

4 Waves

4.1 Waves and Vibrations

Waves that pass through a substance are vibrations that pass through a substance, they are often referred to as **mechanical waves**. When waves progress through a substance, the particles of the substance vibrate in a certain way which makes nearby particles vibrate in the same way and so on.

- Sound waves
- Seismic waves
- Waves on strings

Electromagnetic waves are oscillating electric and magnetic fields that progress through space without the need for a substance - the vibrating **electric field** generates a vibrating **magnetic field**, which generates a vibrating electric field further away, and so on.

- Radio waves
- Microwaves
- Infrared radiation
- Light
- Ultraviolet radiation
- X-rays
- Gamma radiation

Longitudinal waves are waves which the direction of vibration of the particles is parallel to the direction in which the wave travels.

- Sound waves
- Primary seismic waves

Transverse waves are waves which the direction of vibration is perpendicular to the direction in which the wave travels.

- Electromagnetic waves
- Secondary seismic waves
- Waves on a string

Polarisation

Transverse waves are **plane-polarised** if the vibrations stay in one plane only. Otherwise if vibrations changes from one plane to another, then the waves are **unpolarised**.

Longitudinal waves cannot be polarised.

- If **unpolarised light** (e.g. light from a filament lamp) passes through a **polaroid filter**, the transmitted light is polarised.
 - The filter only allow through light which vibrate in a certain direction.
 - According to the alignment of its molecules.
- If unpolarised light is passed through **two polaroid filters**, the transmitted **light intensity** changes if one polaroid is turned relative to the other one.
 - The filters are said to be **cross** when the transmitted intensity is a minimum.
 - At this position, the polarised light from the first filter cannot pass through the second filter - as the alignment of the second filter is 90° to the first.

The **plane of polarisation** of an electromagnetic wave is defined as the plane in which the electric field oscillates.

Polaroid sunglasses reduces the glare of light reflected by water or glass.

- Light reflected by water or glass is **polarised**.
- The intensity of reflected light is reduced when it passes through the polaroid sunglasses.

4.2 Measuring Waves

- The **displacement** of a vibrating particle is its distance and direction from its **equilibrium position**.
- The **amplitude** of a wave is the **maximum displacement** of a vibrating particle.
 - Height of a wave crest for transverse waves.
- One **complete cycle** of a wave is from maximum displacement to the next maximum displacement.
- The **period** of a wave is the time for one complete wave to pass a fixed point.
- The **frequency** of a wave is the number of complete waves passing a point per second.
 - Or the **number of cycles of vibration** of a particle per second.

$$\text{Time period } T = \frac{1}{f}$$

$$\text{Wave speed } c = f\lambda$$

- The **phase** of a vibrating particle at a certain time is the fraction of a cycle it has completed since the start of the cycle.
- The **phase difference** between two particles vibrating at the same frequency is the fraction of a cycle between the vibrations of the two particles.

$$\text{Phase difference} = \frac{2\pi d}{\lambda}$$