UNIT III

WAVE MOTION

APPLIED PHYSICS

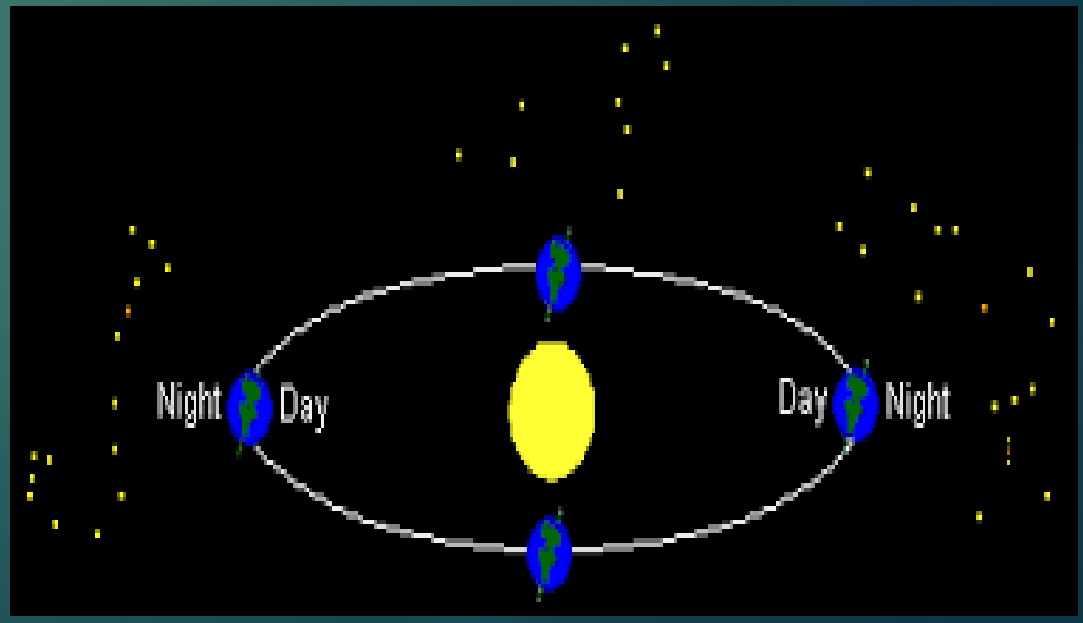
B.SC.(Home Science) Semester III

Mona Soin

Govt. Home Science College, Sector 10, Chandigarh

Periodic Motion

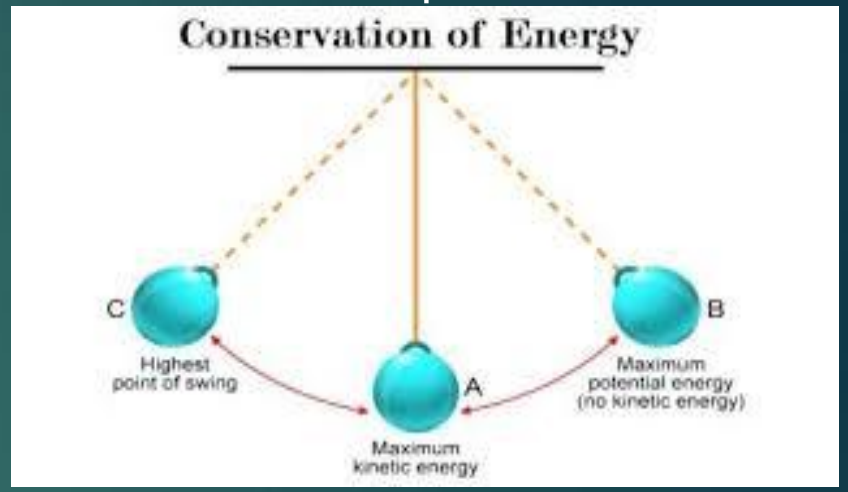
- A motion which repeats itself over and over again after a regular interval of time is called a periodic motion. The regular interval of time after which the periodic motion is repeated again is called its time period.
  e.g.
- Motion of earth around the sun in the same elliptical orbit over and over again, repeating its motion after every one year
- Phases of moon repeat themselves regularly after every twenty eight days
- Motion of the bob of the simple pendulum
- Motion of a bar magnet

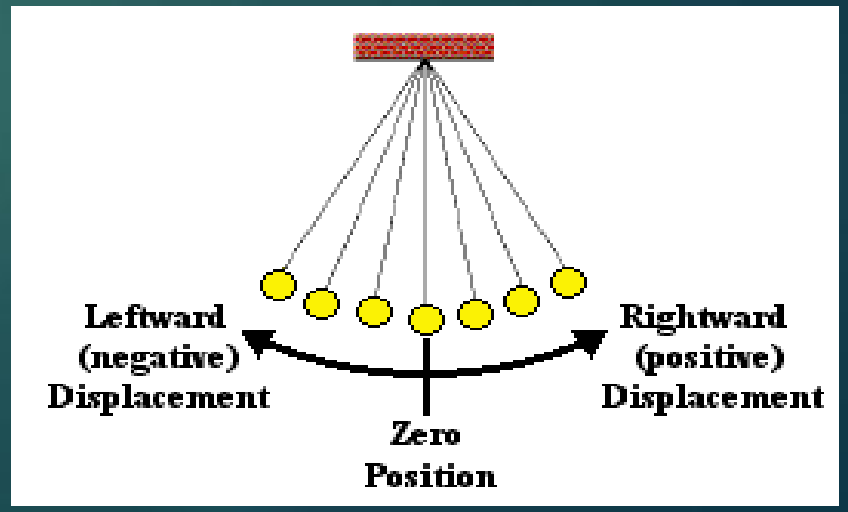


Oscillatory Motion

A motion which repeats itself over and over again after a regular interval of time about its mean position, such that it remains confined within two well defined limits(called extreme positions) on either side of the mean position is called oscillatory or vibratory motion. e.g.

- Motion of bob of a simple pendulum
- On being displaced, a liquid contained in a U tube executes oscillatory motion
- On being pulled and then released, a load attached to a spring executes oscillatory motion
- A piece of wood floating over the surface of liquid is pressed down and released – oscillatory motion



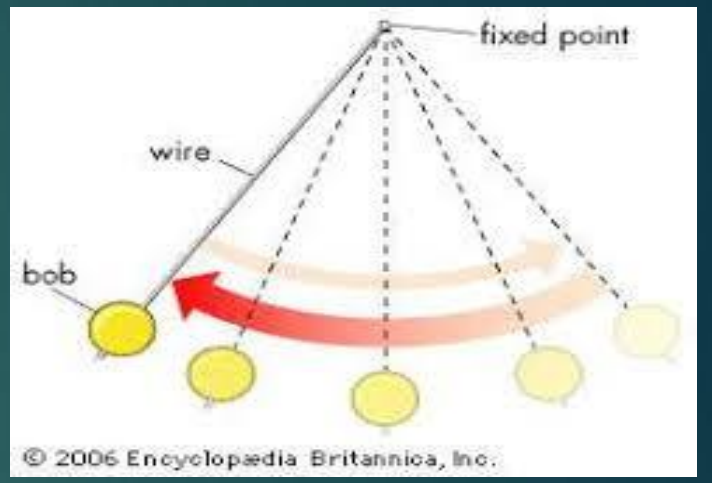


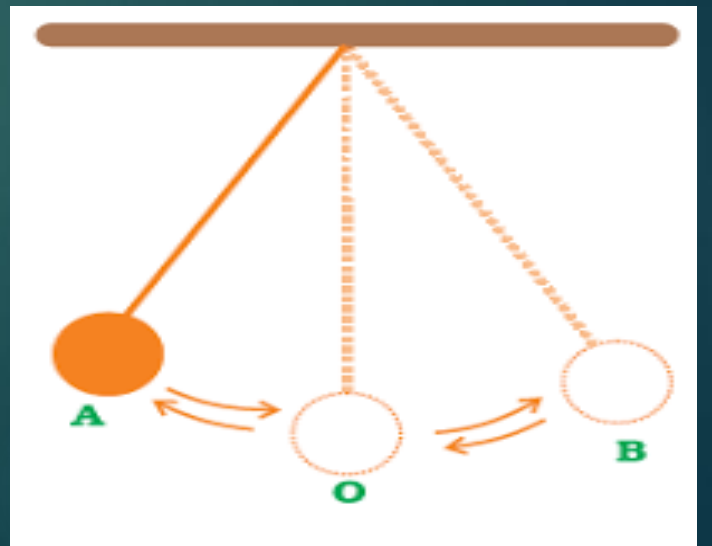
All oscillatory motions are periodic but all periodic motions are not oscillatory motions.

Time Period

- The smallest interval of time after which the periodic motion completes itself is called its time period or simply period. It is denoted by T.
- Time period is also defined as the time taken to complete one oscillation / vibration
- Time period is measured in seconds
- For too slow motions it can be measured in minutes ,hours, days or even years
- For too fast motions it is measured in microsecond (=10^{-6} seconds) or a nanosecond (=10^{-9} seconds)

e.g. the motion of the bob of a simple pendulum





Vibration/Oscillation

The periodic motion executed between the two extremes is called a vibration or oscillation

Frequency

The number of vibrations/oscillations that occur in a unit time is called the frequency of the periodic motion. It is denoted by the symbol 'n'

Number of vibrations in T seconds = 1

Number of vibrations in 1 second = 1/T

As no. of vibrations in 1 second is frequency, therefore

$$n = 1/T$$

Unit of frequency 1/sec or sec^{-1} or Hertz(Hz)

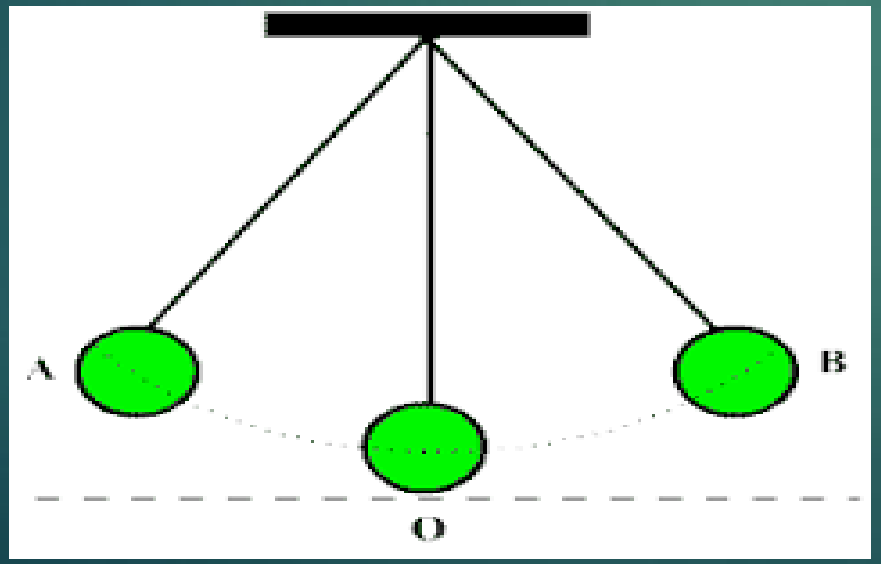
The frequency of a vibrating body is said to be one hertz, if it executes one vibration per second.

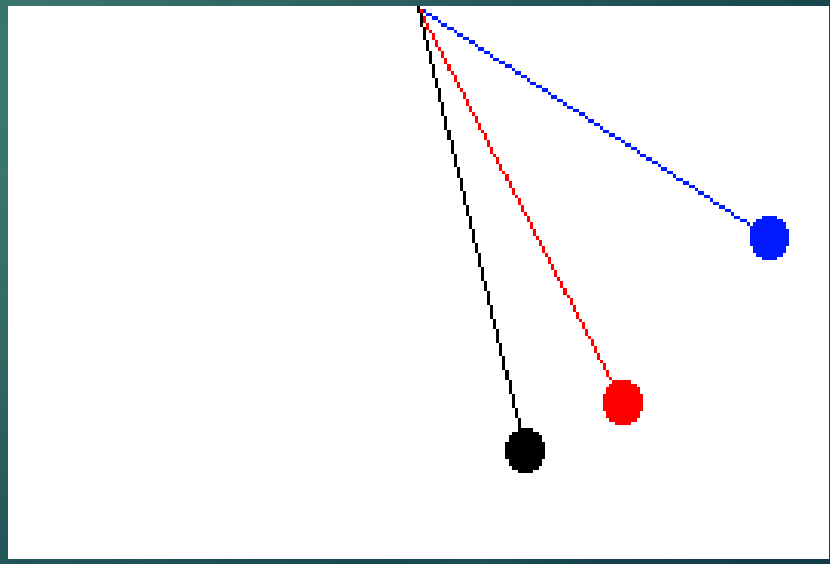
Numerical :

1) Calculate the frequency of a pendulum in hertz if its time period is 2 microseconds.
2) Calculate the time period of a pendulum if its frequency is 0.5 nanoseconds.

Displacement

- The displacement of a particle at any instant is the distance of the oscillating particle from its mean position at that instant
- Displacement may not always be a linear distance from the equilibrium position of the oscillating particle
- In the motion executed by a loaded spring, the displacement is a linear distance
- When the bob of a simple pendulum oscillates, the displacement is angular in nature
- In physics, the displacement in a periodic motion represents change of some measurable physical quantity or some property with time





Wave Motion or Waves

- Wave motion is a **form of disturbance** which travels through a medium due to the **repeated periodic motion** of the particles of the medium **about their mean positions.**
- The disturbance or motion is handed over from one particle to the other without any net transport of the medium

e.g. when a stone is dropped in still water, the water ripples or waves spread out on the water surface around the point of hitting of stone on the water surface.

- The velocity associated with particles of the medium is called particle velocity and the velocity associated with wave propagation is called wave velocity

Amplitude

The maximum displacement of the oscillating particle from the mean position is called **amplitude**.

It is denoted by **A**

Characteristics of Wave Motion

1) Wave motion is the disturbance travelling through the medium.
2) In a wave motion, there is no bodily motion of the particles of the medium from one part to another part of the medium. The particles of the medium only execute vibratory motion about their mean positions.
3) The disturbance (wave motion) from one particle reaches its neighbouring particle a little later and as the disturbance reaches, it also starts executing vibratory motion about its mean position.
4) The velocity of a vibrating particle of the medium is different at its different positions in a vibration but the velocity of the wave motion is always constant. In other words, the particle velocity varies with time , while the wave velocity is independent of time.
5) The displacement of the vibrating particle of the medium is zero over one complete vibration.
6) For propagation of wave motion, the medium should possess elasticity and inertia and there should be minimum friction between various particles of the medium.
7) In a wave motion, energy is propagated from one part of the medium to another, without any net transport of the material medium.

Mechanical/Elastic Waves

A mechanical wave is a periodic disturbance which requires material medium (solid, liquid or gas)for its propagation. They are also called elastic waves because their propagation depends on the elastic properties of the material medium. E.g. waves on water surface, sound waves in air, waves in solids and liquids etc. the wave motion dies out soon if there are large frictional forces in the medium.

Electromagnetic/Non – Mechanical Waves

The electromagnetic wave is a periodic disturbance which requires no material medium for its propagation and can travel through the vacuum. E.g. light waves, radio waves, micro waves, X rays etc.

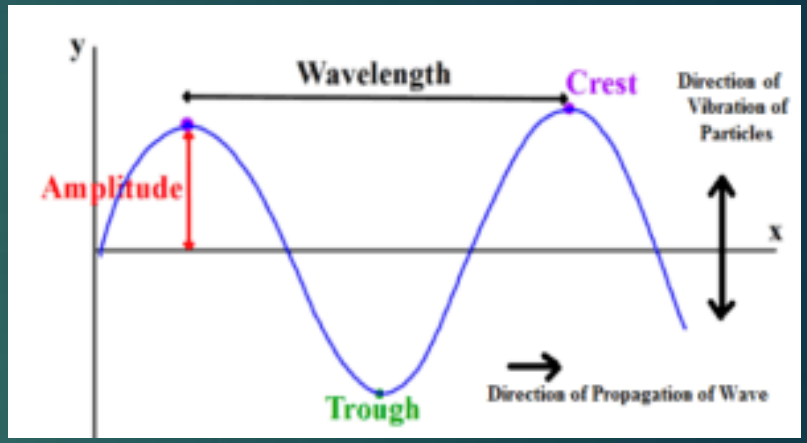
Two types of wave motion:

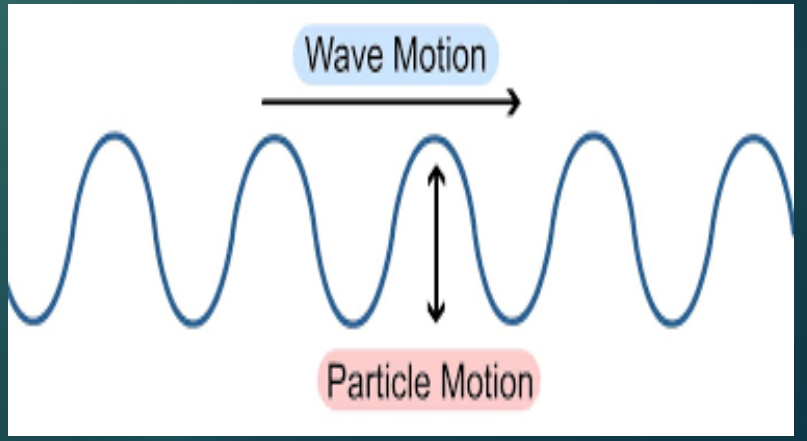
- Transverse Wave Motion
- Longitudinal Wave Motion

Transverse Wave Motion

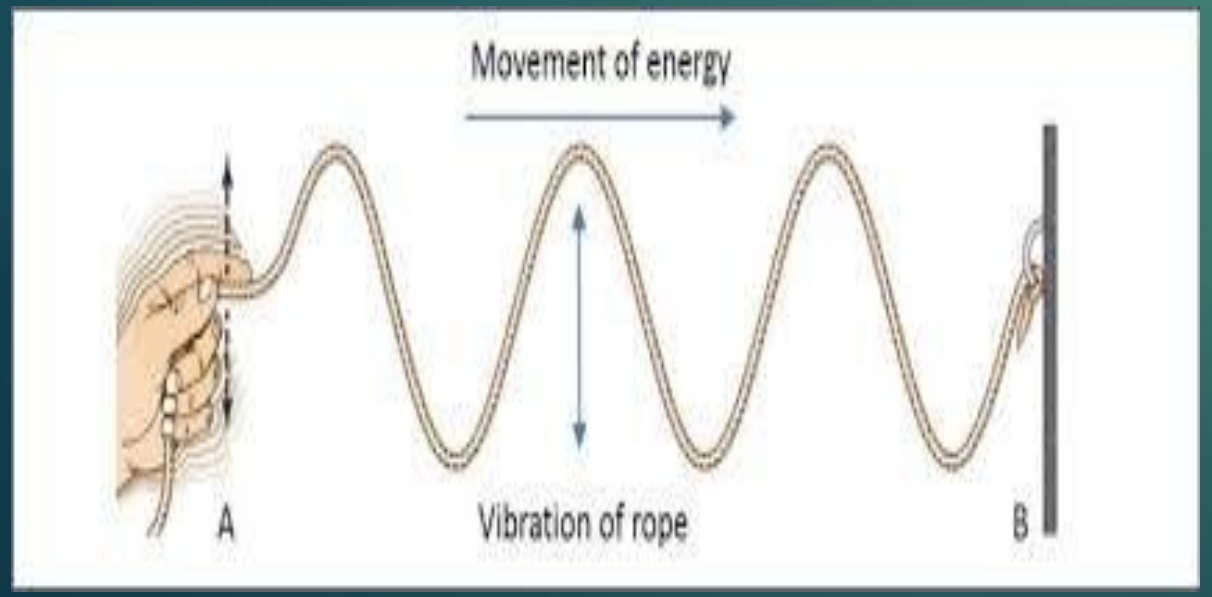
The wave motion in which particles of the medium vibrate about their mean positions at right angle i.e. in a direction perpendicular to the direction of propagation of disturbance (wave), is called **transverse wave or transverse wave motion**. E.g. waves in a stretched string (sitar, guitar, violin etc.), waves on water surface.

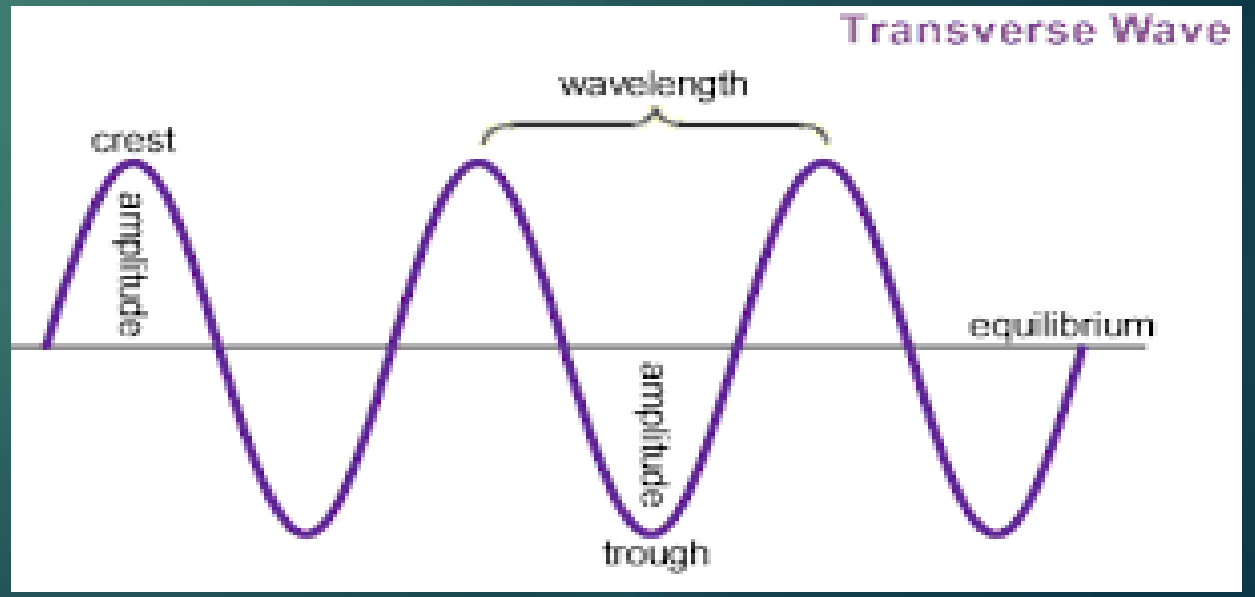
- A transverse wave travels in the form of **crests and troughs**.
- A **crest** is a portion of the medium, which is highly raised above
- the normal positions of rest of the particles of the medium,
- when a transverse wave passes through it.
- A **trough** is a portion of the medium, which is highly depressed below the normal positions of rest of the particles of the medium, when a transverse wave passes through it.
- The maximum displacement of the oscillating/vibrating particle from the mean poiaition is called **Amplitude**. It is denoted by **A** .





- The distance between two successive/consecutive crests or two consecutive troughs ia called **wavelength**. Or
- The distance travelled by the wave (disturbance) in the time, in which particle of the medium completes on e vibration is called **wavelength** . Or
- The distance between two successive particles of the medium which are in phase is called **wavelength**.
- It is represented by the symbol **λ**

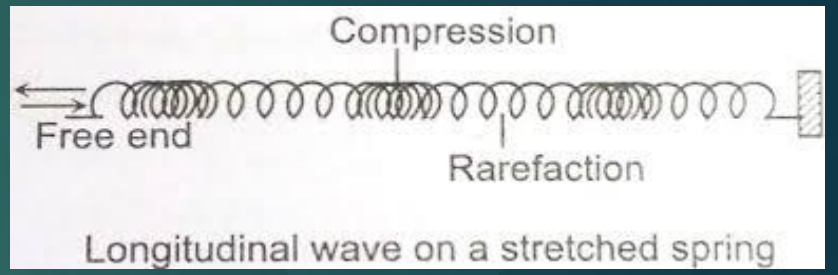


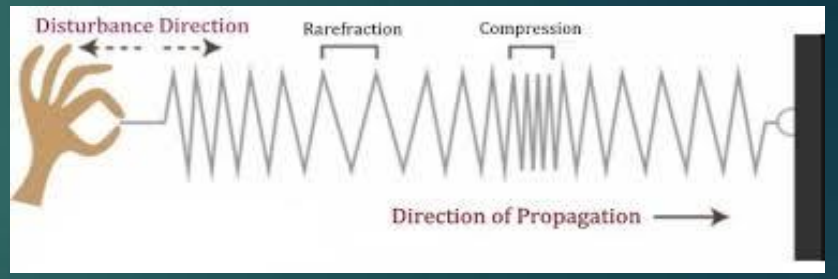


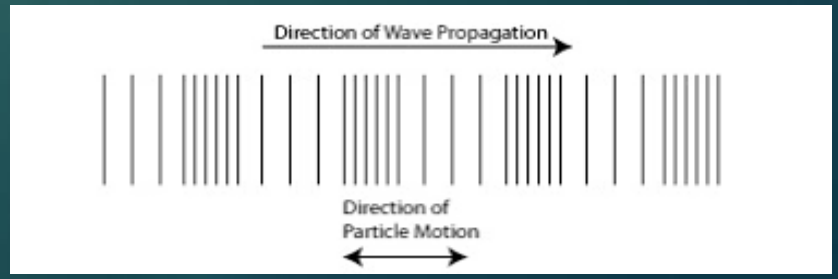
Longitudinal Wave Motion

The wave motion in which the particles of the medium vibrate back and forth about their mean position along the direction of propagation of the wave (disturbance), is called **longitudinal wave motion or longitudinal wave**. E.g. waves in a compressed spring, sound waves etc.

- A longitudinal wave travels in the form of **compressions and rarefactions** .
- A **compression** is a region of the medium, in which particles come to distances less than the normal distance between them. There is a temporary decrease vin volume and increase in density of the medium.
- A **rarefaction** is a region of the medium, in which particles of the medium get apart to distances greater than the normal distance between them. There is temporary increase in volume and decrease in density of the medium.







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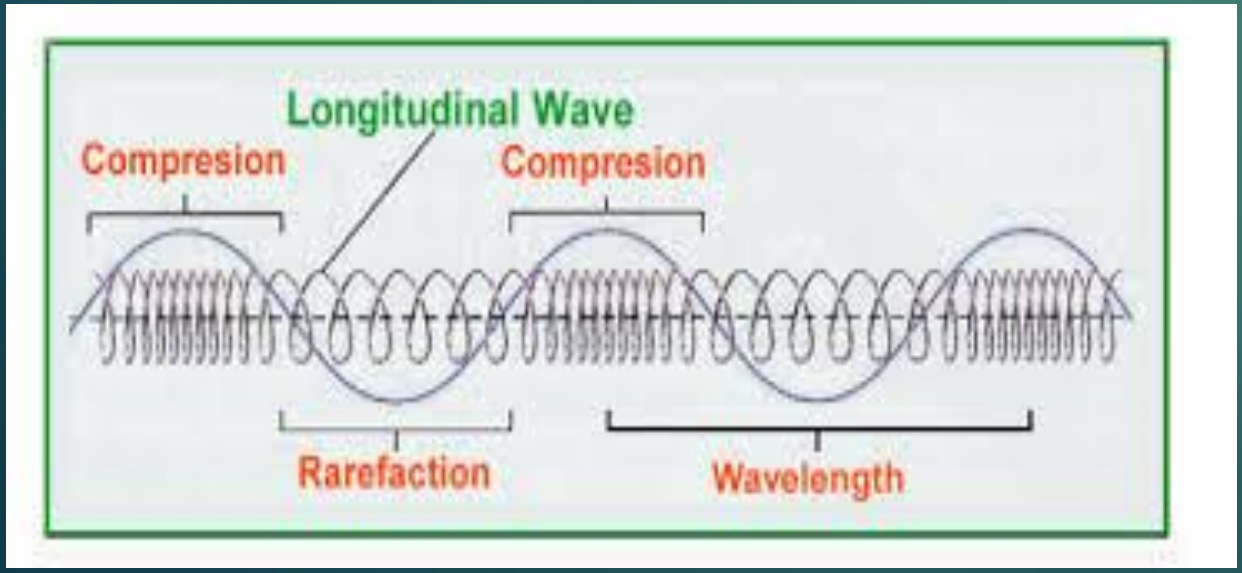

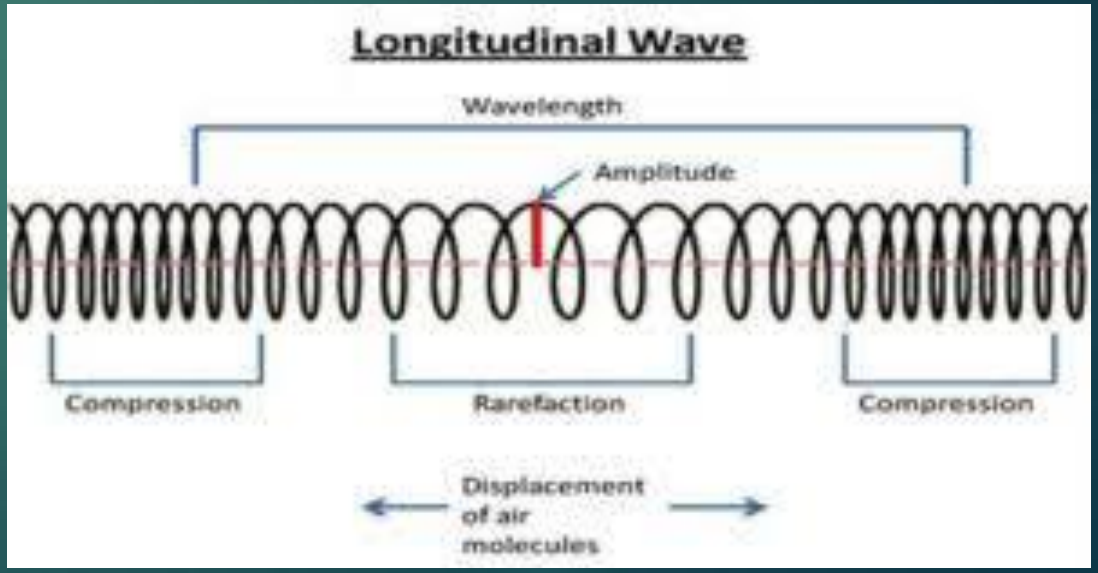

Velocity of Wave

(Transverse and Longitudinal)

Velocity = Distance / Time

$$V = \lambda / T \ \text{m/sec}$$

As $n = 1/T$

Therefore $V = n \lambda$ m/sec

Numerical

1) An ultrasound scanner emits sound of frequency 1500 KHz. If the speed of sound in air is 340 m/sec., find the wavelength of the waves emitted by it.
2) From a radio station, the frequency of waves is 15megacycles/sec. calculate their wavelength.