

Properties of waves

Progressive waves - carries energy without transferring material

Transverse waves - particles oscillate **perpendicular** to the direction of travel of the wave. e.g. EM waves

Longitudinal waves - particles oscillate **parallel** to the direction of travel. e.g. sound waves



Time period: time taken for one cycle

Frequency: number of cycles per second

Phase: position of point on wave

Phase difference: how much one wave is shifted compared to another

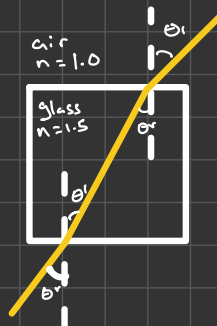
$$v = f \lambda \quad \downarrow \quad \frac{2\pi}{\lambda} \times 360^\circ$$

Refractive index: the ratio of the speed of light in a vacuum to the speed of light in a substance.

$$n = \frac{c}{v}$$

If going to a medium with a higher refractive index, the light bends towards the normal.

medium with lower refractive index = bends away from normal



Reflection: when a wave changes direction at a boundary between 2 mediums and remains in the same medium

Law of reflection $\theta_i = \theta_r$

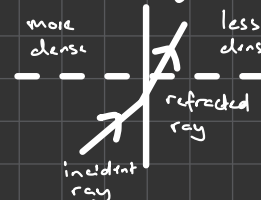


In a reflection frequency and wavelength do not change.

Refraction occurs when a wave changes speed and direction as it moves from one medium to another. Typically frequency remains constant but speed and wavelength change.

Slow down $\rightarrow$ refraction towards normal

Speed up $\rightarrow$ refraction away from normal



Diffraction: the spreading of a wave as it passes through a gap or around an obstacle. Speed, wave length and frequency remain unchanged.

Severity of diffraction depends on size of gap compared to wavelength.

Similar gap and wavelength $\rightarrow$ big diffraction

Total internal reflection: occurs when an incident ray is continually reflected at a boundary between two mediums. e.g. fibre optic cables.

Medium it is in must have a higher refractive index e.g. glass/air boundary can have TIR but air/glass can't.

If $\theta_i >$ critical angle the TIR will occur

$$n_1 \sin \theta = n_2 \sin \theta_2 \quad \sin c = \frac{1}{n}$$

Intensity: the power transmitted per unit area

$$I = \frac{P}{A} \quad \text{Wm}^{-2}$$

EM waves

Properties: Can travel through a vacuum travel at the speed of light Transverse waves with oscillating EM field

EM Spectrum

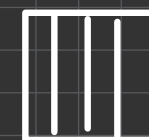
Radio waves	$10^{-1} \leftrightarrow 10^6 \text{ m}$
Microwaves	$10^{-1} \leftrightarrow 10^{-3}$
Infrared	$10^{-3} \leftrightarrow 7 \times 10^{-7}$
visible	$7 \times 10^{-7} \leftrightarrow 4 \times 10^{-7}$
ultraviolet	$4 \times 10^{-7} \leftrightarrow 10^{-8}$
x-rays	$10^{-8} \leftrightarrow 10^{-10}$
Gamma rays	10^{-10} and much smaller 10^{-16} m

Polarisation of EM waves

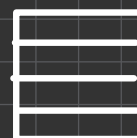
A wave is plane polarized if the particles (or EM fields) oscillate in a single plane. This is a property of transverse waves

Longitudinal waves can not be polarised as their oscillations are parallel to the direction of energy transfer. Their oscillations are already limited to a single plane.

Polarising filters



Absorbs horizontal component



Absorbs vertical component

Chapter 11 Waves 1