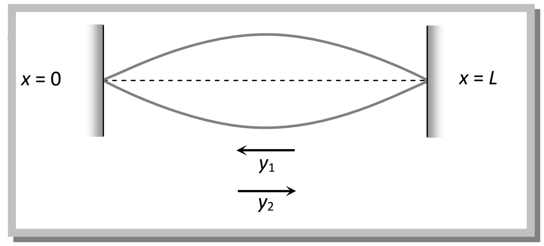
# Standing Waves on a String.

When a string under tension is set into vibration, transverse harmonic waves propagate along its length. When the length of string is fixed, reflected waves will also exist. The incident and reflected waves will superimpose to produce transverse stationary waves in a



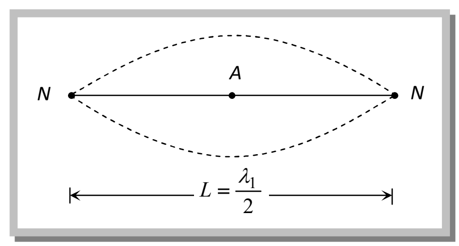

Incident wave y1 = a sin $\frac{2\pi}{\lambda}$ (vt + x)

Reflected wave $y_2 = a\sin\frac{2\pi}{\lambda}[(vt - x) + \pi] = -a\sin\frac{2\pi}{\lambda}(vt - x)$

According to superposition principle: y = y1 + y2 = 2 a cos $\frac{2\pi vt}{\lambda}\sin\frac{2\pi x}{\lambda}$

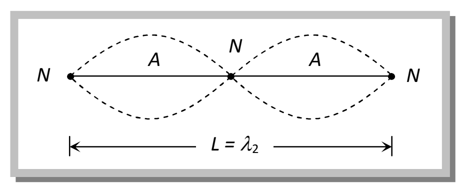
General formula for wavelength $\lambda = \frac{2L}{n}$ where n = 1,2,3, ... correspond to 1st , 2nd, 3rd modes of vibration of the string.

(1) First normal mode of vibration $n_1 = \frac{v}{\lambda_1} = \frac{v}{2L} \Rightarrow n_1 = \frac{1}{2L}\sqrt{\frac{T}{m}}$



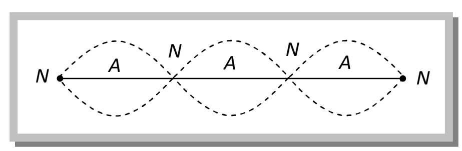

This mode of vibration is called the fundamental mode and the frequency is called fundamental frequency. The sound from the note so produced is called fundamental note or first harmonic.

(2) Second normal mode of vibration: $n_2 = \frac{v}{\lambda_2} = \frac{v}{L} = \frac{2v}{2L} = 2(n_1)$




This is second harmonic or first over tone.

(3) Third normal mode of vibration: $n_3 = \frac{v}{\lambda_3} = \frac{3v}{2L} = 3n_1$




This is third harmonic or second overtone.

Position of nodes: $x = 0, \frac{L}{n}, \frac{2L}{n}, \frac{3L}{n} .......... ..L$

For first mode of vibration x = 0, x = L [Two nodes]

For second mode of vibration x = 0, x = $\frac{L}{2}, x = L$ [Three nodes]

For third mode of vibration x = 0, x = $\frac{L}{3}, x = \frac{2L}{3}, x = L$ [Four nodes]

Position of antinodes: $x = \frac{L}{2n}, \frac{3L}{2n}, \frac{5L}{2n} \ldots\ldots\ldots . \frac{(2\eta - 1)L}{2n}$

For first mode of vibration x = L/2 [One antinode]

For second mode of vibration x = $\frac{L}{4}, \frac{3L}{4}$ [Two antinode]