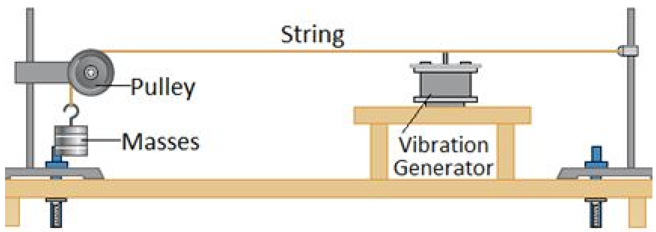
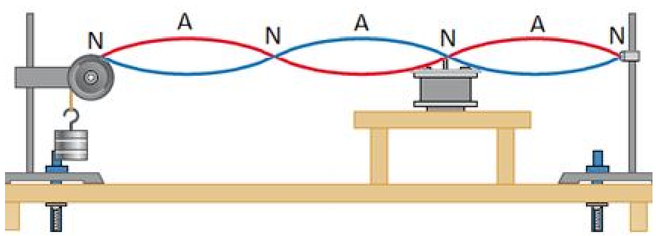
Standing Waves

When two similar waves travel in opposite directions, they can superpose to form a standing (or stationary) wave. Here is the experimental set up of how we can form a standing wave on a string. The vibration generator sends waves down the string at a certain frequency, they reach the end of the string and reflect back at the same frequency. On their way back the two waves travelling in opposite direction superpose to form a standing wave made up of nodes and antinodes.





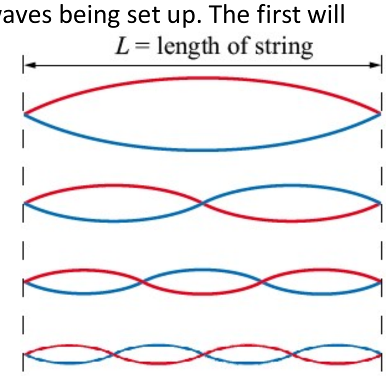
Nodes Positions on a standing wave which do not vibrate. The waves combine to give zero displacement

Antinodes Positions on a standing wave where there is a maximum displacement.

	Standing Waves	Progressive Waves
Amplitude	Maximum at antinode and zero at nodes	The same for all parts of the wave
Frequency	All parts of the wave have the same frequency	All parts of the wave have the same frequency
Wavelength	Twice the distance between adjacent nodes	The distance between two adjacent peaks
Phase	All points between two adjacent nodes in phase	Points one wavelength apart in phase
Energy	No energy translation	Energy translation in the direction of the wave
Waveform	Does not move forward	Moves forwards

Harmonics

As we increase the frequency of the vibration generator, we can see standing waves being set up. The first will occur when the generator is vibrating at the fundamental frequency, f_0, of the string.



First Harmonic $f = f_0$ $\lambda = 2L$

2 nodes and 1 antinode

Second Harmonic $f = 2f_0$ $\lambda = L$

3 nodes and 2 antinodes

Third Harmonic $f = 3f_0$ $\lambda = \frac{2}{3}L$

4 nodes and 3 antinodes

Fourth Harmonic $f = 4f_0$ $\lambda = \frac{1}{2}L$

5 nodes and 4 antinodes

A string with a free end will produce an anti-node at the end point, compared to a node if the end is fixed. Similarly, standing waves in open ended pipes produce anti-nodes at the ends, whereas closed pipes produce nodes at the end points.