Edexcel IAL Physics A-Level

Topic 2.1 - Waves and the Particle Nature of Light

Flashcards

Define amplitude / frequency / period / speed / wavelength.

Define amplitude / frequency / period / speed / wavelength.

A: maximum displacement of particles from their undisturbed position.

F: number of cycles (vibrations) per second passing a given point.

P: time taken for a whole cycle to be completed.

S: distance travelled by a point on a wave in a set amount of time.

W: the length of one whole wave cycle (e.g. peak to peak).

What is the wave equation?

What is the wave equation?

$$Speed = frequency \times wavelength$$

$$c = f\lambda$$

What is the difference between transverse and longitudinal waves?

What is the difference(s) between transverse and longitudinal waves?

Transverse waves oscillate **perpendicular** to their direction of energy transfer. They have peaks and troughs and can be polarised. Electromagnetic waves are transverse.

Longitudinal waves oscillate **parallel** to their direction of energy transfer. They have compressions (high pressure) and rarefactions (low pressure) and cannot be polarised.

How can you measure amplitude/wavelength on a displacement-displacement graph?

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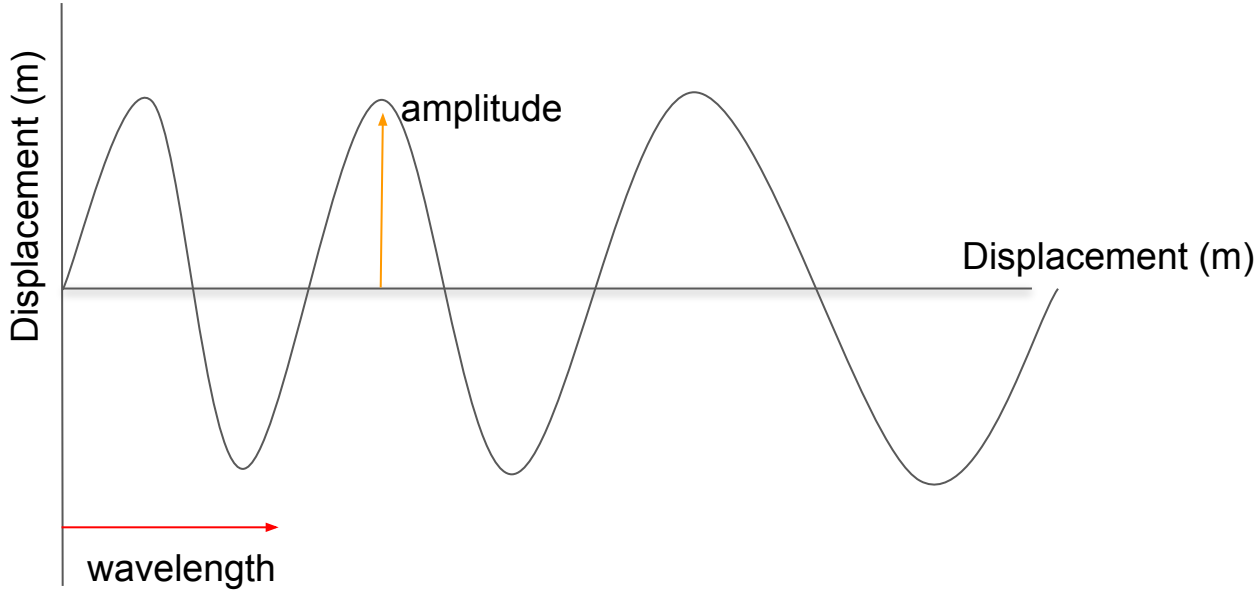

Define wavefront / coherence / path difference / superposition / interference.

Define wavefront / coherence / path difference / superposition / interference.

WF: line of corresponding points of a wave that vibrate in unison.

C: when waves have the same wavelength, frequency & amplitude and a fixed phase difference.

PD: difference between lengths of 2 paths.

SP: the principle that when 2 waves interact, the resultant wave is the vector sum of the displacements of each wave.

IF: when 2 or more waves superpose each other. Can be either constructive or destructive.

What is the relationship between phase difference and path difference?

What is the relationship between phase difference and path difference?

Phase difference decides the nature of the interference, however the phase difference is found from the path difference. Phase difference is relative to wavelength, path is purely distance.

What is a standing wave and how is it caused?

What is a standing wave and how is it caused?

A standing wave is the superposition of 2 coherent, progressive waves moving in opposite directions. It is formed when a wave reflects at a right angle to a boundary and the node will be the boundary.

What are nodes and antinodes?

What are nodes and antinodes?

Nodes are points of zero displacement on a standing wave.

Antinodes are points of maximum displacement (reach the amplitude) on a standing wave.

What is the equation for speed of transverse waves on a string? Therefore what factors affect the fundamental frequency?

What is the equation for speed of transverse waves on a string, therefore what factors affect the fundamental frequency?

$$\text{Speed} = \sqrt{\text{Tension/mass per unit length}}$$

- Longer string = lower frequency (longer wavelength)
- Heavier string = lower frequency (slower wave)
- Looser string = lower frequency (slower wave)

What is the intensity of radiation?

What is the intensity of radiation?

The power transferred per unit area radiation is incident on.

What is Snell's law and what is the derivation for the critical angle?

What is Snell's law and what is the derivation for the critical angle?

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

At the critical angle, $\theta_2 = 90^0$, $\theta_1 = C$, $n_2 = 1$

Therefore, $\sin C = 1/n$ where n is the refractive index of the material.

What is total internal reflection and when does it occur?

What is total internal reflection and when does it occur?

TIR (total internal reflection) is where all waves are reflected in a material and no waves are refracted. TIR occurs when the angle of incidence is **greater than** the critical angle.

When it is less, there is partial reflection and refraction.

When it is the critical angle, more is reflected and some waves are refracted at 90^0 to the material.

What is the principal axis of a lens?

What is the principal axis of a lens?

An imaginary line that passes through the centre of a lens at 90º to it. It is used in ray diagrams to measure things such as focal length.

What is the focal length of a lens?

What is the focal length of a lens?

The focal length is the distance between the centre of the lens and the focal point/principal focus of the lens, which is the point where light rays travelling parallel to the principal axis converge.

What is the power lens equation and thin lens equation?

What is the power lens equation and the thin lens equation?

$$Power = 1 / focal\ length$$

$$Total\ Power = P_1 + P_2 + P_3$$

What is the difference between a real and virtual image?

What is the difference between a real and virtual image?

Real = image formed where light rays converge, can be projected on a screen.

Virtual = image where light rays appear to come from but don't come from the source e.g. mirror. Cannot be projected on a screen as the rays never converge.

How can the power of a lens be found using object and image lengths?

How can the power of a lens be found using object and image lengths?

1 / focal length = (1/distance from object to lens) + (1/distance from image to lens)

What is the equation for magnification?

What is the equation for magnification?

$$M = \frac{\text{image height}}{\text{object height}}$$

or

$$\frac{\text{Distance of image to lens}}{\text{distance of object to lens}}$$

Define plane polarisation.

Define plane polarisation.

Making light rays oscillate in a single plane. This can be done by shining light through a polarising filter – light in all other planes is blocked, so the light becomes polarised.

Define diffraction and Huygens' principle.

Define diffraction and Huygens' principle.

Diffraction is the spreading out of waves as they pass by an obstacle/gap.

Huygens' principle suggests that every wavefront is considered to be a point source of secondary wavelets that spread out in the forward direction at the speed of the wave.

What is the diffraction grating equation?

What is the diffraction grating equation?

$$d\sin\theta = n\lambda$$

d is the distance between the diffraction grating slits (m), θ is the angle between the normal to the grating and the direction of the wavefront (rad or °), n is the order, λ is wavelength (m).

How do diffraction experiments provide evidence for the wave nature of electrons?

How do diffraction experiments provide evidence for the wave nature of electrons?

Diffraction is a wave property. Electrons can be diffracted through the gaps between atoms in a crystal to form diffraction rings showing that they have wave properties.

What is the de Broglie wavelength of an electron with momentum 5.4×10^{-25} kgms^{-1}?

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$\lambda = h/\rho = 6.63 \times 10^{-34} / 5.4 \times 10^{-25}$

$\lambda = 1.23 \times 10^{-9}$ m

What is the energy of a photon with frequency 3×10^6 Hz?

What is the energy of a photon with frequency 3x10^6 Hz?

$$E = hf$$

$$E = (6.63 \times 10^{-34})(3 \times 10^{6})$$

$$E = 2.0 \times 10^{-27}$$

What phenomenon can be used to show that light behaves as a particle?

What phenomenon can be used to show that light behaves as a particle?

The photoelectric effect.

Describe the photoelectric effect.

Describe the photoelectric effect.

When light above the threshold frequency is shone on a metal, electrons are emitted from the surface; these electrons are “photoelectrons”.

What is the threshold frequency?

What is the threshold frequency?

The minimum frequency of light required for an electron to be emitted by the photoelectric effect.

What equation is used to determine the energy of a photon?

What equation is used to determine the energy of a photon?

Energy = Planck's constant x frequency

$$E = hf = hc / \lambda$$

Energy = $(6.63 \times 10^{-34} \times 3 \times 10^{8}) /$ photon wavelength

Why does a photon need to have a minimum frequency in order to liberate an electron?

Why does a photon need to be of a minimum frequency to liberate an electron?

The energy of the photon is determined by its frequency, the photon's energy must be greater than the work function of the metal in order for an electron to be emitted.

Define the work function.

Define the work function.

The minimum energy required for an electron to be released from the surface of a metal. This is characteristic of the metal, so some metals will require more energy than others.

The work function is represented by the Greek letter Phi (ϕ).

If a photon has a frequency higher than the threshold frequency, what would occur?

If a photon has a frequency higher than the threshold frequency, what would occur?

The electron will be liberated and the remaining energy will become the kinetic energy of the electron.

If light is incident on a metal and photoelectric emission does NOT occur, what is the effect of increasing light intensity?

If light is incident on a metal and photoelectric emission does NOT occur, what is the effect of increasing light intensity?

- If it is more intense then there would be more photons incident on the metal each second.
- However each photon still carries the same amount of energy as before.
- Therefore it still **does not** contain enough energy to liberate an electron.
- No effect.

What is the photoelectric equation?

What is the photoelectric equation?

$$hf = \phi + E_{k(max)}$$

Planck's constant x frequency =
work function + maximum kinetic energy of the photoelectrons

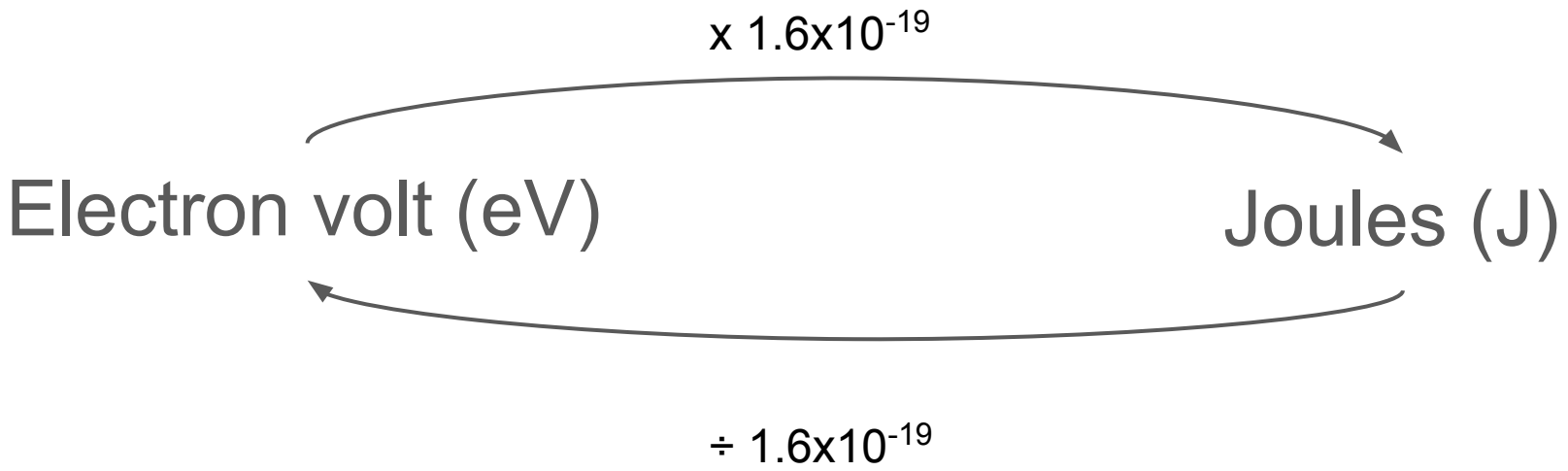
What is an electron volt?

What is an electron volt?

The energy required to move an electron through a potential difference of 1V.

How do you convert between electron volts and joules?

How do you convert between electron volts and joules?



How does a fluorescent tube work?

How does a fluorescent tube work?

- High voltage applied across mercury vapour accelerates fast moving free electrons through the tube, which collide with the mercury atoms.
- Mercury electrons become excited and then return to the ground state, releasing a UV photon.
- The tube's phosphorus coating absorbs the UV photons and its atoms become excited, they then de-excite and emit visible light photons in the process.

What can be used as evidence for the discrete energy levels in atoms?

What can be used as evidence for the discrete energy levels in atoms?

Line emission and absorption spectra. The lines appear at discrete points which show where a light photon of specific frequency and wavelength has been absorbed or emitted, this shows electrons can only absorb an exact amount of energy to be excited to the next discrete energy level.

Define wave-particle duality.

Define wave-particle duality.

All particles have both particle- and wave-like properties, and waves can have particle-like properties.

For example, light acts as a particle in the photoelectric effect and as a wave when it is diffracted.