3.5 Stationary wave or standing wave:

When two progressive waves of same amplitude and wavelength travelling along a straight line in opposite directions superimpose on each other, standing waves are formed.

Analytical method:

Let us consider a progressive waves of amplitude 'a' and wavelength λ travelling in the direction of X-axis

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

This wave is reflected from a free end and it travels in the negative direction of X – axis then

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

According to principle of superposition, the resultant displacement is

$y = y_1 + y_2$

$a[\sin 2\pi(\frac{t}{T} - \frac{x}{\lambda}) + \sin 2\pi(\frac{t}{T} + \frac{x}{\lambda})]$

[using trigonometry identity

Sin (A-B) + Sin(A+B) = 2 sin Acos B]

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

$= a[2\sin 2\pi \frac{t}{T}\cos 2\pi\frac{x}{\lambda}]$

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

This is the equation of a stationary wave.