LAKSHYA

MHTCET 2025

Physics

Lecture - 02

Superposition of Waves

By - Sushant Sir

Topics

to be covered

1. Stationary Waves

Revision :

- **Wave** : disturbance travel through medium
  - Mechanical — Medium is required
  - Non Mechanical — Medium is not required.

- **Progressive wave** : Wave continously travel in a medium without damping or obstruction.

- Superposition of wave.

$\rightarrow y = y_1 + y_2$.

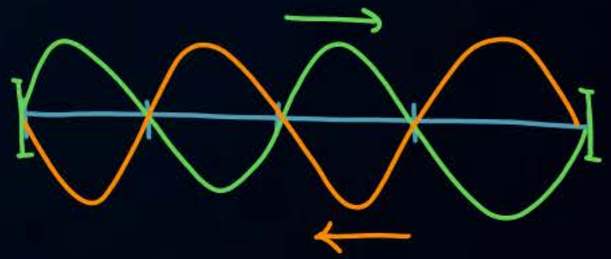
- Reflection of waves

→ transverse wave
  - → R → D $\Rightarrow$ C $\leftrightarrow$ T
  - → D – R $\Rightarrow$ C–C, T-T

→ longitudinal wave
  - → R-D $\Rightarrow$ C-C, R-R
  - → D-R $\Rightarrow$ C $\leftrightarrow$ R.

Stationary Waves

When two identical waves travels through medium but in opposite direction interfere/superimpose then Stationary Wave is formed.



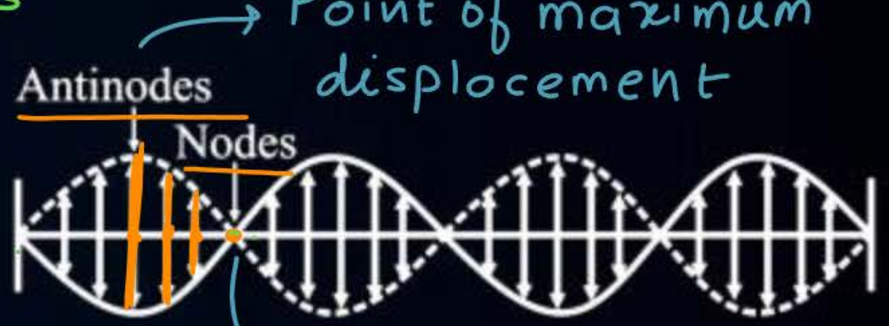
Formation of Stationary Waves

$y_1 = a \sin(\omega t - kx) \longrightarrow$ +ve x-axis

$y_2 = a \sin(\omega t + kx) \longrightarrow$ -ve x-axis

$y = y_1 + y_2$.

$y_1 = a \sin\left[2\pi n t - \frac{2\pi x}{\lambda}\right]$



Point of maximum displacement

Point of minimum displacement.

$$y_1 = a\sin 2\pi\left[nt - \frac{x}{\lambda}\right]$$

$$y_2 = a\sin 2\pi\left[nt + \frac{x}{\lambda}\right]$$

$$y = y_1 + y_2$$

$$y = a\left[\underbrace{\sin 2\pi\left[nt - \frac{x}{\lambda}\right]}_{C} + \underbrace{\sin 2\pi\left[nt + \frac{x}{\lambda}\right]}_{D}\right]$$

By using formula

$$\sin C + \sin D = 2\sin\frac{(C+D)}{2} \cdot \cos\frac{(C-D)}{2}$$

$$\therefore y = a\left[2\sin 2\pi \times 2nt \cdot \frac{1}{2} \cdot \cos 2\pi \frac{x}{\lambda \cdot 2}\right]$$

$$\therefore y = 2a \sin 2\pi nt \cdot \cos \frac{2\pi x}{\lambda}$$

$$y = 2a \cos \frac{2\pi x}{\lambda} \cdot \sin \omega t$$

$$\boxed{y = R \sin \omega t}$$

where, $\boxed{R = 2a \cos \frac{2\pi x}{\lambda}}$

In stationary amplitude is the function of position

Condition for node

At node : $R = 0$

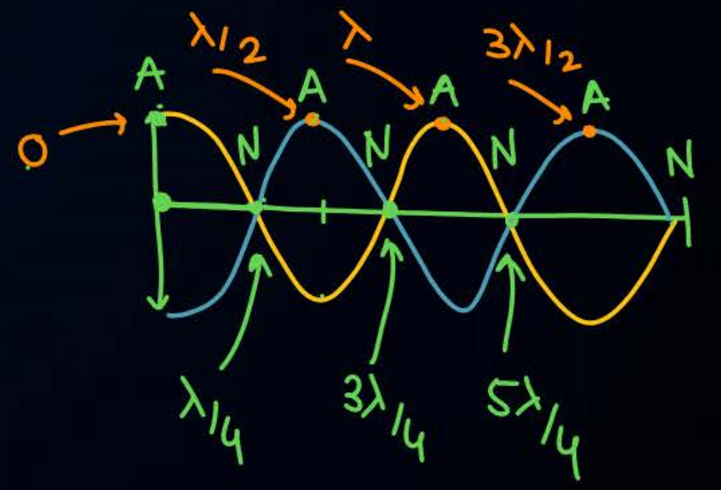
$$2a\cos\frac{2\pi x}{\lambda} = 0$$

$$\cos\frac{2\pi x}{\lambda} = 0$$

$$\frac{2\pi x}{\lambda} = \pi/2, 3\pi/2, 5\pi/2 \ldots$$

$$\frac{x}{\lambda} = \frac{1}{4}, \frac{3}{4}, \frac{5}{4} \ldots$$

$$x = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4} \ldots$$



Condition for antinode

For Antinode ; $R = \pm 2a$.

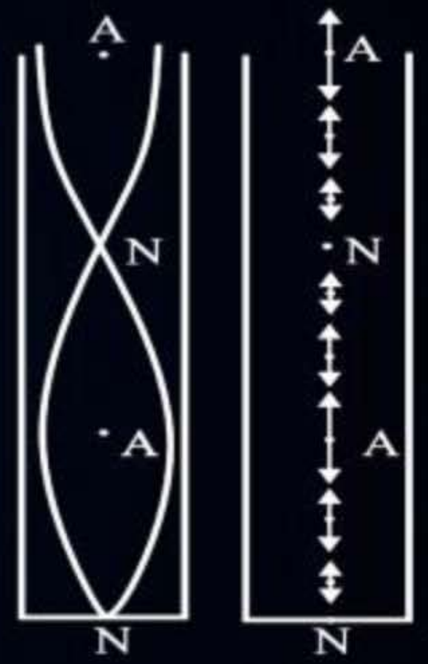
$$\frac{2a}{2a}\cos\frac{2\pi x}{\lambda} = \pm 2a$$

$$\cos\frac{2\pi x}{\lambda} = \pm 1$$

$$\frac{2\pi x}{\lambda} = 0, \pi, 2\pi \ldots.$$

$$\frac{x}{\lambda} = 0, \frac{1}{2}, 1 \ldots.$$

$$x = 0, \lambda/2, \lambda \ldots.$$



Properties of Stationary Waves

- It consists of alternate node & antinode
- Node — '0' displacemt
- Antinode ⟶ '$\pm 2a$' displacement.
- Distance betⁿ successive node or antinode is '$\lambda/2$'
- Distance betⁿ sucessive node & antinode is $\lambda/4$.
- All particles in a loop have same phase.

QUESTION

Find the distance between two successive nodes in a stationary wave on a string vibrating with frequency 64 Hz. The velocity of progressive wave that resulted in the stationary wave is 48 m s^{-1}.

a) 0.285 m

b) 0.335 m

c) 0.375 m

d) 2 m

$n = 64\ Hz$

$v = 48\ m/s$

$\frac{\lambda}{2} = \ell$

$v = n\lambda$

$\lambda = \frac{v}{n} = \frac{48^{6}}{64_{8}} = \frac{3}{4}$.

$\lambda = \frac{3}{4}\ m$

$\lambda/2 = \frac{3}{8}\ m = 0.375\ m$.

Free and Forced Vibrations

→ Same as oscillation.

Summary

1) Stationary waves.

Homework

1) Compare Progressive & stationary wave.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