when L>>d, has been included.
Light as a particle Apply the quantised energy of photons: $E = hf = \frac{hc}{\lambda}$ Analyse the photoelectric effect with reference to: evidence for the particle-like nature of light experimental data in the form of graphs of photocurrent versus electrode potential, and of kinetic energy of electrons versus frequency kinetic energy of emitted photoelectrons: $\boldsymbol{E_{k\,max} = hf - \phi}$, using energy units of joule and electron-volt effects of intensity of incident irradiation on the emission of photoelectrons Describe the limitation of the wave model of light in explaining experimental results related to the photoelectric effect.	Has been included. No change No change

Matter as particles or waves	
Interpret electron diffraction patterns as evidence for the wave-like nature of matter.	No change
Distinguish between the diffraction patterns produced by photons and electrons.	No change
Calculate the de Broglie wavelength of matter: $\lambda = \frac{h}{p}$	No change
Similarities between light and matter	
Discuss the importance of the idea of quantisation in the development of knowledge about light and in explaining the nature of atoms.	Has been included.
Compare the momentum of photons and of matter of the same wavelength including calculations using: $p = \frac{h}{\lambda}$	No change
	explain how diffraction from a single slit experiment can be used to illustrate Heisenberg's uncertainty principle, has been deleted.
	explain why classical laws of physics are not appropriate to model motion at very small scales, has been deleted.
	describe the quantised states of the atom with reference to electrons forming standing waves, and explain this as evidence for the dual nature of matter; has been deleted.
Explain the production of atomic absorption and emission line spectra, including those from metal vapour lamps.	No change
Interpret spectra and calculate the energy of photons absorbed or emitted, $\Delta E = hf$;	No change
Analyse the emission or absorption of a photon by an atom in terms of a change in the electron energy state of the atom, with the difference in the states' energies being equal to the photon energy $E = hf = \frac{hc}{\lambda}$.	emission or has been included. state replaces 'levels'. with the difference in the states' energies being equal to the photon energy replacing 'due to electrons changing state'.

Interpret the single photon and the electron double slit experiment as evidence for the dual nature of light and matter.	the frequency and wavelength of emitted photons, $E = hf = \frac{hc}{\lambda}$ (not including the bombardment of atoms by electrons); has been deleted Has been included
Einstein's special theory of relativity Describe the limitation of classical mechanics when considering motion approaching the speed of light. Describe Einstein's two postulates for his special theory of relativity that: the laws of physics are the same in all inertial (non-accelerated) frames of reference. the speed of light has a constant value for all observers regardless of their motion or the motion of the source. Interpret the null result of the Michelson-Morley experiment as evidence in support of Einstein's special theory of relativity. Compare Einstein's special theory of relativity with the principles of classical physics. Describe proper time (t_0) as the time interval between two events in a reference frame where the two events occur at the same point in space Model mathematically time dilation and length contraction at speeds approaching c using the equations: $t = t_0\gamma$ and $L = \frac{L_0}{\gamma}$ = where $\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$	Has changed from 'theory of special relativity' Has been included. special theory of relativity replaces 'theory of special relativity'. Has been included. No change No change No change

Explain and analyse examples of special relativity including that: muons can reach Earth even though their half-lives would suggest that they should decay in the upper atmosphere. particle accelerator lengths must be designed to take the effects of special relativity into account. time signals from GPS satellites must be corrected for the effects of special relativity due to their orbital velocity.	and analyse examples of special relativity including that: has been included. Upper has replaced 'outer' Has been included. Has been included.
Relationships between energy and mass Interpret Einstein's prediction by showing that the total 'mass-energy' of an object is given by: $E_{tot} = E_k + E_0 = \gamma mc^2$ where $E_0 = mc^2$, and where kinetic energy can be calculated by: $E_k = (\gamma - 1)mc^2$. Apply the energy-mass relationship to mass conversion in the Sun, to positron-electron annihilation and to nuclear transformations in particle accelerators (details of the particular nuclear processes are not required).	No change Has replaced 'describe how matter is converted to energy by nuclear fusion in the Sun, which leads to its mass decreasing and the emission of electromagnetic radiation.'

Area of Study 2 **How is scientific enquiry used to investigate fields, motion or light?**	
Investigation design Identify the physics concepts specific to the investigation and explain their significance, including definitions of key terms and physics representations. Explain the characteristics of the selected scientific methodology and method including: techniques of primary qualitative and quantitative data generation relevant to the selected investigation; and appropriateness of the use of independent, dependent and controlled variables in the selected scientific investigation	Identify has been included. explain has been included. Explain has been included. selected scientific methodology and method has replaced 'scientific research methodologies'. generation has replaced 'collection' and appropriateness of the use of has been included. in the selected scientific investigation has been included.

Identify and apply concepts of accuracy, precision, repeatability, reproducibility, resolution and validity of data; and the identification of, and distinction between, error and uncertainty. identify and apply health, safety and ethical guidelines relevant to the selected investigation.	repeatability, reproducibility, resolution have been included. 'reliability' has been deleted. error and uncertainty replace 'uncertainty and error'. and apply health has replaced 'and application of relevant'. and ethical has been included. relevant to the selected investigation, has been included. including experiments (gravity, magnetism, electricity, Newton's laws of motion, waves) and/or the construction and evaluation of a device has been deleted.
Scientific evidence Discuss the nature of evidence that supports or refutes a hypothesis, model or theory. Apply methods of organising, analysing and evaluating primary data to identify patterns and relationships including: the physical significance of the gradient of linearised data; causes of uncertainty; use of uncertainty bars; and assumptions and limitations of data, methodologies and methods. Model the scientific practice of using a logbook to authenticate generated primary data,	Discuss has been included. Apply has been included. the physical significance of the gradient of linearised data has been included. causes of uncertainty replaces 'sources of uncertainty and error'. use of uncertainty bars; and assumptions has been included. Has been included.
Science communication Apply the conventions of science communication: scientific terminology and representations; symbols, equations and formulas; standard abbreviations; significant figures; and units of measurement. Apply the conventions of scientific poster presentation, including succinct communication of the	Apply has been included. communication has been included. scientific has replaced 'physics'. Apply has been included.

selected scientific investigation, and acknowledgement of references. Explain the key findings and implications of the selected investigation.	succinct communication of the selected scientific investigation has been included. models and theories, and their use in organising and understanding observed phenomena and physics concepts including their limitations has been deleted. Has replaced 'the key findings of the selected investigation and their relationship to concepts associated with waves, fields and/or motion'.