MECHANICAL WAVES

Mechanical waves are those waves that require a material medium for propagation. Water waves, Sound waves and waves on a rope are examples of mechanical waves.

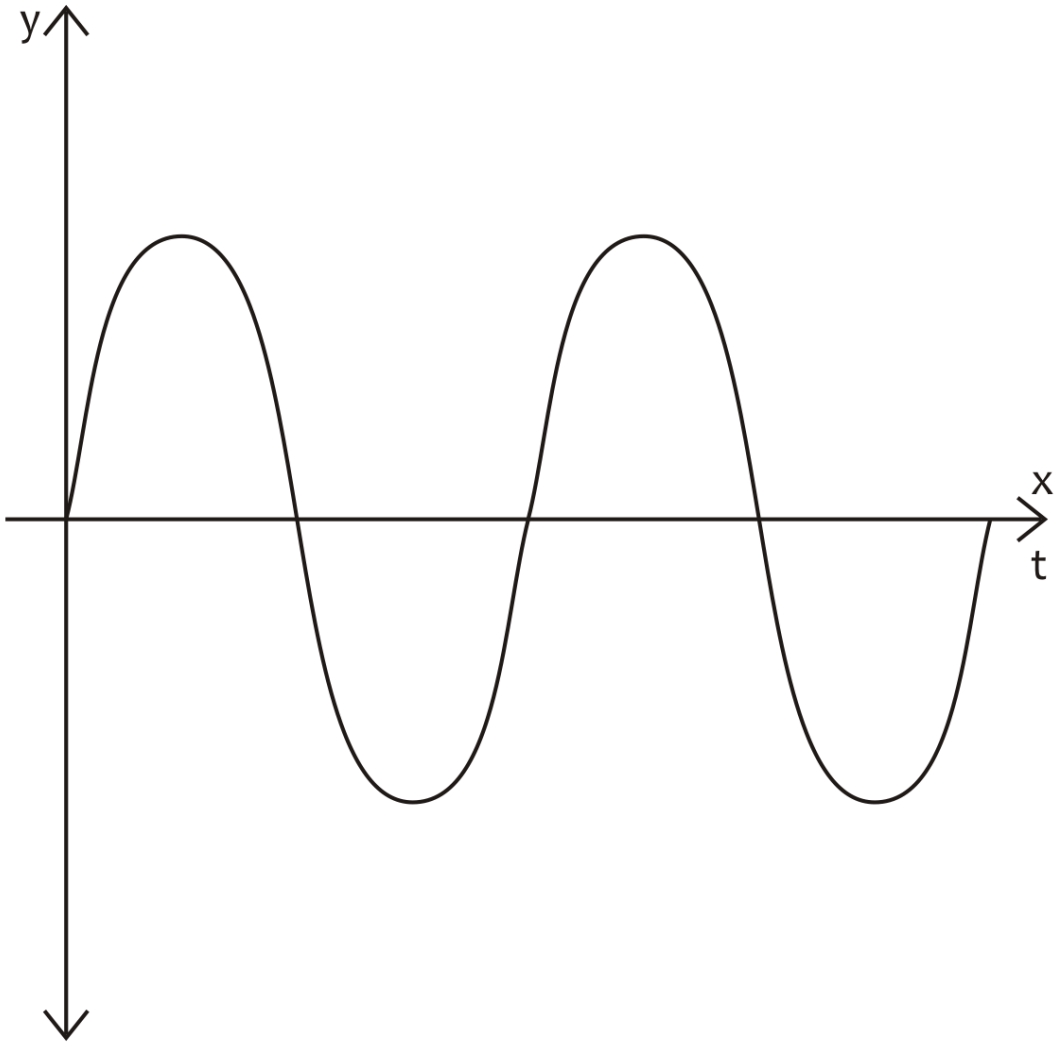
Transverse and Longitudinal

Wave originates from the vibrations of the particles of a medium. Such a wave allows energy to be transferred from one point to another some distances away without any particles of the medium travelling between the two points.

A Progressive or Travelling wave is a wave that transfers energy in travelling or moving away from the source of the disturbance. There are two types of progressive wave - the Transverse and Longitudinal waves.

Transverse Waves: These are waves which travel perpendicularly to the direction of the vibration producing the waves. Examples of transverse waves are water waves, light, radio waves and waves produced in a rope or string. In

all such waves, the vibrations are vertical and the direction of the wave motion is horizontal.



A graph of the displacement (y) of the vibrating particles about a mean position against time (t)

The displacement (y) of the various particles will also vary according to their position or distance (x) from some chosen origin such as the centre of disturbance. The graph shows a series of up and down movements. Some portions are displaced upwards while some portions are displaced downwards. A displacement above the mean is taken as positive and that below is taken as negative. The region of maximum positive (or upward) displacement is called a crest. The region of maximum downward displacement is called trough.

Longitudinal Waves: These are waves which travel in a direction parallel to the vibration of the medium. Longitudinal waves are readily formed in a stretched spring or 'slinky' by alternatively compressing and expanding one end or by moving the slinky to and fro in the direction of its length. A series of compressions and expansions or rarefactions propagate along the slinky or spring. The compressions are area where the coils are momentarily close together, rarefactions or

expansions are areas where the coils are momentarily far apart. Compressions and rarefactions correspond to crests and troughs respectively of a transverse wave. A longitudinal can be represented graphically by plotting the density or pressure of air molecular (or coils of a slinky) against position.

Terms Used in Describing Waves

Phase: Particles which are at the same vertical distances from their positions of rest and are moving in the same direction said to be in the same phase. Particles A and B in the figure above are in phase.

Cycle: is a complete to-and-fro movement or oscillation of a vibrating particle.

Amplitude (A): This is the maximum displacement of a particle from its rest position. It is measured in metres.

Wavelength (λ): This is the distance between two successive crests or successive troughs (or two successive points in phase) of a wave. It is measured in metres.

Frequency (f): This is the number of complete vibrations or cycles that a particle makes in one second. Given mathematically as

$$f = \frac{number\ of\ cycles}{time} = \frac{n}{t}$$

The S.I unit of frequency is the Hertz (Hz) which is defined as one cycle or oscillation per second (1cps).

Period (T): This is the time taken by a wave particle to make one complete oscillation. it is measured in seconds. The period is also the time taken by the wave to travel one wavelength. The period (T) is given as

$$T = \frac{time\ taken}{number\ of\ oscillation\ or\ cycle} = \frac{t}{n} = \frac{1}{f}$$

Wave Speed (v): This is the distance which the wave travels in one second. Its unit is metre-per-second (ms^{-1}). Wave speed (v) is given as:

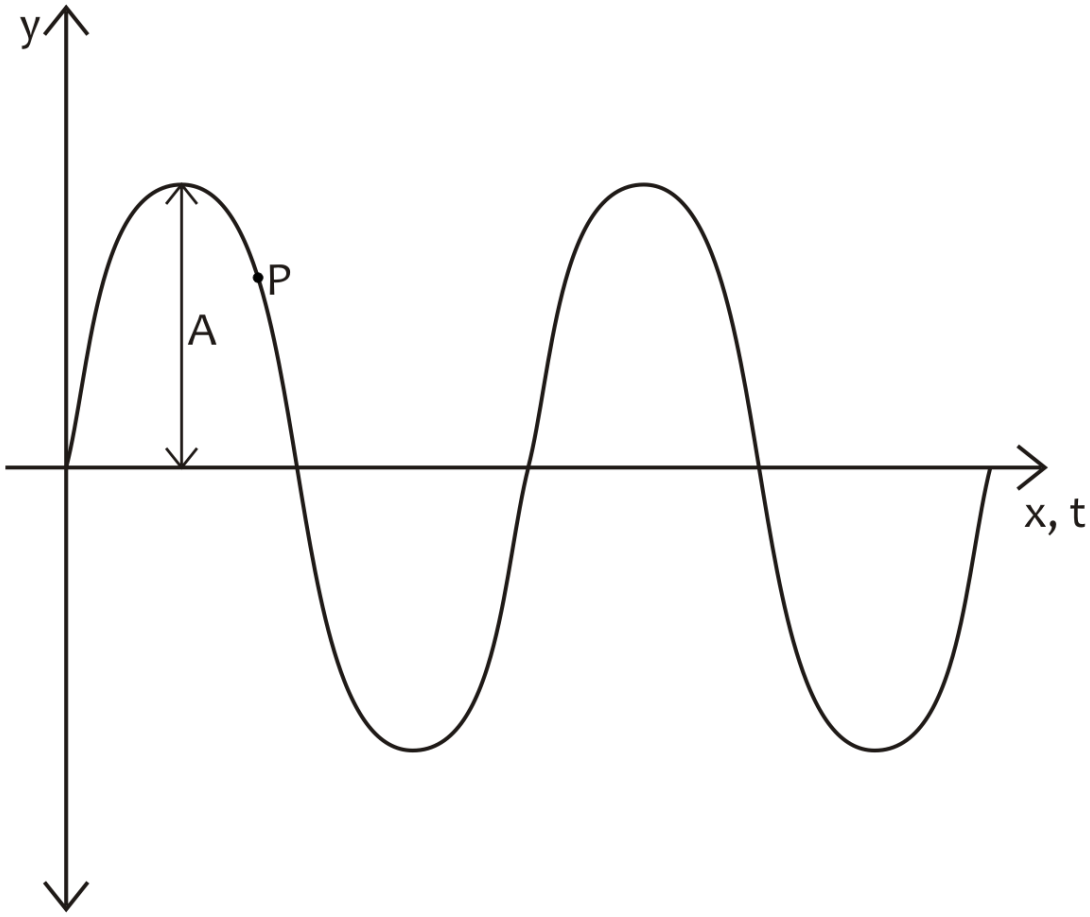
$$v = \frac{distance\ travelled\ by\ wave}{time\ taken} = \frac{wavelength}{time\ period}$$

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

$$v = \frac{\lambda}{T}; T = \frac{1}{f}$$

$$\rightarrow v = f\lambda$$

Progressive Wave Equation



We can represent a wave mathematically by the equation:

$$y = A \sin\left(\frac{2\pi x}{\lambda}\right)$$

where y = vertical displacement of vibrating particles, p.

A = Amplitude of wave

x = horizontal coordinate of the vibrating particle from the origin.

The above equation gives the displacement of any particle at a distance x from the origin. The relationship gives a shape that repeats itself every wavelength. It is a sine wave form. The displacement of the particle t seconds after is given by

$$y = A \sin \frac{2\pi}{\lambda}(x - vt)$$

where v is the velocity of the wave.

$$y = A \sin \left(\frac{2\pi x}{\lambda} - \frac{2\pi vt}{\lambda} \right)$$

$$= A \sin \left(2\pi x - \frac{2\pi f \lambda t}{\lambda} \right) = A \sin \left(\frac{2\pi x}{\lambda} - wt \right)$$