when two progressive waves of same amplitude and wavelength travelling along a straight line in opposite direction superimpose on each other the waves are formed.

$$y_1 = a \sin 2\pi \left(\frac{t}{T} - \frac{x}{\lambda}\right)$$

and the equation of reflection from free end and in -ve x axis.

$$y_2 = a \sin 2\pi \left(\frac{t}{T} + \frac{x}{\lambda}\right)$$

Principle of superposition

$$y = y_1 + y_2$$

$$= a \sin 2\pi \left(\frac{t}{T} - \frac{x}{\lambda}\right) + a \sin 2\pi \left(\frac{t}{T} + \frac{x}{\lambda}\right)$$

$$= 2a \cos\left(\frac{2\pi x}{\lambda}\right) \sin\left(\frac{2\pi t}{T}\right)$$ this the equation of Stating wave.

From the equation $y = 2a \cos\frac{2\pi x}{\lambda} \sin\frac{2\pi t}{T}$

a) at point $x = 0, \frac{\lambda}{2}, \lambda, \frac{3\lambda}{2}$ the values of $\cos\frac{2\pi x}{\lambda}$ will be ± 1 at this point the amplitude will be maximum these points are called antinodes.

b) at point $x = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}$ the value of $\cos\frac{2\pi x}{\lambda} = 0$ the amplitude becomes zero these points are called node.

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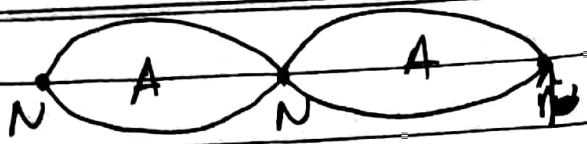

c) When $t = 0, \frac{T}{2}, T, \frac{3T}{2}, 2T$ then $\sin \frac{2\pi t}{T} = 0$ the displacement is zero.

d) $t = T/4, \frac{3T}{4}, \frac{5T}{4}$ then $\sin \frac{2\pi t}{T} = \pm 1$ the displacement is maximum.

Characteristics of Stationary waves:

1. nodes and antinode are formed alternately
2. Pressure change at nodes are maximum while at antinode are minimum.
3. Distance between node ~~and antinode is~~ or antinode is $\frac{\lambda}{2}$, and node and antinode is $\frac{\lambda}{4}$.
4. Ist harmonics $L = \frac{1}{2}\lambda$

IInd Harmonic

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

Mathematical relationships

Harmonic	Pattern	Loops	Length and wavelength relation
1		1	$L = \frac{1}{2}\lambda$
2.		2	$L = \frac{2}{2}\lambda$
3		3	$= L = \frac{3}{2}\lambda$
:			
n	....		$n = L = \frac{n}{2}\lambda$

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~~Normal modes of~~

Group velocity :- Group velocity is the velocity with which the overall envelope shape of the wave's amplitude known as envelope of wave propagate through the space.

$$V_g = \frac{d\omega}{dK}$$

Phase velocity of a wave is the velocity at which the phase of one frequency component of wave travel.

$$V_p = \frac{\omega}{K}$$

Relation between group velocity and phase velocity

we know that $\lambda = \frac{2\pi}{K}$, $V_p = \frac{\omega}{K}$

$$\lambda = \frac{2\pi V_p}{\omega}$$

$n \rightarrow$ refractive index $= \frac{c}{V_p} = \frac{\lambda_0}{\lambda}$

$V_p = \frac{\omega}{k}$ then $\omega = k V_p$

$k = \frac{2\pi}{\lambda}$ $\qquad$ λ_0 is the wavelength in vacuum.

~~...~~

$$V_g = \frac{c}{n + \omega \frac{dn}{d\omega}} = \frac{c}{n - \lambda_0 \frac{dn}{d\lambda_0}}$$

$$V_g = V_p\left(1 + \frac{\lambda}{n}\frac{dn}{d\lambda}\right) = V_p - \lambda\frac{dV_p}{d\lambda} = V_p + k\frac{\partial V_p}{\partial k}$$

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Sound waves.

Sound waves are longitudinal waves that travel through medium. Compression and rarefaction. Example tuning fork. It is also known as pressure waves.

Sound is produced by vibrating object. The matter or substance through which sound is transmitted is called medium it can be solid, liquid or gas

Object vibrates → medium vibrate → force on each object, sound need medium

Intensity and Loudness of Sound.

Intensity of sound is the power of the sound in watt divided by area the sound cover in square meter.

Loudness is the subjective perception of sound pressure.

$L = \log \frac{I}{I_0}$ Io is the minimum

Io is minimum intensity detectable by Human ear.

$L = 10 \log \frac{I}{I_0}$ unit is Decibel.