Definitions and Concepts for OCR (B) Physics A-level

Module 4: Understanding Processes

4.1: Waves and Quantum Behaviour

Amplitude: The maximum displacement of a vibrating particle or wave from its equilibrium position.

Aperture: A gap that light can travel through. Usually used when talking about diffraction.

Coherence: Where two or more waves have the same frequency and a constant phase difference.

Constructive Interference: Interference when the two waves are in phase. The two peaks (or troughs) line up so that the amplitude of the resulting wave is equal to the sum of the two individual amplitudes.

De Broglie Hypothesis/Relationship: All particles have a wave-like nature and a particle-like nature. The wavelength of a particle is inversely proportional to the particle's momentum.

Destructive Interference: Interference when the two waves are in antiphase. The peak of one wave lines up with the trough of the other so that the amplitude of the resulting wave is as small as it can be. (If the two waves in antiphase have the same amplitude, they will completely cancel each other out- total destructive interference occurs).

Diffraction: The spreading of waves as they pass through a gap of a similar magnitude to their wavelength.

Diffraction Grating: A grating with hundreds of slits per millimetre, that results in sharper interference patterns. They are used to calculate atomic spacing and to analyse elements.

Electron Diffraction: Electrons diffract to produce diffraction patterns. This showed electrons having wave-like properties and showing quantum behaviour.

Electronvolt: The kinetic energy gained by one electron that is accelerated through a potential difference of 1 volt. Equal to 1.6×10^{-16} J.

Frequency: Of a wave, how many wavelengths pass a fixed point per second. It is the reciprocal of time period.

Intensity: The power transferred by a wave per unit area.

Interference: The effect of two waves overlapping at a point. Their displacements combine and

the total displacement at that point becomes the sum of the individual displacements.

Line Spectrum: A spectrum containing isolated lines that show the emission or absorption of discrete frequencies or energies. Its plural is “line spectra”.

Oscilloscope: A device which displays a graph of how a signal changes over time, used to view oscillations of waves. The horizontal axis of the graph is referred to as the time-base (representing time), and the vertical axis represents voltage.

Particle Model of Light: The idea that light travels in perfectly elastic small discrete particles called “corpuscles”. This is supported by the reflection of light, however fails to explain interference, diffraction, and polarisation. The particle explanation for refraction (speed increases in a more optically dense medium) was also disproven.

Path Difference: A measure of how far ahead a wave is compared to another wave, or the difference between how far they’ve travelled to a given point. Usually expressed either in terms of the wavelength, or in metres.

Period: Also known as time period. The time required for one complete cycle of a vibration to occur. Of a wave, it is the time taken for one wavelength to pass. It is the reciprocal of frequency.

Phase: A measure of how far through the wave’s cycle a given point on the wave is. Two waves can be described as in phase, out of phase, or in antiphase.

Phase Difference: The difference in phase between two points on a wave. It is usually expressed in radians.

Phasor: A rotating vector. It consists of a circle and a phasor arrow, the arrow performs one full anticlockwise rotation as one wavelength of a wave pattern passes. Used to represent a point in a given waveform: its vertical height gives the current displacement, and the angle it’s pointing at gives the current phase. Useful for working out phase difference, or the superposition between two waves.

Photoelectric Effect: The phenomena of photoelectrons being released from a metal surface when light of a high enough frequency is incident on it. LEDs rely on this effect.

Photon: A discrete packet of energy. The quantum of light.

Photon Model of Light: The idea that light travels as a stream of photons, both particle-like and wave-like properties of light are justified due to the concept of wave-particle duality (E=hf). Photons exchange energy in quanta.

Planck’s Constant: Relates the energy of light photons to their frequency. It can be determined by using different coloured LEDs.

Plane Boundary: The surface separating two different mediums.

Probability: How likely it is for something to happen.

Quantum: The smallest discrete amount of something. Its plural is “quanta”. All photons are examples of quanta, but not all quanta are photons.

Quantum Behaviour: Quanta have a certain probability of arrival at any given point. Quantum behaviour models a ray of light as taking every possible path between where it’s emitted and detected. The probability is obtained by combining amplitude and phase for all possible paths.

Refraction: The changing in direction of a wave due to it passing into a new medium with a different optical density at an angle. This is caused by a change in the wave’s speed- a more optically dense medium will decrease the wave’s speed, causing it to refract towards the normal.

Refractive Index: A material property that is equal to the ratio between the speed of light in a vacuum, and the speed of light in a given material.

Resonance Tube: A long cylindrical tube partially filled with water. Used to determine the speed of sound in air by formation of stationary waves.

Snell’s Law: A law linking a wave’s angle of incidence to its angle of refraction, with the use of the refractive indexes of the mediums involved.

Stationary/Standing Wave: A wave that stores energy instead of transferring it. They are formed by a propagating wave being reflected back on itself causing two waves of the same wavelength and similar amplitude travelling in opposite directions. They superpose and form a stationary/standing wave.

Superposition: When two waves overlap at a point. Interference occurs as a result of this.

Threshold Frequency: The minimum frequency of light needed to cause electrons to be released from a metal surface in the photoelectric effect. Intensity has no effect of this.

Wavelength: The distance a wave travels during one complete wave cycle. Typically measured peak to peak or trough to trough.

Wave Model of Light: The idea that light has a wave-like nature. This is supported by light being able to produce diffraction patterns, however fails to explain the photoelectric effect.

Work Function: The minimum energy required to remove an electron from a metal’s surface.

Young’s Double-Slit Experiment: An experiment that demonstrates the diffraction of light by passing monochromatic light across two narrow slits and observing the resulting pattern of bright and dark fringes.

4.2: Space, Time and Motion

Acceleration: The rate of change of velocity.

Components of a Force: Any force can be described as the result of multiple individual forces called components.

Conservation of Energy: Energy cannot be created or destroyed - it can only be transferred into different forms.

Conservation of Momentum: In a closed system with no external forces the momentum of the system before an event is equal to the momentum of the system after the event.

Displacement: The direct distance between an object's starting and ending positions. It is a vector quantity and so has both a direction and a magnitude.

Displacement-Time Graphs: Plots showing how displacement changes over a period of time. The gradient gives the velocity. Curved lines represent an acceleration.

Energy: The quantitative property required for something to be able to do work.

Force: The rate of change of momentum of an object. A force will change the motion of an object with mass if unopposed.

Free-Fall: An object is said to be in free fall when the only force acting on it is the force of gravity.

Gravitational Potential Energy: Energy due to being in a gravitational field. It is the type of energy gained by an object when it is raised by a height in a gravitational field.

Impulse: The change of momentum of an object when a force acts on it. Equal to the area underneath a force-time graph.

Kinematic Equations: Also referred to as 'suvat' equations. Equations relating displacement, initial and final velocity, acceleration, and time for motion under constant acceleration.

Kinetic Energy: Energy due to motion. It is the amount of energy that would be transferred from an object when it decelerates to rest.

Mass: The quantity of matter in a body, measured by its acceleration under a given force.

Momentum: The product of an object's mass and its velocity.

Newton's First Law: An object at rest or moving with a constant velocity will remain in its current state of motion, unless acted on by a resultant force where the object will be able to accelerate.

Newton's Second Law: If an object is acted upon by a resultant force it will accelerate. The

acceleration is inversely proportional to the mass of the object and directly proportional to the force acting upon it.

Newton's Third Law: Every action has an equal and opposite reaction. If an object A exerts a force on object B, object B will exert a force of equal magnitude but of opposite direction on object A.

Power: The rate of transfer of energy.

Resolution of a Vector: When a vector is split into two components at right angles to each other. This can make calculations easier because you can see the independent effects of each component.

Scalar Quantities: A quantity with only magnitude and no direction (e.g. mass, energy, length).

Speed: The rate of change of distance. It is a scalar quantity and so only has a magnitude.

Terminal Velocity: The maximum velocity an object can achieve. It is the point at which frictional forces and driving forces are balanced so no acceleration occurs and the resultant force on the object is 0 N.

Vector Quantities: A quantity that has both a magnitude and an associated direction. Examples include velocity and displacement.

Velocity: The rate of change of displacement. It is a vector quantity and so has both a direction and a magnitude.

Velocity-Time Graphs: Plots showing how velocity changes over a period of time. The gradient gives acceleration and the area enclosed by the graph is the distance (if taking the area under the x-axis into account as negative, the positive area minus the negative area is equal to the displacement). Curved lines represent changing acceleration.

Work Done: The energy transferred when a force is applied over a given distance.