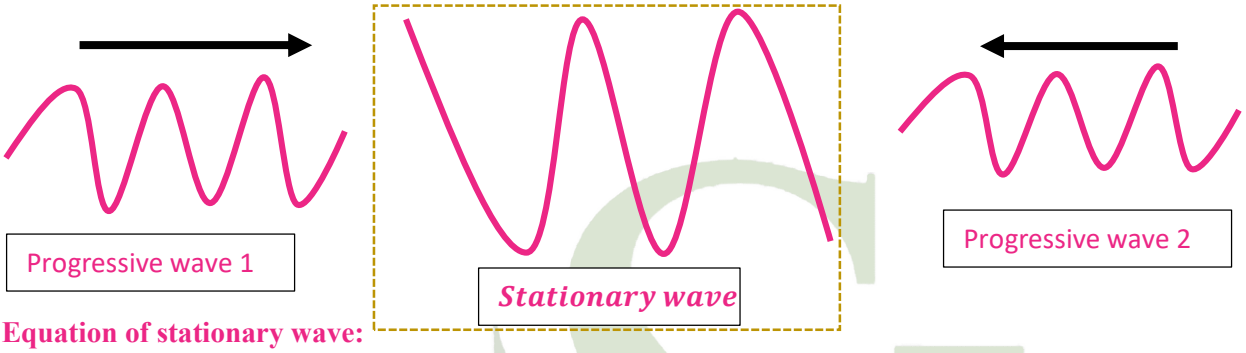
Stationary wave (Standing wave):

When two progressive waves of same frequency and same amplitude travelling in opposite direction with same speed superpose (interact) each other, the resultant wave thus produced is called as stationary wave.

The term stationary is in the sense that there is no net flow of energy along the wave (however, the wave seems to be moving).



Equation of stationary wave:

Consider two progressive waves of amplitude (a) and frequency (f) are travelling in opposite direction (one along +X axis and another along -X axis) with same speed.

The equation of first wave is written as: $y_1 = a\sin(\omega t - kx)$ … … … (1)

And, the equation of second wave is written as: $y_2 = a\sin(\omega t - kx)$ … … … (2)

When these two waves superpose each other, then a stationary wave is formed. According to principle of superposition, the resultant displacement (y) is:

$$y = y_1 + y_2$$

Or $$y = a\sin(\omega t - kx) + a\sin(\omega t + kx)$$

Or $$y = a\left[2\,sin\left\{\frac{\omega t - kx + \omega t + k}{2}\right\}\ \cos\left\{\frac{\omega t - kx - \omega t - k}{2}\right\}\right]$$

Or $$y = 2a\sin\omega t\ \cos kx$$

Or $$y = 2a\cos kx\ \sin\omega t$$

Or $$y = A\ sin\omega t$$ … … … … … … … (3) [we replaced $2a\ coskx$ by A]

Equation (3) is the equation of stationary wave. The amplitude of the wave is: $\boldsymbol{A = 2a\ coskx}$.

Since the amplitude is sinusoidal in x (position), it is maximum at some point and is minimum (zero) at some point. The points corresponding to maximum amplitude are called as **antinodes** and the points corresponding to minimum (zero) amplitude are called as **nodes**.

Positions of antinodes (maximum amplitude):

The amplitude of stationary wave is:

$$A = 2a\ coskx$$

The amplitude will be maximum if $coskx$ is maximum,

i.e., $coskx = \pm 1$ **and** $A_{max} = 2a$

or $$\cos\frac{2\pi}{\lambda}x = \cos(0, \pi, 2\pi, 3\pi, \ldots\ \ldots)$$

Positions of antinodes:

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

Distance between two successive antinodes $\Delta x = \frac{\lambda}{2}$

Antinode is a point of maximum displacement (or amplitude) and minimum pressure (minimum pressure variation). Hence the displacement antinode is called as pressure node.

No (minimum) sound is heard at antinode (as sound wave is a pressure wave).