WAVES

Displacement: Distance of a point from its undisturbed position.

Amplitude: Maximum displacement of particle from undisturbed position.

Time Period: Time taken for one complete oscillation.

Wavelength: Distance from any point on the wave to the next exactly similar point (e.g. crest to crest) .

Wave speed: Speed at which the waveform travels in the direction of the propagation of the wave.

Progressive waves : Waves that transfer energy from one position to another.

Intensity: Rate of energy transmitted per unit area perpendicular to direction of wave propagation.

$$Intensity = \frac{Power}{Cross\ Section\ \ Area}$$

- The intensity of a progressive wave is also proportional to its amplitude squared and frequency squared.

$$I \propto A^2 \quad and \quad I \propto f^2$$

Deducing Wave Equation

Speed is a total distance travelled per unit time.

$$Speed = \frac{Distance}{Time}$$

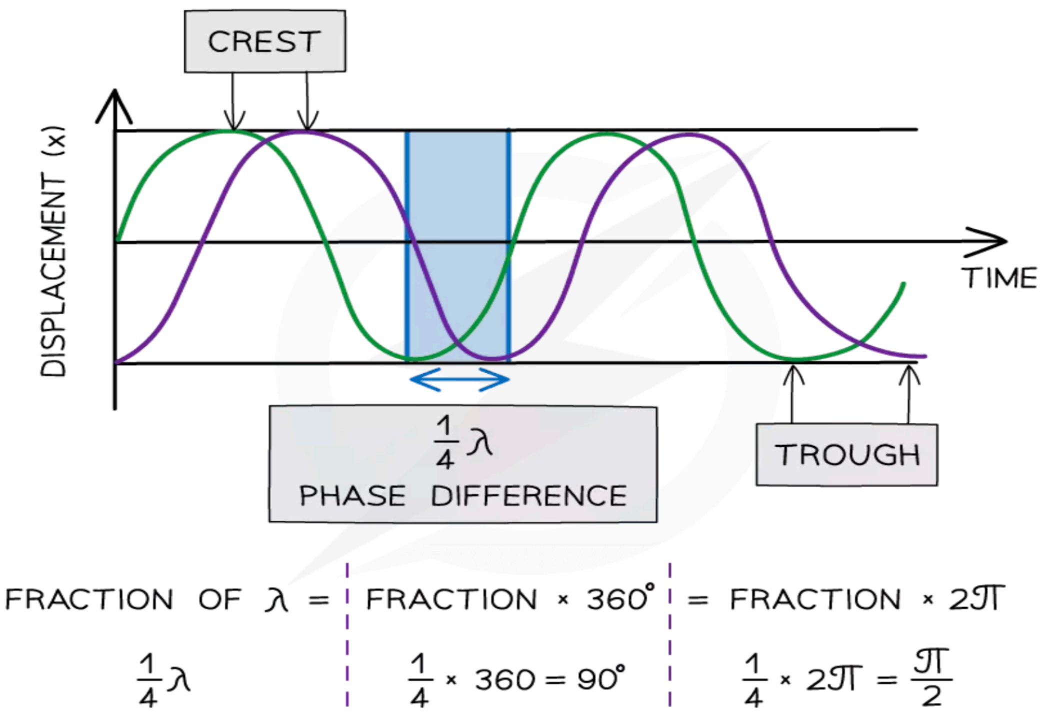
Distance of 1 wavelength is λ and time taken for this is T.

$$so,\ v = \frac{\lambda}{T} = \lambda\frac{1}{T} = \lambda f$$

$$\therefore v = \lambda f$$

Phase Difference

- The phase difference tells us **how much a point or a wave is in front or behind another**
- This can be found from the relative positive of the crests or troughs of two different waves of the same frequency
  - When the crests or troughs are aligned, the waves are **in phase**
  - When the crest of one wave aligns with the trough of another, they are in **antiphase**
- The diagram below shows the green wave **leads** the purple wave by ¼ λ



Two waves ¼ λ out of phase

- In contrast, the purple wave is said to **lag** behind the green wave by ¼ λ
- Phase difference is measured in **fractions of a wavelength, degrees** or **radians**
- The phase difference can be calculated from two different points on the same wave or the same point on two different waves
- The phase difference between two points:
  - **In phase** is **360°** or 2π radians
  - **In anti-phase** is **180°** or π radians

Transverse And Longitudinal

In mechanical waves, particles oscillate about fixed points, The direction of oscillations with regards to the direction of wave travel determine what type of wave it is.

Transverse waves:

- A transverse wave is one where the particles oscillate **perpendicular** to the direction of the wave travel (and energy transfer)
- Transverse waves show areas of **crests** (peaks) and **troughs**

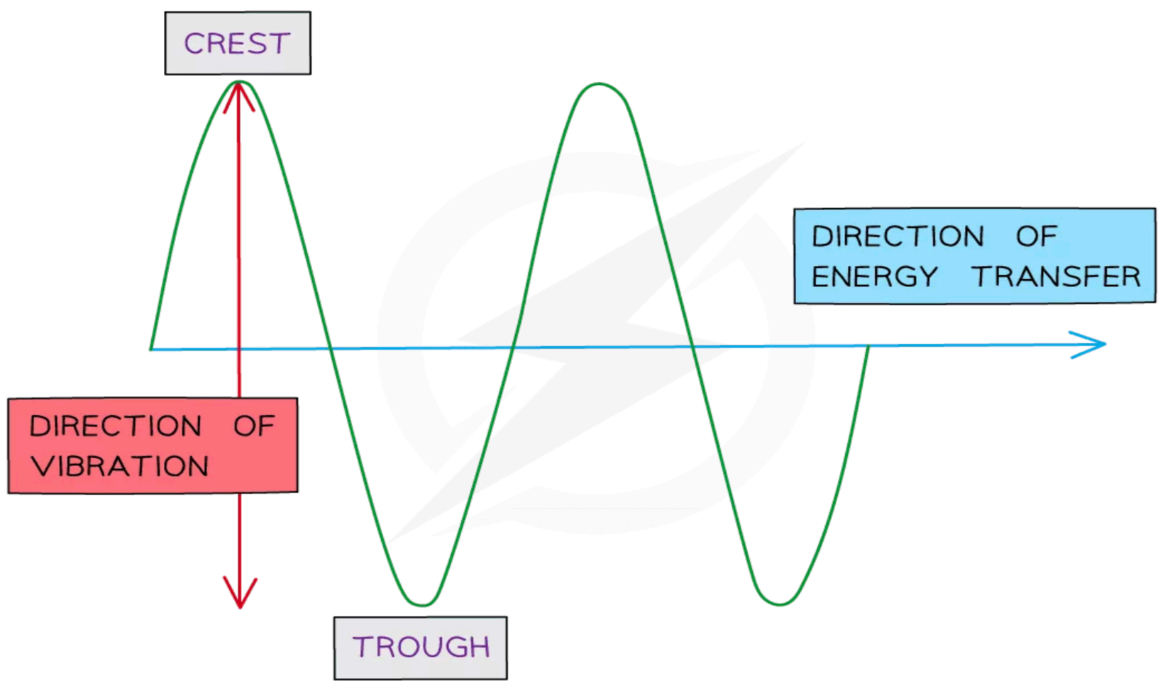


Diagram of a transverse wave

- Examples of transverse waves are:
  - Electromagnetic waves e.g. radio, visible light, UV
  - Vibrations on a guitar string
- These can be shown on a rope
- Transverse waves **can** be polarised

Longitudinal waves:

- A longitudinal wave is one where the particles oscillate **parallel** to the direction of the wave travel (and energy transfer)
- Longitudinal waves show areas of **compressions** and **rarefactions**

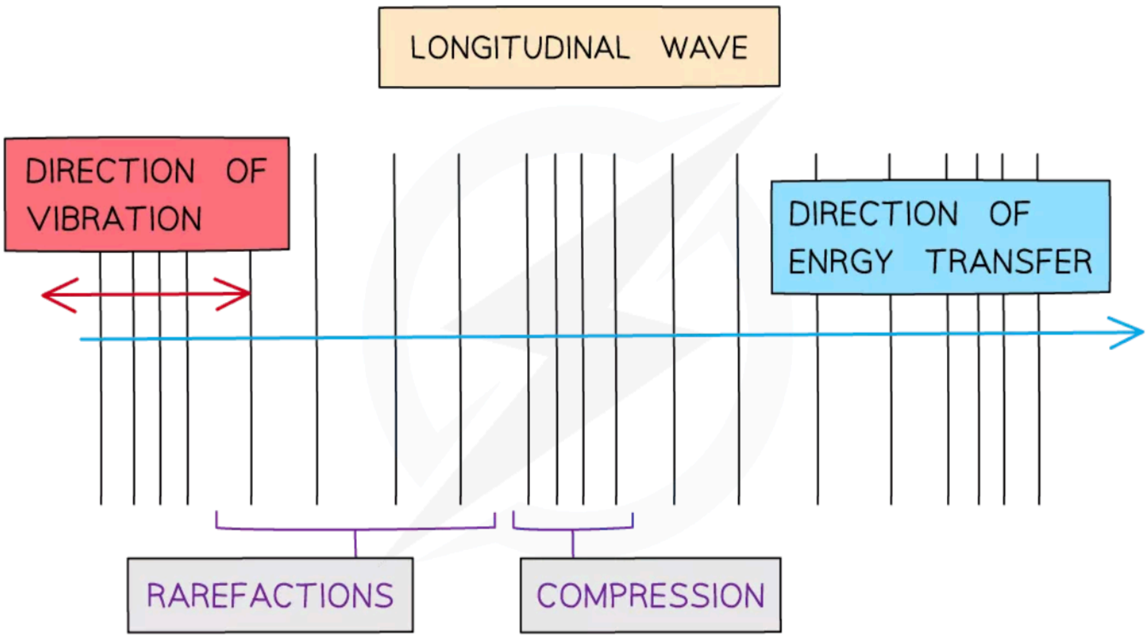


Diagram of a longitudinal wave

- Examples of longitudinal waves are:
  - Sound waves
  - Ultrasound waves
- These can be shown on a slinky spring
- Longitudinal waves **cannot** be polarised

The Doppler Effect

The whistle of a train or the siren of an ambulance appears to decrease in frequency (sounds lower in pitch) as it moves further away from you.This frequency change due to the relative motion between a source of sound or light and an observer is known as the **doppler effect** (or **doppler shift**)

- When the observer (e.g. yourself) and the source of sound (e.g. ambulance siren) are both **stationary**, the waves are at the **same** frequency for both the observer and the source.

$$f_o = f_s$$

- When the source starts to move **towards** the observer, the wavelength of the waves is **shortened**. The sound therefore appears at a **higher** frequency to the observer.

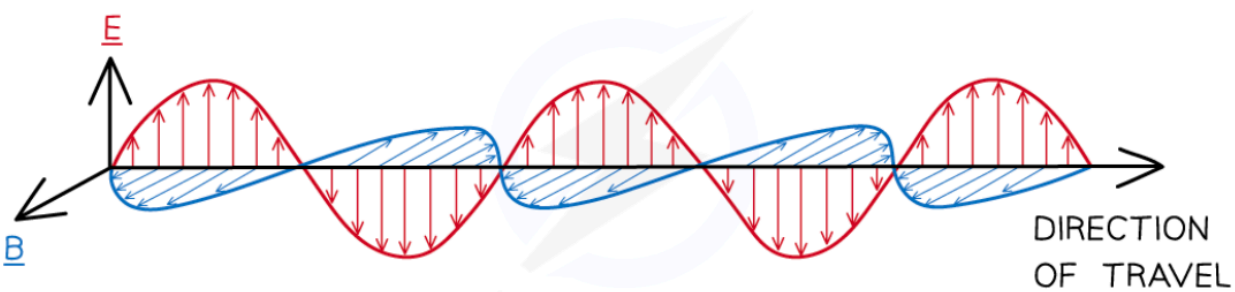
$$f_o = f_s\left(\frac{v}{v - v_s}\right)$$

- When the source starts to move **away from** the observer, the wavelength of the waves is **broaden**. The sound therefore appears at a **lower** frequency to the observer.

$$f_o = f_s\left(\frac{v}{v + v_s}\right)$$

Electromagnetic Waves

- **All electromagnetic waves have the following properties in common:**
  - They are all **transverse** waves
  - They can all travel in a **vacuum**
  - They all travel at the **same speed** in a vacuum (free space) — the speed of light **3×10^8 ms^{-1}**



Oscillating electric and magnetic fields in an electromagnetic wave

- These transverse waves consist of electric and magnetic fields oscillating at right angles to each other and to the direction in which the wave is travelling (in 3D space)
- Since they are transverse, all waves in this spectrum can be reflected, refracted, diffracted, polarised and produce interference patterns.

EM spectrum wavelengths:

Radiation	Wavelength range / m
radio waves	$>10^{6}$ to 10^{-1}
microwaves	10^{-1} to 10^{-3}
infrared	10^{-3} to 7×10^{-7}
visible	7×10^{-7} (red) to 4×10^{-7} (violet)
ultraviolet	4×10^{-7} to 10^{-8}
X-rays	10^{-8} to 10^{-13}
γ-rays	10^{-10} to 10^{-16}

Use of Electromagnetic waves:

WAVE	USE
Radio	Communication (Radio and T.V)
Micro Wave	Communication (Wi Fi, Mobile Phones, Satellites)
Infrared	Remote controls Fiber optic communication Night vision Thermal imaging (Medical use) Heating or cooking things Motion sensors
Visible Light	Seeing and taking photographs/ Videos
Ultravoilet	Flurorescent bulbs Getting a suntan
X-Ray	X-Ray imaging (Medicine, Airport security and industry)
Gamma Rays	Sterilising medical instruments treating cancer