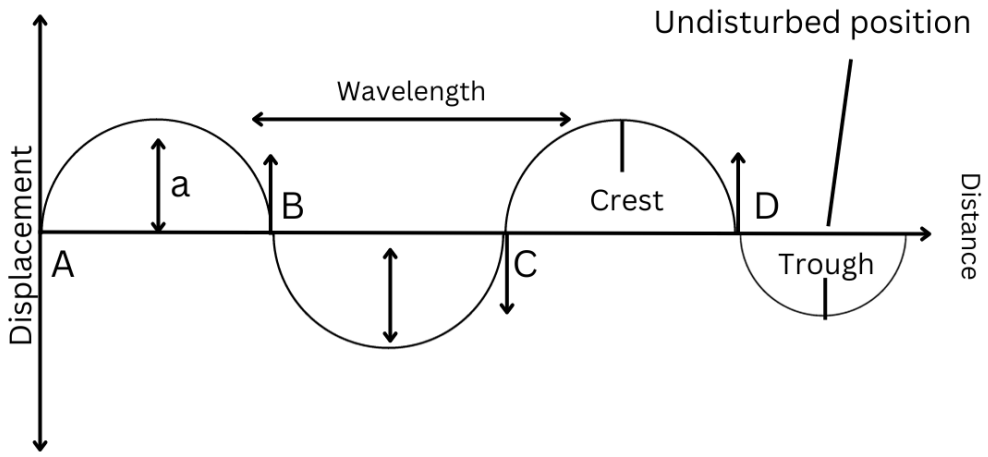
Waves

4.1 General Properties of Waves

Waves: This is a disturbance that travels through space and time carrying energy with it.

The general properties of a wave can be explained using the displacement-distance graph:



Wavelength: It is represented by the Greek letter lambda (**λ**). It is the distance between two points or two successive crests (Peaks) or troughs (calculated in m)

- Wavelength and frequency are inversely Proportional.

Frequency: Is represented by f. It is the number of complete waves generated per second". Its units are hertz (Hz)

Wave speed: It is represented by V. This is how fast a wave travels from one place to another. It is the distance moved in the direction of travel of the wave by a crest or any point on the wave in one second.

Amplitude: It is represented by a. This is the height of a crest or depth of a trough measured from the undisturbed Position.

Phase: These are the short arrows at A, B, C, and D Showing the Vibration.

The wave equation:

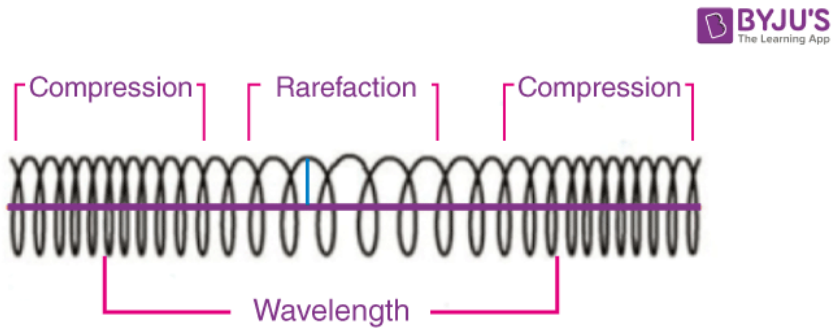
Speed of wave= Frequency x Wavelength
v= f x **λ**

$$f = \frac{1}{t}$$

t is Time

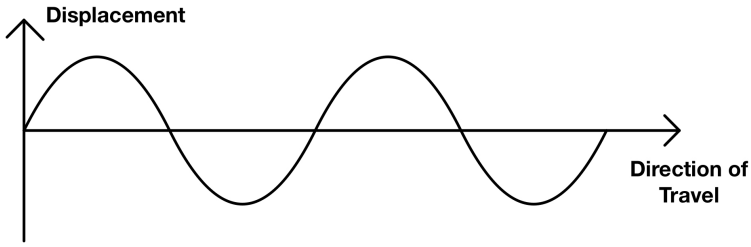
4.2 Types of Waves

Longitudinal waves: The Oscillations are parallel to the direction of energy transfer Such as sound waves and Seismic P-waves.



Rarefaction (R): The particles are Spread out.
Compression (C): Where particles are densely packed

Transverse waves: The direction of disturbance is at right angles/perpendicular to the direction of energy transfer. For example, a transverse wave can be sent along fixing one rope by end and moving the Other rapidly up and down. The disturbance is generated by the hand, the humps, and the hollow of the wave traveling along the rope as each Part of the rope vibrates transversely about its undisturbed Position.
Transverse waves can be water waves or electromagnetic radiation.



Credit: thescienceandmathszone

4.3 Sound and Light Waves

Sound waves

Sound waves are produced by Vibrating sources. They are longitudinal waves. Vibrations can be from guitar strings or a loudspeaker and more. "Sound cannot travel in a vacuum as light can. A medium is needed to transmit sound waves. It travels fastest in Solids, and slowest in gases

A speaker has a cone which is made to vibrate in and out by an electric current. When the cone moves out, the air in front is compressed, when it moves in, the air is rarefied (becomes thinner). The air particles (molecules), vibrate backward and forward a little as the wave progresses through air. When the waves enter your ear, the compressions and rarefactions cause small, rapid pressure changes on the eardrum and you experience the sensation of sound.

Fact: Humans hear only sounds with frequencies from about 20Hz to 20000Hz, these are the limits of audibility in a healthy human ear. The upper limit decreases with age!

Reflections and echoes

Sound waves are reflected well from hard, flat surfaces Such as walls or cliffs. They obey the same laws of reflection as light.

The reflected sounds form an **echo**.

Reverberation: This is a reflection and continued bouncing of Sound waves after the Source has stopped producing sound.

Speed of sound in air= $\frac{2d}{t}$ → This equation is used if an echo is produced

d is Distance

t is time

Pitch: This is how high or low the sound is. The frequency of the Sound.

A high-pitched note has a high frequency and a Short wavelength.

Loudness is the amplitude of a Sound wave. It is a measure of how loud or soft a sound is. A sound will become louder if the source is vibrating with a larger amplitude

Ultrasound is sound with a frequency higher than 20kHz. It can be detected by the human ear, electronically and displayed on a cathode ray oscilloscope (CRO)

Light

Light waves are electromagnetic waves that make up the visible spectrum of electromagnetic radiation.

Sources of light

Note: You can only see an object if light from it enters your eyes.

1) **Luminous source:** they make light on their own. Such as the Sun, electric lamps, and candles.

2-) **Non-luminous source:** They do not make their light but reflect light from luminous sources. Such as the moon, humans, and planets.

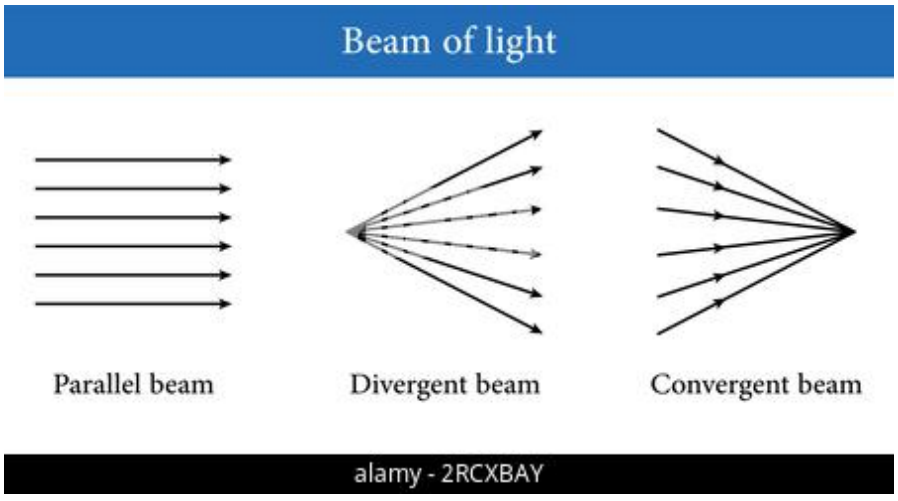
Rays and beams

Beams are visible because dust particles in the air reflect light into our eyes. For example light from the cinema projector on its way to the screen.

Ray: The direction of the path in which light travels.

There are 3 types of beams:

- Parallel beams.
- Diverging beam.
- Converging beam.

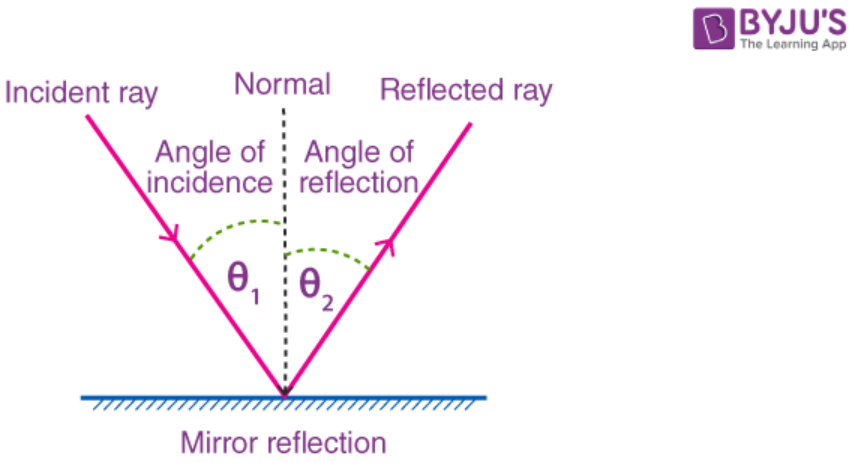


The speed of light is faster in Vacuum

speed of light is faster than Speed of sound that is why lightning is seen first and then the thunder is heard.

Law of reflection

Normal Line that is perpendicular to the distance.



The angle of incidence: the angle between the incidence ray and the normal to a surface.

The angle of reflection: the angle between the reflected ray and normal to a surface.

The law of reflection states that:

The angle of incidence is equal to the angle of reflection

Refraction of light

Light is refracted because its speed changes when it enters another medium.

Refractive index (n): The ratio of the speeds of a wave in two different regions.

$$n = \frac{Sine\ of\ angle\ between\ ray\ in\ air\ and\ normal}{angle\ between\ ray\ in\ glass\ and\ normal}$$

$$n = \frac{Sin\ i}{Sin\ r}$$

Refraction is the bending of light when it passes from one medium to another.

It is the change in direction of light when it is traveling obliquely from one medium to one

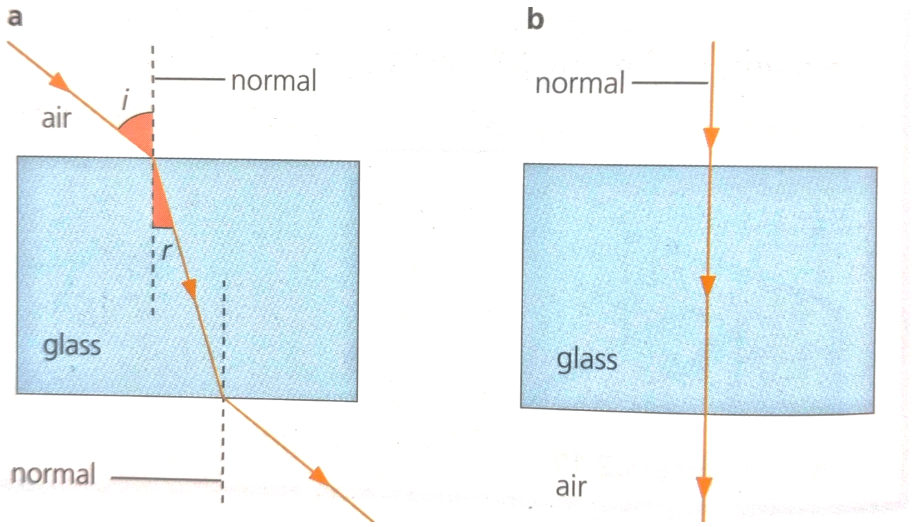
Refraction happens due to the Change in speed of light. The greater the Change in speed the greater will be the bending Of light.

When light travels from a rarer medium to a denser medium, the speed of light decreases, and the light bends towards the normal. The angle of incidence is greater than the angle of refraction.

i >r

When light travels from a denser material to a rarer material, the speed of light increases, and the light bends away from the normal. The angle of incidence is lesser than the angle of refraction.

i <r



Credit: Cambridge IGCSE™ Physics Forth Edition Hodder Education