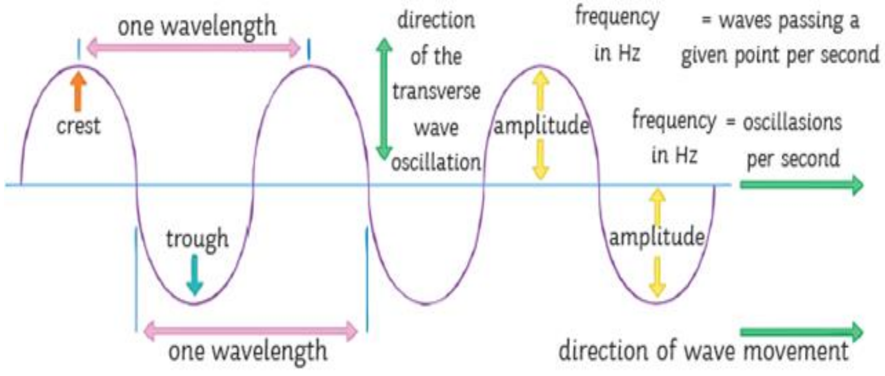
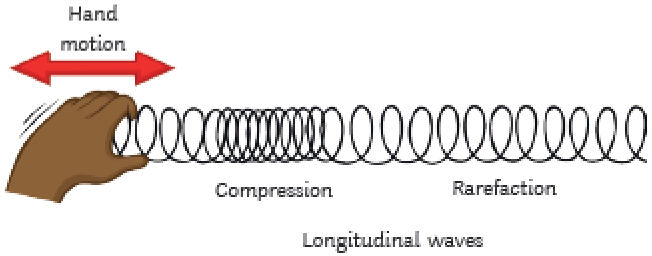
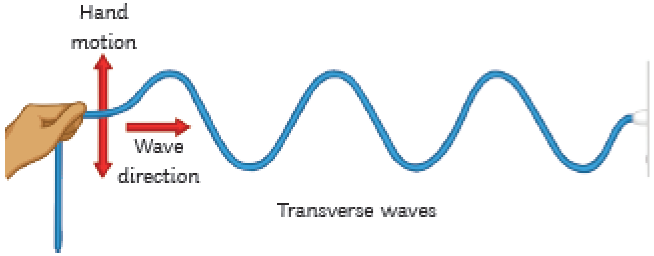
# WAVES




In a longitudinal wave, the vibrations are in the same direction (**parallel**) as the energy transfer. The wave has areas of **compression** and **rarefaction**. Examples of this type of wave are **sound waves**.




In a transverse wave, the vibrations are at a right angle (**perpendicular**) to the direction of the energy transfer. The wave has **peaks** (or crests) and **troughs**. Examples include **water waves** and **light waves**.




The **frequency** of a wave is the number of waves which pass a given point every second.

**time period (s) = 1 ÷ frequency (Hz)**

**t = 1 ÷ f**

The **wave speed** is how quickly the energy is transferred through a medium (how quickly the wave travels).

**wave speed (m/s) = frequency (Hz) × wavelength (m)**

**v = f × λ**

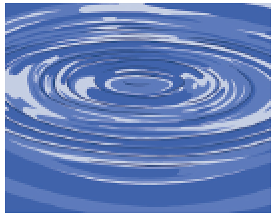
When light hits a surface, some of it is absorbed and some of it is reflected. The light that is reflected is the colour of the object in that light. For example, a blue object absorbs all the colours of the spectrum except blue: it reflects blue light.

| | White paper | Red apple | Green apple |
|---|---|---|---|
| **Colours(s) that the object can reflect** | All | Red only | Green only |
| **Appearance of object in white light** | White (no colours absorbed) | Red (all colours absorbed except red) | Green (all colours absorbed except green) |
| **Appearance of object in red light** | Red (only red light to reflect) | Red | Black (no green light to reflect) |
| **Appearance of object in green light** | Green (only green light to reflect) | Black (no red light to reflect) | Green |
| **Appearance of object in blue light** | Blue (only blue light to reflect) | Black (no red light to reflect) | Black (no green light to reflect) |

Waves can be either **transverse** or **longitudinal**.

When a wave travels, energy is transferred but the matter itself does not move. Particles of water or air vibrate and transfer energy but do not move with the wave.

This can be shown by placing a cork in a tank of water and generating ripples across the surface. The cork will bob up and down on the **oscillations** of the wave but will not travel across the tank.



**Iris** - Coloured circle around the pupil. It controls the size of the pupil

**Pupil** - Black part of the eye. This is an opening that lets light in

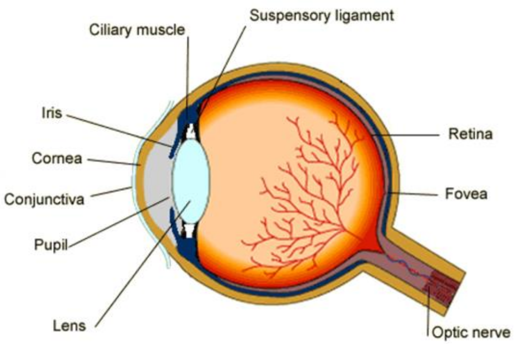
**Lens** - This focuses light onto the retina

**Retina** - Light-sensitive layer at the back of the eye. It is made up of **rods** and **cones**

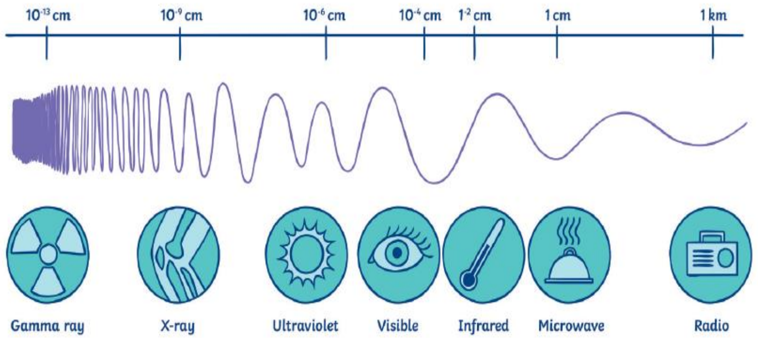
**Rods** - Sense cells that help us see the shapes of things

**Cones** - Sense cells that help us see colours

**Optic nerve** - Carries messages from the retina to the brain. The brain turns these into an image of what we are looking at




**Electromagnetic waves** transfer energy from a source to an **absorber** as **transverse** waves. The different waves are grouped depending on their **frequency** and form a continuous spectrum known as the **electromagnetic spectrum**. Each of the frequencies of waves travel at the same **velocity** and can pass through a **vacuum** as well as **air**.

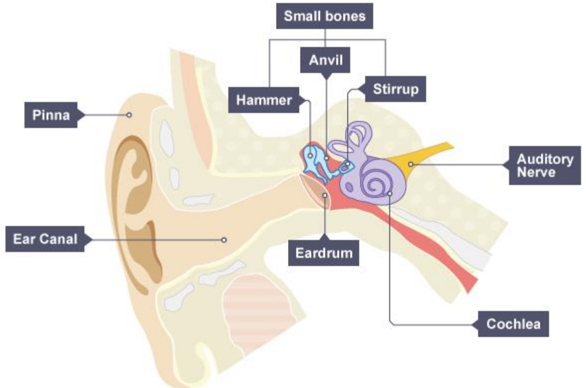




The colours of the **visible spectrum** can be remembered with the rhyme **Richard Of York Gave Battle In Vain** (red – orange – yellow – green – blue – indigo – violet).

These are all the **wavelengths** which are visible and detectable by the **human eye**. Each colour has a narrow range of wavelength and frequency within the spectrum.

**White light** is the combination (full spectrum) of wavelengths in the visible light region of the electromagnetic spectrum.




A sound wave can travel through a solid material. This is because the space between the particles is so small (almost non-existent) and the vibrations are transmitted more quickly than in liquids or gases.

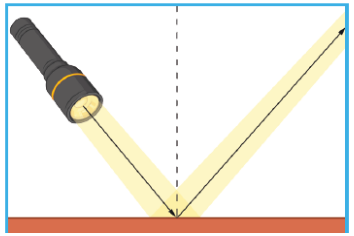
The speed of sound in air is about 330m/s. As the majority of space is a **vacuum** (no particles), sound waves do not travel in space.

Sound waves within the range of **20Hz to 20kHz** can usually be detected by the **human ear**.

Vibrations are passed along air particles down the ear canal and to the ear drum. The ear drum vibrates and transmits this to the small ear bones and then along the cochlea. The cochlea carries the vibrations to the auditory nerve which carries the sound wave as an electrical impulse to the brain.

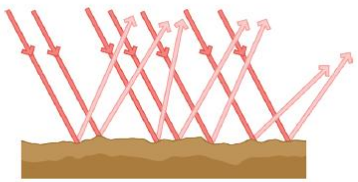
When a **wave** comes into contact with a **surface** or a **boundary** between two media (different materials), it can be **reflected** or it can be **absorbed**.

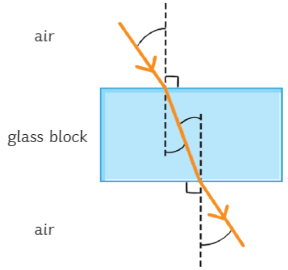
**Specular reflection** occurs when a wave is reflected in a **single direction** from a perfectly **smooth surface**.



**angle of incidence = angle of reflection (i = r)**

**Diffuse reflection** occurs when a wave is reflected in **many directions** and happens at a rough or **uneven surface**.






As the wave moves **to** a more dense medium (e.g. from gas to solid), it slows down and bends so that the angle from the normal becomes smaller. The angle of incidence is larger than the angle of refraction.

As the wave moves **from** a more dense medium (e.g. from solid to gas), it speeds up and bends so that the angle from the normal becomes larger. The angle of refraction is larger than the angle of incidence.

The angle at which a wave enters the glass block is equal to the angle that it leaves the glass block (when entering and leaving the same medium); however, if a wave crosses a boundary between two mediums at an angle of 90°C, then it will not change direction but instead carry on in a straight line.

White light is a mixture of many different colours, each with a different **frequency**. White light can be split up into a **spectrum** of these colours using a prism, a triangular block of glass or Perspex.

Light is refracted when it enters the prism, and each colour is refracted by a different amount. This means that the light leaving the prism is spread out into its different colours, a process called **dispersion**.