WJEC (Wales) Physics GCSE

1.5: Features of Waves

Detailed Notes

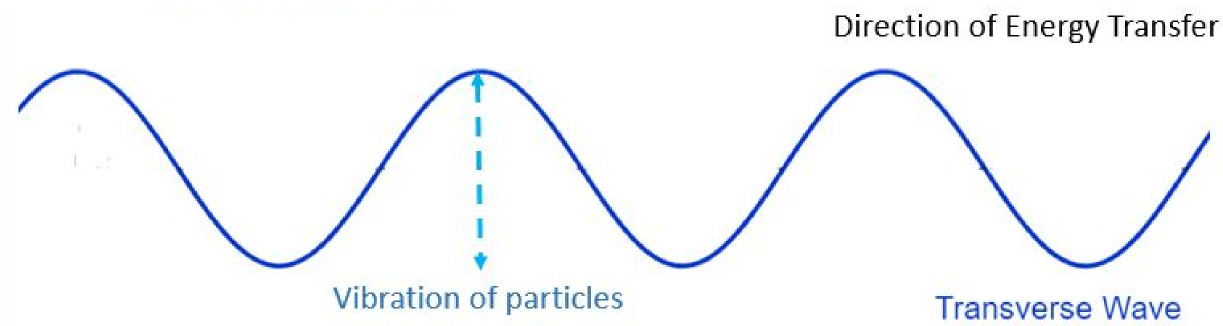
(Content in **bold** is for higher tier **only**)

Wave Motion

A wave transfers energy through **vibrations** and there are two main types.

Transverse Waves

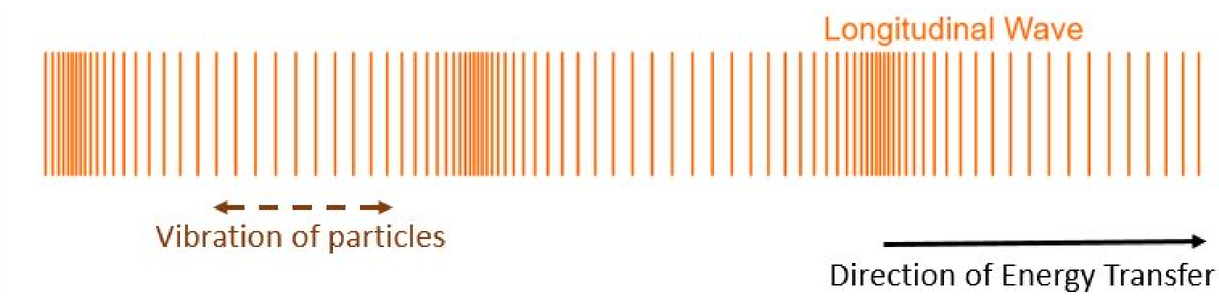
Transverse waves form when particles vibrate **perpendicular** to the direction of energy transfer in a series of **peaks and troughs**. Seismic S-waves, light and other Electro-Magnetic (EM) waves are all transverse.



A transverse wave with peaks and troughs (onlinemathlearning.com).

Longitudinal Waves

Longitudinal waves form when particles vibrate **parallel** to the direction of energy transfer in a series of **compressions and rarefactions**. Compressions are where the particles move close together and rarefactions where they spread out to be further apart. Sound waves are longitudinal.



A longitudinal wave with compressions and rarefactions (onlinemathlearning.com).

Describing Wave Motion

Wave motion can be measured and analysed using displacement-distance graphs.

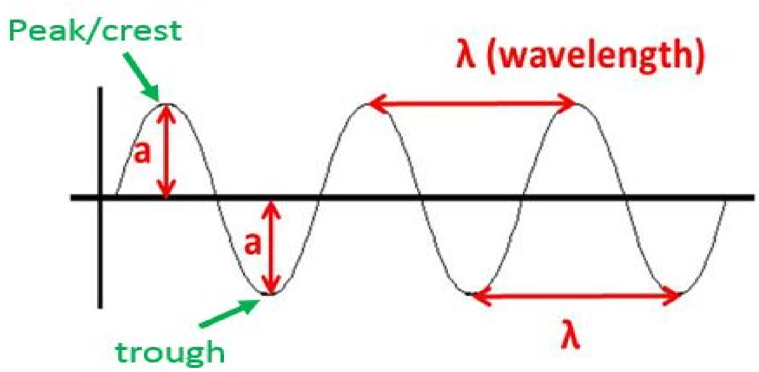
Amplitude (a)

The amplitude of a wave is the **maximum displacement** that a particle will experience from zero. It can be measured as the **peak height** from the undisturbed position.

Wavelength (λ)

This is the **horizontal distance** travelled by a single wave cycle (one peak and one trough). It can be measured as the **distance between a point** on a wave and the **same point** on the next wave cycle. This point can be anywhere on the wave but measuring wavelength between peaks or troughs is often easiest.

Frequency (*f*)
This is the **number of wave cycles** that pass a single point in **one second**. It is measured in **hertz (Hz)**, where 1 Hz is one wave per second.



Features of a transverse wave (studyrocket.co.uk).

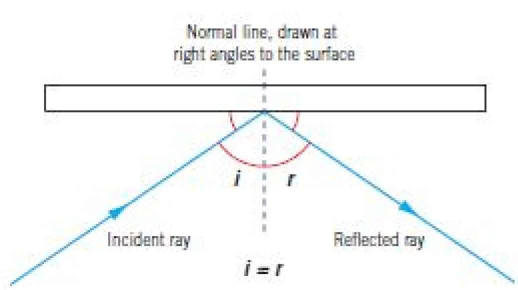
Wave Speed (v)
The speed of a wave is **proportional** to its frequency and wavelength.

$$v = f\lambda$$

v is velocity in m/s, f is frequency in hertz (Hz) and λ is wavelength in meters (m).

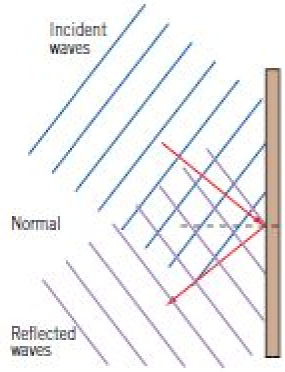
Reflection

Waves incident on a surface will be **reflected**. They reflect at the **same angle** that they were incident at (ie. angle of incidence (i) = angle of reflection (r)). Both of these angles are measured from the **normal**, the dotted line **perpendicular** to the reflecting surface.



Ray diagram of a reflected ray off a planar surface (revisionscience.com).

Reflection can also be shown using **planar wave fronts** (how a wave appears when viewed from above) instead of with rays.



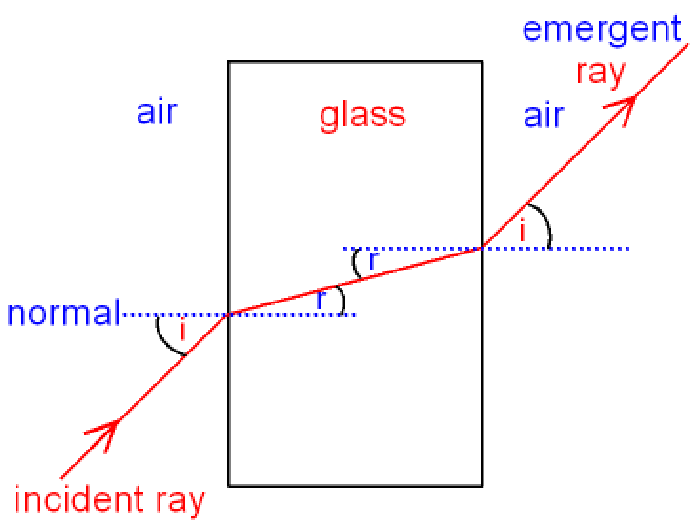
Reflection of plane wave fronts off a planar surface (revisionscience.com).

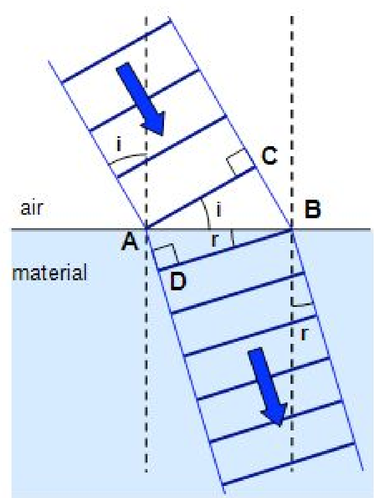
Refraction

Waves **change speed** when they move between two different substances (media) with **different densities**. This change in speed also results in a **change in direction** of the wave, an effect known as refraction.

When the wave enters a **denser** medium, it will **slow down** and its **wavelength decreases** (frequency remains constant). When it slows down, the direction of wave transmission **bends towards the normal**. As a result the angle of refraction will be lesser than the angle of incidence ($i > r$).

When the wave enters a **less dense** medium, it will **speed up** and its **wavelength increases**. The direction of wave transmission therefore **bends away from the normal** ($i < r$).





(Left) refraction of a ray of light passing through a glass block (gcsescience.com).
(Right) refraction of plane wave fronts passing from air to a more optically dense medium (schoolphysics.com).

Electromagnetic Waves

Electromagnetic waves (EM waves) are waves made up of **magnetic and electric fields**. They do not require oscillating particles to transfer energy so can **travel in vacuums** and are referred to as **radiation**.

There are seven types of EM wave that form a spectrum with **varying frequencies** and **wavelengths**. All EM waves have the **same speed** (3×10^8 m/s) but **varying energies** due to the different frequencies and wavelengths.

Type of Radiation	Wavelength	Frequency	Energy	Uses
Gamma	very short	very high	very high	- cancer radiotherapy
X-Rays				- medical imaging
Ultraviolet (UV)				- sterilisation - fluorescent light
Visible Light				- illumination
Infrared (IR)				- heating - remote control
Micro-waves				- cooking food
Radio-waves	very long	very low	very low	- broadcasting - communications

Radiation can also refer to energy given out by **radioactive materials**. Gamma, X-rays and UV all have very short wavelengths and **very high energy** meaning they can **damage cells** through interaction with atoms. This means they are a form of **ionising radiation**.

Satellite Communication

Electromagnetic waves can be used for **communication**. They are especially good for longer range communications using **satellites in orbit**, as they can still transfer energy in a vacuum.

Many modern communication devices such as mobile phones use **radio-waves** to receive and send messages between cell towers. These cell towers communicate with satellites using **micro-waves**.

Satellite Orbits

There are different types of satellite orbit used for different types of communication.

Geosynchronous

These orbits are ‘in sync’ with Earth’s rotation, so they have an **orbital period of 24 hours** and will return to the same position once every 24 hours.

Geostationary

These orbits are also geosynchronous with an **orbital period of 24 hours** but also remain **stationary above a single point** above Earth’s surface. This means a base station at that point would be in **constant communication** with the satellite unlike a satellite in geosynchronous orbit.