Waves

Lecture Outline

1) Wave
2) Classification of waves
3) Mechanical Wave
4) Transverse Wave
5) Longitudinal Wave
6) Surface Wave
7) Electromagnetic Wave
8) Matter Wave
9) Characteristics of Wave

Wave: The periodic disturbance that advances through a material medium transfers energy from one place to another place but does not displaced the particle of the medium permanently is known as wave.

A few examples of waves are: water wave, sound wave, light wave, electromagnetic wave etc.

Waves can be classified into two types:

1. **Mechanical wave**
2. **Electromagnetic wave**

Mechanical Wave

The waves which require a material medium for their propagation are known as mechanical waves.

Examples: Vibration of string, the surface wave produced on the surface of solid and liquid, sound waves, tsunami waves, earthquake P-waves, ultra sounds, vibrations in gas, and oscillations in spring, internal water waves, and waves in slink etc.

Types of Waves:

Waves generated by the simple harmonic motion of the particles of a medium are called **simple harmonics waves** or **sine waves**. They are of two types, viz.

(i).Transverse wave,

(ii).Longitudinal wave,

(i).Transverse Wave

A wave motion, in which the particles of the medium oscillate about their mean positions at right angles to the direction of propagation of the wave, is called transverse wave.

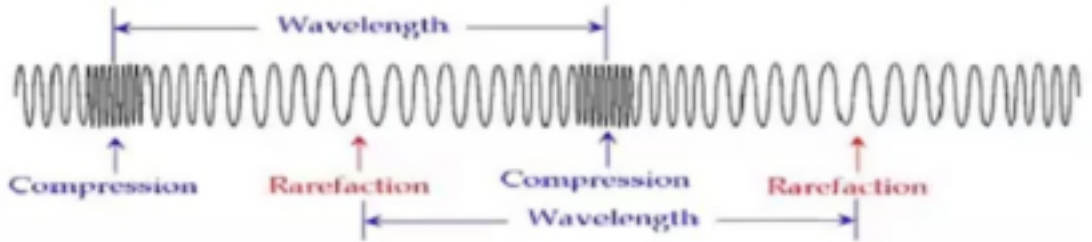
Particles of the medium oscillate in a direction perpendicular to the direction of propagation. Thus, during their oscillations, the particles may move upwards or downwards from the plane

passing through their mean positions. The uppermost point of the wave, i.e., the position of maximum positive displacement is **crest** and the lowest point, i.e. the position of maximum displacement is called **trough**. Thus in a transverse wave crests and troughs appear alternatively.

For example: A stretched string fixed at b0th ends is pulled perpendicular to its length and released, a wave is produced in the string. It is observed that the particles in the string oscillate perpendicular to the direction of motion of the wave. So, the wave produced in a stretched string is a transverse wave.

(ii).Longitudinal Wave

A wave motion, in which the particles of the medium oscillate about their mean positions in the direction of propagation of the wave, is called longitudinal wave.



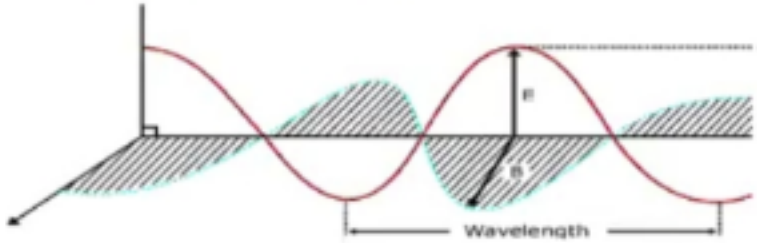
A Longitudinal wave proceeds in the form of compression and rarefaction which is the stretched rubber band. For a longitudinal wave at places of compression the pressure and density tends to be maximum, while at places where rarefaction takes place, the pressure and density are minimum. Longitudinal waves are known as **Compression waves**.

Examples of longitudinal wave:

Waves in a spring & sound wave.

Electromagnetic Wave

When electric and magnetic fields fluctuate together they lead to formation of the propagating waves called Electromagnetic waves.



The various properties of Electromagnetic waves are:

1. The Velocity of electromagnetic wave in vacuum is **3 ×× 10^8 m/s.**
2. The existence of medium is not essential for propagation.
3. In vacuum, E.M waves travel with light velocity.
4. E.M waves can be polarized.
5. E.M waves are transverse in nature.
6. E.M waves have momentum.
7. There is no deflection on account of magnetic or electric field.
8. They can exhibit diffraction and interference.

Examples of Electromagnetic Waves: Radio waves, Light waves, thermal radiation, X ray, visible light, microwave, infrared, gamma rays etc. are the example of electromagnetic waves. These waves together form the electromagnetic spectrum.

Characteristics of wave

The basics terms to understand waves are amplitude, wavelength, frequency, speed, complete oscillation and time period.

1. Wavelength

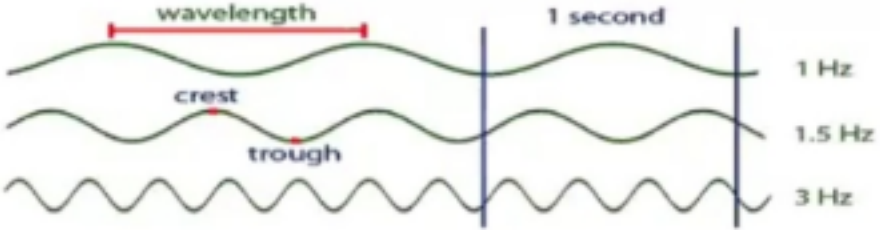
A **wavelength** is the shortest distance between two adjacent crests or troughs of a transverse wave. For longitudinal waves, it is the distances between two adjacent compressions or rarefactions. Wavelength is measured in meter (m).

2. Amplitude

Amplitude of a wave is the mixture distance of the particles of the medium from the rest position. We can also say that it is the height of the crest or depth of a trough (transverse

3. Frequency

The number of vibrations produced by a vibrating body in one second is called its **frequency.** Frequency is measured in units called hertz (Hz). When one wave passes in one second its frequency is 1 wave per second or 1 hertz.



3. Speed

Imagine watching a flash or lightning and thundering of cloud. First we see the flash of lighting. A few seconds later we hear thunder. This happens because sound and light travel at different speeds. Light travels much faster than sound. Different waves travel at different speed. This distance a wave covers in units time is called its **speed.** Speed is measured in meter per second. Sound travels at different speed in different mediums.

Complete oscillation: When an oscillating body starting from a point comes back to the same point from the same direction, then it is called one complete oscillation.

Time Period: Time required by a particle of the medium to execute one complete oscillation is called the Time period of the wave. It is denoted by **T**.

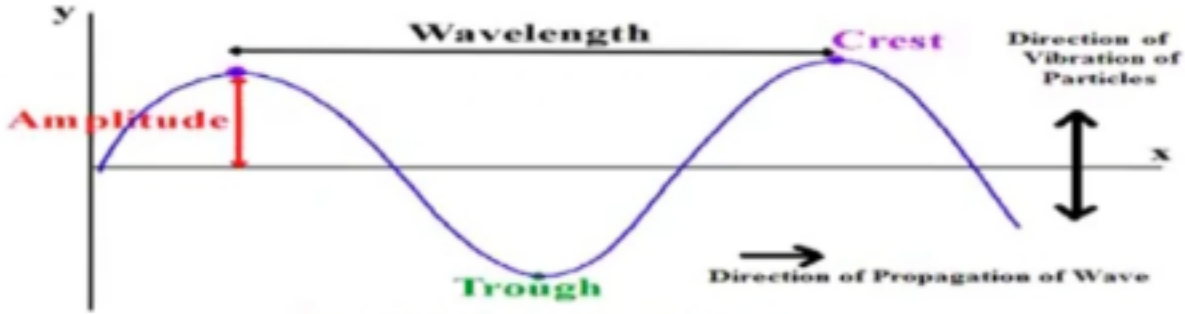


Fig: Basic Properties of Wave

Phase: State of motion of a vibrating particle of wave at any instant is called its Phase. State of motion of a vibrating particle at any instant is determined by its displacement, velocity and acceleration at that instant.

Difference between Transverse wave & Longitudinal wave:

Transverse Wave	Longitudinal Wave
The wave in which the particles of the medium vibrate perpendicular to the direction of propagation of the wave is called transverse wave.	The wave in which the particle of the medium vibrates parallel to the direction of propagation of the wave is known as longitudinal wave.
During propagation of the wave crests and troughs are produced in the medium.	During propagation of the wave compression and rarefaction of the medium take place.

Frank is making waves on a rope by moving his arm up and down, which he does 20 times in 10 seconds. What is the frequency of the waves that Frank creates?

$N = 20$

$t = 10$

$f = \frac{N}{t} = 25^{-1}$

$2\,Hz$

a, x, f, T, V

$v = \frac{d}{t}$

$s = vt$

$v = \frac{s/d}{t}$

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

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

$v = f\lambda$

Kelly is floating on an inner tube in the ocean and notices that she bobs up and down 6 times every minute. What is the time period of the ocean on which Kelly is floating?

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

$$= \frac{60}{6} = 10\,s$$

What is the speed of a water wave that has a wavelength of 8meters and a period of 4 seconds?

$\lambda = 8$

$T = 4$

$T = \frac{1}{f} \Rightarrow f = \frac{1}{T}$

$v = f\lambda$

$= \frac{\lambda}{T}$

$= \frac{8}{4}$

$= 2 m/s$