Sound

SOUND :

Sound is a form of energy which makes us hear and travels in the form of waves.

Sound is produced by various sources. Though sound is mechanical in nature, its perception is, of course, largely physiological.

PROPAGATION OF SOUND

The sound produced by vibrating objects reaches the listener only when it passes through a medium which may be a liquid, a solid or a gas. Let us now briefly discuss as to how sound travels from the source point of generation to the listener.

(i) The vibration of the object sets the particles of the medium around it vibrating.
(ii) The particles do not travel from the vibrating object to the ear. A particle of the medium in contact with the vibrating object is first displaced from its equilibrium position as shown in the figure. This particle exerts a force on a neighboring particle (2) which is displaced from its equilibrium position and also starts moving. After displacing particle (2), particle (1) comes back to its mean position. This process continues till the particle near the listener's ear starts vibrating.

Thus, sound created by the source reaches the listener through the particles of the medium without any net transport of the medium.

(a) Type of waves on the basis of material medium

(i) Elastic waves or mechanical waves : Those waves which need a material medium for their propagation are called **elastic waves** or **mechanical waves** e.g., sound waves and water waves are elastic or mechanical waves.

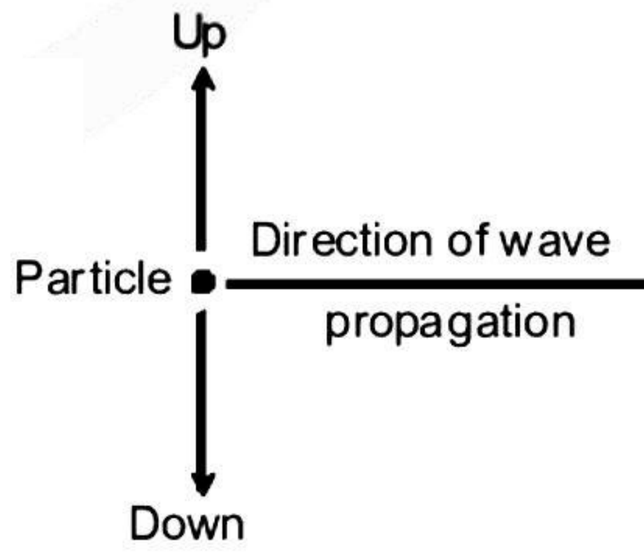
(ii) Electromagnetic waves : Those waves which do not need a material medium for their propagation are called **electromagnetic waves**. These waves can travel through vacuum as well as through medium e.g. light waves and radio waves are electromagnetic waves.

(iii)Seismic waves: The disturbances inside the earth which cause waves moving in all direction are called **seismic waves**. It is these waves which cause earth quakes.

(b) Types of waves on the basis of its direction of propagation

(i) **Transverse waves :** The waves in which the particles of the medium vibrate up and down 'at right angles' to the direction in which the wave is moving, are called **transverse waves**.

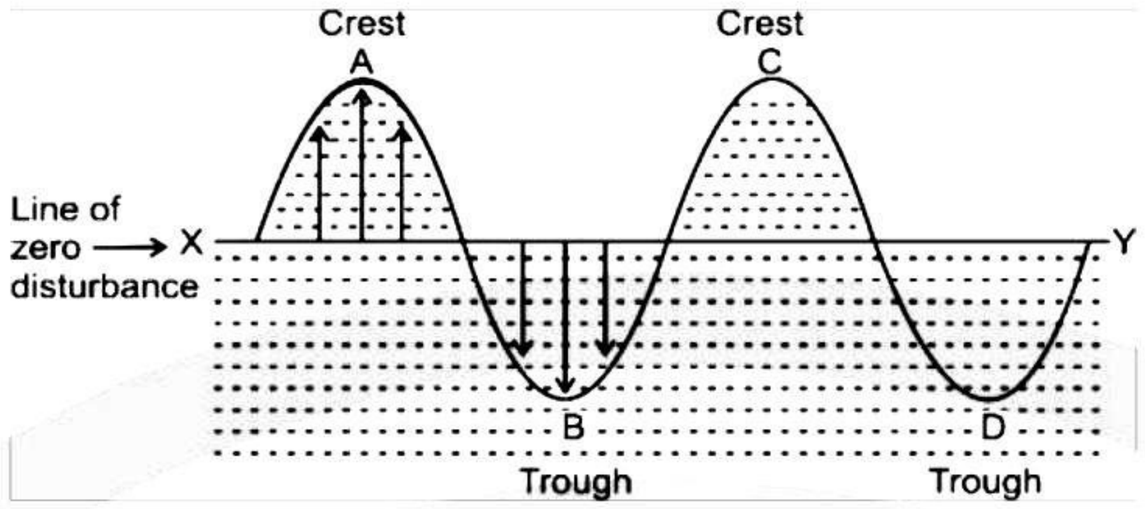
Eg., light waves, radio waves, water waves etc.



The water waves (or ripples) formed on the surface of water in a pond are transverse waves. This is because of the fact that in a water wave, the molecules of water move up and down in the vertical direction when the wave travels in the horizontal direction along the water surface. When a stone is dropped in a pond of water, transverse water waves are produced on the surface of water.

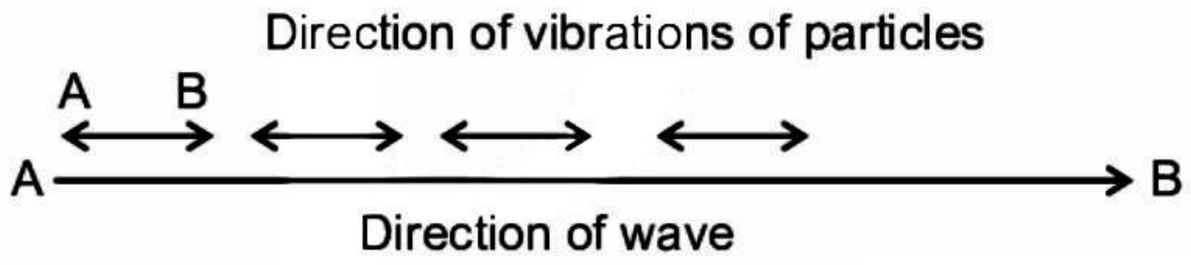
The **'elevation' or 'hump'** in a transverse wave is called **crest**. In other words, a crest is that part of the transverse wave which is above the line of zero

disturbance of the medium. In figure, XY is the line of zero disturbance and A and C are the two crests of the transverse water waves.



The **'depression' or 'hollow'** in a transverse wave is called **trough**. In other words, a trough is that part of the transverse wave (B and D) which is below the line of zero disturbance.

(ii) **Longitudinal waves:** A wave in which the particles of the medium vibrate back and forth in the 'same direction' in which the wave is moving, is called longitudinal wave. Eg. – Sound waves.



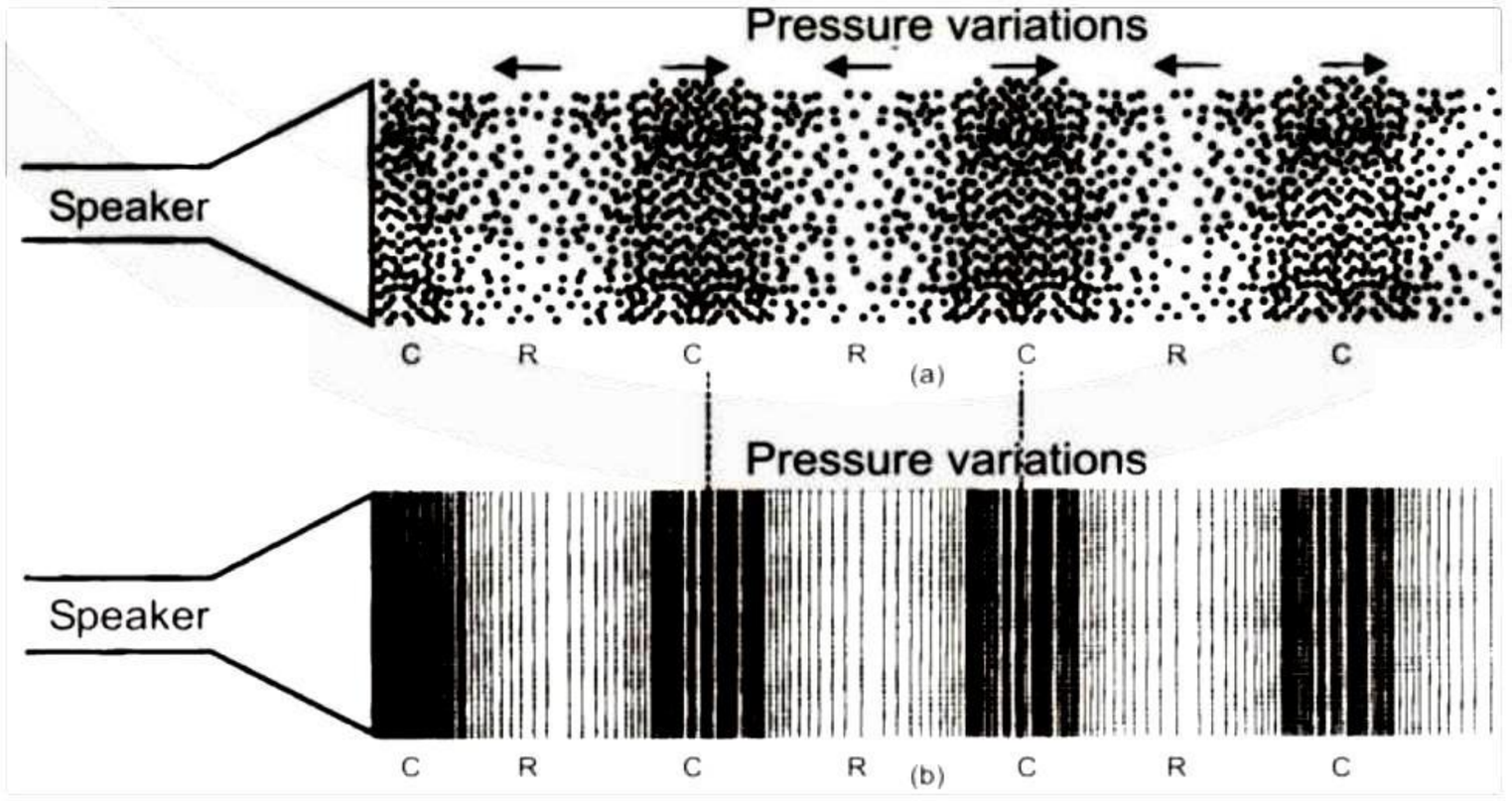
Characteristics of a Sound Wave

As already discussed, sound waves are produced due to variations in pressure and density of the medium. The various other characteristics are:

(a) Compression and rarefaction

A compression is formed when particles of the medium lie closer to each other whereas a rarefaction is formed when the particles of the medium lie farther apart than the normal distance.

(i) Compression : A portion of the medium where a temporary decrease in volume and consequently a increase in density takes place when a sound wave passes through the medium, is called a compression or a condensation.



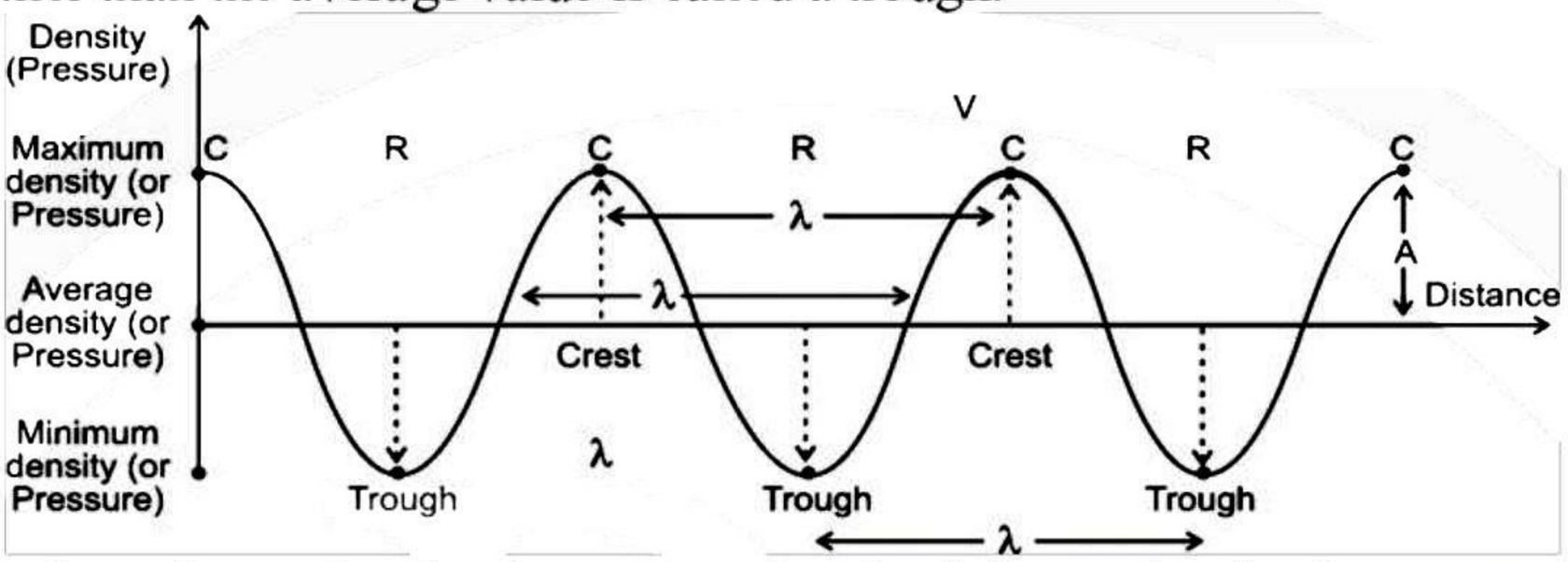
(ii) Rarefaction: A portion of the medium where a temporary increase in volume and consequently a decrease in density takes place when a sound wave passes through the medium, is called a rarefaction.

(b) Graphical representation of sound wave

The graphical representation of sound wave is given below :

(i) Crest : The portion of the medium where the density (or pressure) has a value larger than its average value is called a crest.

(ii) Trough : The portion of the medium where the density (or pressure) has a value smaller than the average value is called a trough.



The points of maximum density (or pressure) and minimum density (or pressure) are also called crests and troughs respectively.

(iii) Amplitude (A) : The magnitude of the maximum disturbance in the medium on either side of the

mean position is called the amplitude of the wave. It is usually represented by the letter A. In case of sound, the unit of A is the same as that of density or pressure.

(iv) Oscillation : As is clear from the graph, the density (or pressure) of the medium oscillates

between a maximum value and a minimum value. The change in density (or pressure) from maximum value to the minimum value and again to the maximum value is called an oscillation.

(v) Frequency (ν) : The frequency of a sound wave is defined as the number of complete oscillations

per second. It is denoted by the symbol **ν** (Greek letter, nu). Unit of frequency is **cycle per second (cps)** or $\mathbf{s^{-1}}$ or **hertz (Hz)** which is named after **Heinrich Hertz** (1857-1894). Bigger units of frequency are kilohertz (kHz, 10^3 Hz) and megahertz (MHz, 10^6 Hz).

(vi) Time Period (T) : The time taken for one complete oscillation in density (or pressure) of the

medium is called the time period of the wave.

Time period of the wave is also defined as the time taken by its two consecutive compressions or rarefactions to cross a fixed point.

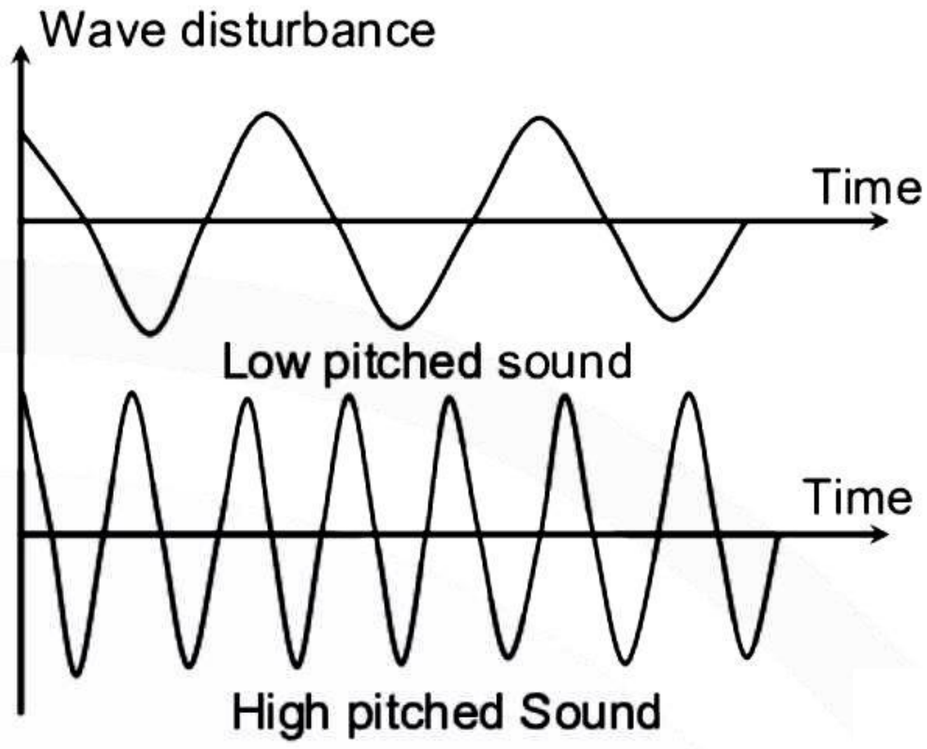
(vii) Wavelength (λ) : The distance between two consecutive compressions or two consecutive

rarefactions is called the wavelength of the wave. It is denoted by the symbol **λ** (Greek letter, lambda). Wavelength of a sound wave is also equal to the distance travelled by it in its periodic time (T). Unit of wavelength is **metre (m)**.

Pitch or frequency

Pitch is that property of sound which help in differentiating between a shrill sound and a grave (flat or dull) sound.

High pitched sounds are called **treble** and low pitched sounds are called **bass**. Pitch is directly proportional to the frequency. The voice of a lady is shriller than that of a man because the frequency of a women's ordinary voice is around 280 Hz and that of man is around 140 Hz.



Quality or timbre

The property of a sound which distinguishes it from another of the same pitch and loudness is called quality or timbre.