WAVES

1. **Transverse and longitudinal waves**
2. **Displacement relation in a progressive wave**
3. **The speed of a travelling wave**
4. **The principle of superposition of waves**
5. **Reflection of waves, Beats, Doppler effect**

Angular wave number: It is phase change per unit distance.

i.e. $k = \frac{2}{\pi}$; S.I unit of k is radian per meter.

Relation between velocity, frequency and wavelength is given as :-

Velocity of Transverse wave:-

1. In solid molecules having modulus of rigidity 'n' ' and density 'ρ' is

$$V = \sqrt{\frac{n}{p}}$$

1. In string for mass per unit length 'm' and tension 'T' is $V = \sqrt{\frac{T}{m}}$

Velocity of longitudinal wave:-

(i) in solid $V = \sqrt{\frac{Y}{p}}$, Y= young's modulus
(ii) in liquid $V = \sqrt{\frac{K}{P}}$, K=bulk modulus
(iii) in gases $V = \sqrt{\frac{K}{P}}$, K= bulk modulus

According to Newton's formula: When sound travels in gas then changes take in the medium are isothermal in nature.

$$V = \sqrt{\frac{P}{P}}$$

According to Laplace: When sound travels in gas then changes take place in medium are adiabatic in nature.

$$V = \sqrt{\frac{P\gamma}{p}}\ \ where\ \ \gamma = \frac{Cp}{Cv}$$

Factors effecting velocity of sound :-

(i) Pressure – No effect

(ii) Density $-v\alpha\frac{1}{\sqrt{p}}\ or\ \frac{V1}{V2} = \sqrt{\frac{\rho^1}{\rho^2}}$

Temp-$V\alpha\sqrt{T}\ \ \ or\ \frac{V1}{V2} = \sqrt{\frac{T1}{T2}}$

(iii) Effect of humidity:– sound travels faster in moist air

(iv) Effect of wind –velocity of sound increasing along the direction

Wave equation if wave is travelling along +ve x-axis

- Y=A sin (ax - kx), Where, $K = \frac{2\pi}{\gamma}$
- $\mathrm{Y} = \mathrm{A}\ \sin\ 2\pi(\frac{t}{T}\ -\ \frac{x}{\lambda})$
- $\mathrm{Y} = \mathrm{A}\ \sin\ \frac{2\pi}{\gamma}(vt - x)$

If wave is travelling along –ve x- axis

- $\mathrm{Y} = \mathrm{A}\ \sin\ (\mathrm{ax} + \mathrm{kx}),\ \mathrm{Where,}\ \mathrm{K} = \frac{2\pi}{\gamma}$
- $\mathrm{Y} = \mathrm{A}\ \sin\ 2\pi(\frac{t}{T}\ -\ \frac{x}{\lambda})$
- $\mathrm{Y} = \mathrm{A}\ \sin\ \frac{2\pi}{\gamma}(vt + x)$

Phase and phase difference

Phase is the argument of the sine or cosine function representing the wave.

$$\phi = 2\pi(\frac{t}{T} - \frac{x}{\lambda})$$

Relation between phase difference (($\Delta\phi$) and time interval is $\Delta\phi = \frac{2\pi}{T}\Delta t$

Relation between phase difference(Δp) and path difference(Δx) is $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$

Equation of stationary wave:-

$$Y_1 = a\ \sin\ 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)\ (\text{ incidnet wave})$$

$$Y_1 = \pm\, a\ \sin 2\pi\left(\frac{t}{T} + \frac{x}{\lambda}\right) \text{(reflected wave)}$$

(1) Stationary wave formed

$Y = Y_1 + Y_2 = \pm 2a\ \cos\frac{2\pi x}{\lambda}\ \sin\frac{2\pi l}{T}$

(2) For (+ve) sign antinodes are at x= 0, $\frac{\lambda}{2},\ \lambda,\ \frac{3\lambda}{2}$

And nodes at x= $\frac{\lambda}{4},\quad \frac{3\lambda}{2}, \frac{5\lambda}{4}.....$

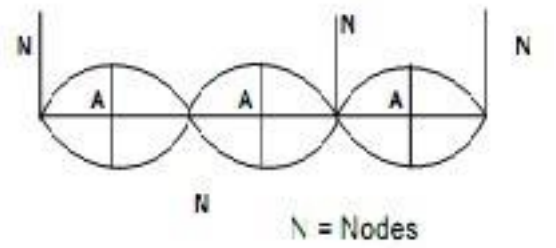
(3) For (-ve) sign antinodes are at x= $\frac{\lambda}{4},\quad \frac{3\lambda}{2}, \frac{5\lambda}{4}.....$

Nodes at x=0, $\frac{\lambda}{2},\ \lambda,\ \frac{3\lambda}{2}$

(4) Distance between two successive nodes or antinodes are $\frac{\lambda}{2}$ and that between nodes and nearest antinodes is $\frac{\lambda}{4}$

(5) Nodes- point of zero displacement-

Antinodes- point of maximum displacement-



A = Antinodes

Mode of vibration of strings:-

1. $v = \frac{p}{2L}\sqrt{\frac{T}{m}}\ where,\ T = Tension$

M= mass per unit length

V= frequency, V=velocity of second , P=1, 2, 3, ...

b) When stretched string vibrates in P loops $\nu P = \frac{P}{2L}\sqrt{\frac{T}{m}}\ = P\nu$

c) For string of diameter D and density ρ $\nu = \frac{1}{LD}\sqrt{\frac{T}{\pi P}}$

d) Law of length $\nu x \alpha \frac{1}{L}, \nu L$ = constant