Wave Parameters and Behaviours

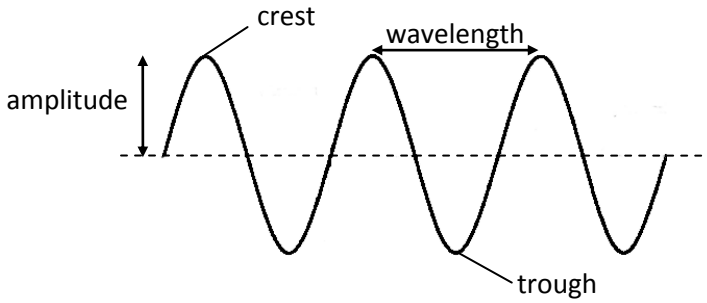
Summary

A wave is a regular disturbance which carries **energy** but has no mass.

Some waves require a medium to travel through (e.g. water waves) others, like light, can travel through a vacuum.

In **transverse** waves the particles of the medium vibrate at right angles to the direction of energy transfer. Water, light, radio and television waves are transverse.

In **longitudinal** waves the particles of the medium vibrate in the same direction as the energy transfer. Sound waves are longitudinal waves.



Wave Term	Symbol	Definition	Unit
frequency	f	number of waves passing a point each second	Hz
wavelength	λ	distance from one point on a wave to the same point on the next wave	m
speed	v	distance travelled by a wave in one second	$m\ s^{-1}$
amplitude		size of maximum disturbance from the zero position	
period	T	time taken for a wave to pass a point	s

Frequency

Hz

$$frequency = \frac{number\ of\ waves}{time}$$

s

$$f = \frac{N}{t}$$

$$t = \frac{N}{f}$$

Frequency and Period

Hz

$$frequency = \frac{1}{period}$$

s

$$f = \frac{1}{T}$$

$$t = \frac{1}{f}$$

Distance, Speed and Time

m

$$speed = \frac{distance}{time}$$

m s^{-1}

s

$$v = \frac{d}{t}$$

$$d = vt$$

$$t = \frac{d}{v}$$

Speed, Frequency and Wavelength

m s^{-1} m

$$speed = frequency \times wavelength$$

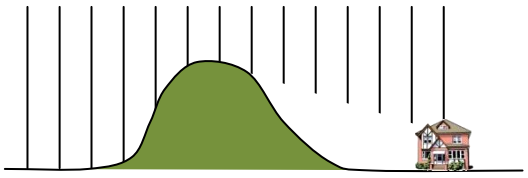
Hz

$$v = f\lambda$$

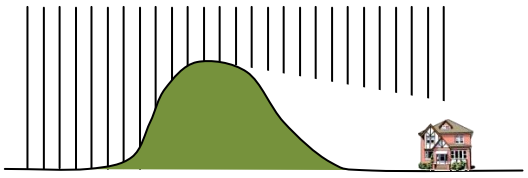
$$f = \frac{v}{\lambda}$$

$$\lambda = \frac{v}{f}$$

Diffraction is the ability of waves to bend round corners. All waves diffract to some extent, but the longer the wavelength of a wave, the greater the amount of diffraction that takes place.



long wavelengths diffract more
(radio wave reaches house behind hill)



short wavelengths diffract less
(television wave does not reach house behind hill)

Waves

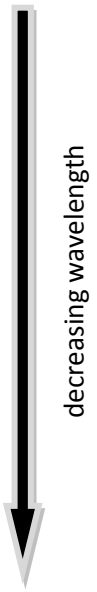
Electromagnetic Spectrum

Summary

Electromagnetic radiation is an oscillation of electrical and magnetic fields that travels through space as a wave and carries energy

The **electromagnetic spectrum** is the range of all possible frequencies of electromagnetic radiation.

The electromagnetic spectrum is split into several regions, according to its wavelength (or frequency). Different regions of the spectrum require different detectors and have different applications.



Region	Detector(s)	Applications
Radio	aerial	communication (e.g. broadcast radio) MRI scanners
Microwave	aerial	satellite communication (e.g. satellite TV) mobile phone communication Wifi radar GPS
Infrared	photodiode thermochromic film	night vision thermograms remote controls
Visible light	photodiode CCD (charge-coupled device) photographic film	photography lasers (e.g. surgery)
Ultraviolet	fluorescent chemicals photodiode	fluorescence (e.g. security markings) treatment of skin conditions sterilisation of medical instruments excessive exposure causes skin cancer
X-rays	photographic film	radiographs (internal images of objects/people) radiotherapy (treatment of cancer)
Gamma	Geiger-Muller tube photographic film	treatment of cancer radioactive tracers

All waves in the electromagnetic spectrum travel at the same speed (300 000 000 meters per second in a vacuum), but have different wavelengths and frequencies.

Distance, Speed and Time

$$speed = \frac{distance}{time}$$

m s^{-1} — m — s

$$v = \frac{d}{t}$$

$$d = vt$$

$$t = \frac{d}{v}$$

Speed, Frequency and Wavelength

$$speed = frequency \times wavelength$$

m s^{-1} — Hz — m

$$v = f\lambda$$

$$f = \frac{v}{\lambda}$$

$$\lambda = \frac{v}{f}$$

Since the frequencies of electromagnetic waves are often very large, and their wavelengths can be very small, it is common to use prefixes for their units.

Prefix	*Symbol*	*Factor*
giga	G	1 000 000 000 = 10^9
mega	M	1 000 000 = 10^6
kilo	k	1 000 = 10^3
milli	m	0·001 = 10^{-3}
micro	μ	0·000 001 = 10^{-6}
nano	n	0·000 0000 01 = 10^{-9}

Waves

Refraction of Light

Summary

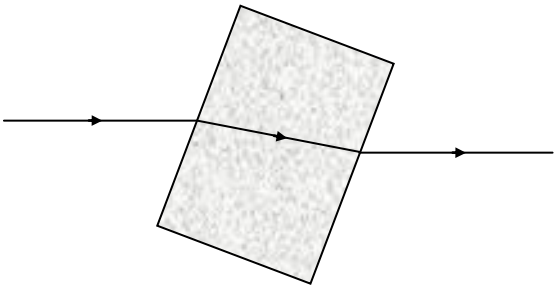
Light is an electromagnetic wave that is visible to the human eye.

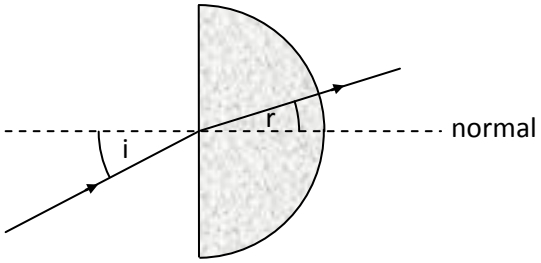
Light travels in straight lines

Refraction

Refraction is the **change in speed** of light as it passes from one material (medium) into another. This can cause a change in direction.

When light passes from a fast medium into a slow medium it bends towards the normal and when it passes from a slow medium into a fast medium it bends away from the normal.





i = angle of incidence
r = angle of refraction