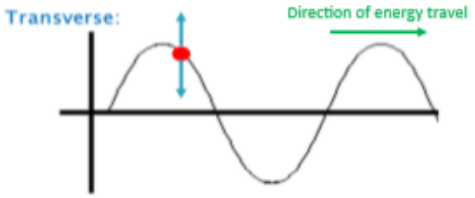
Waves and their properties:

Waves are **vibrations** that pass through a material. They transfer **energy** from one place to another, but none of the material is transferred.

All waves are either **transverse** or **longitudinal**.



The particles in transverse waves vibrate **perpendicular** (at right-angles) to the direction that the energy travels.

Water waves, light and all other **electromagnetic waves** are transverse waves.

The particles in longitudinal waves vibrate back and forth **parallel** to the direction that the energy travels.

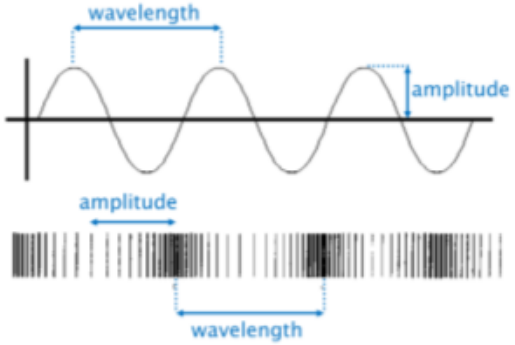
Longitudinal waves also have **compressions** (areas where the particles are squashed together) and **rarefactions** (areas where the particles are spread further apart).

Sound waves are longitudinal waves.

The **speed** of sound waves in air can be measured by having two people stand a certain **distance** away from each other, where they can still see each other. If one of the people fires a starting gun or bangs two cymbals together, the other person will see it before he hears it and time how long it takes before he can hear the sound.

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

Wave definitions and measurements:



The **amplitude** of a wave is the maximum displacement of a point on a wave away from its rest position.

The **wavelength**, **λ**, of a wave is the distance from a point on one wave to the same point on the adjacent (next) wave.

The **frequency**, **f**, of a wave is the number of waves passing a point per second *(or the number of vibrations per second)*.

The **period**, **T**, of the wave is the time taken for one complete wave to pass a given point.

The **wave speed**, **v**, is the speed at which the energy is transferred through a material.

$$\underset{[s]}{\text{Period}} = \frac{1}{\underset{[Hz]}{\text{frequency}}} \qquad T = \frac{1}{f}$$

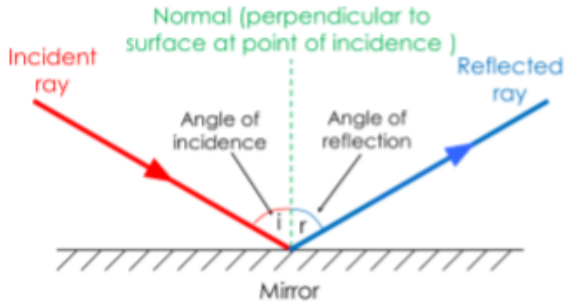
$$\underset{[m/s]}{v} = \underset{[Hz]}{f} \times \underset{[m]}{\lambda}$$

$$\text{Wave speed} = \text{frequency} \times \text{wavelength}$$

Reflection and refraction

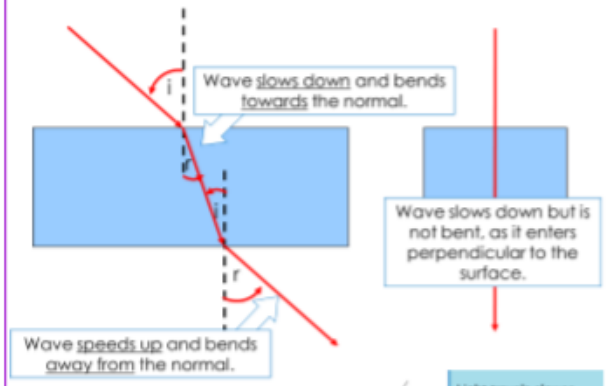
All waves can be **reflected** and **refracted**.

Reflection is when waves bounce of a surface:

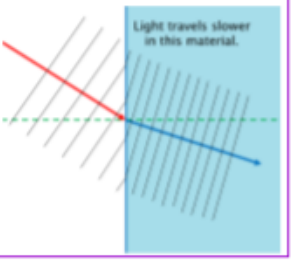


For reflected waves, the **angle of incidence** is equal to the **angle of reflection**.

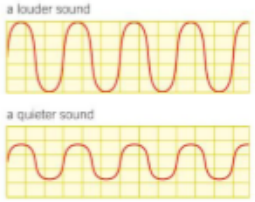
Refraction is when waves change direction when they cross a boundary between two different materials.



Refraction occurs because waves travel at different speeds in different materials.



Sound waves



- Sound waves can travel through solids causing vibrations in the solid
- Within the ear, sound waves cause the ear drum and other parts to vibrate which causes the sensation of sound
- The range of normal human hearing is from 20 Hz to 20 kHz

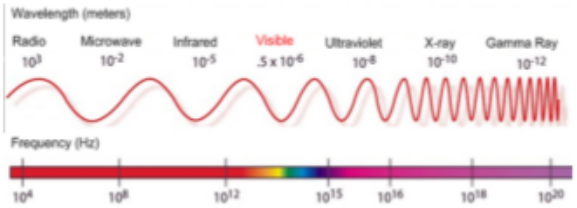
Uses of ultrasound

Ultrasound waves have a frequency higher than the upper limit of hearing for humans.

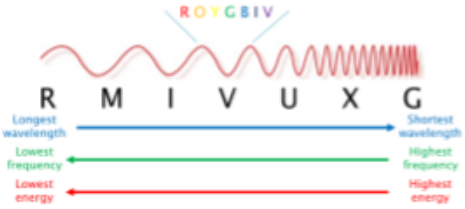
Ultrasound waves are partially reflected when they meet a boundary between two different media.

The time taken for the reflections to reach a detector can be used to determine how far away such a boundary is.

The electromagnetic spectrum:



The electromagnetic spectrum is a continuous spectrum of waves that is approximately divided into seven different categories of wave based upon their wavelength (or frequency).



Visible light is the only part of the EM spectrum that we can see. It is broken down into the different colours.

All electromagnetic waves travel at a speed of 300 million metres per second (**3 x 10⁸ m/s**) in a vacuum.

The different waves in the electromagnetic spectrum have different uses:

Radio waves are used for television and radio.
Microwaves are used for satellite communications, mobile phones and cooking.
Infrared is used for heating, cooking food and infrared cameras.
Visible light is the light that we can see, and it is used for fibre optics.
Ultraviolet light is used for tanning and energy efficient lamps.
X-rays are used for medical imaging.
Gamma rays can be used for treating cancer patients.

Light and colour

Colour filters work by absorbing certain wavelengths and transmitting other. Red filters only allow the red light from white light to pass through

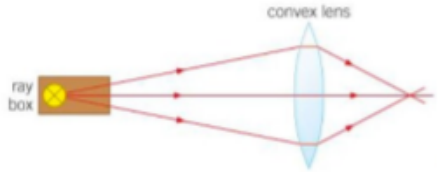
⇒ **Transparent** objects transmit all the incident light

⇒ **Translucent** let light pass through but the light is scattered/refracted

⇒ **Opaque** objects absorbs all light

Lenses

- A convex lens makes parallel rays converge to a focus, this is called the focal point



- A concave lens makes parallel rays spread out (diverge)