

Superposition and Standing Waves

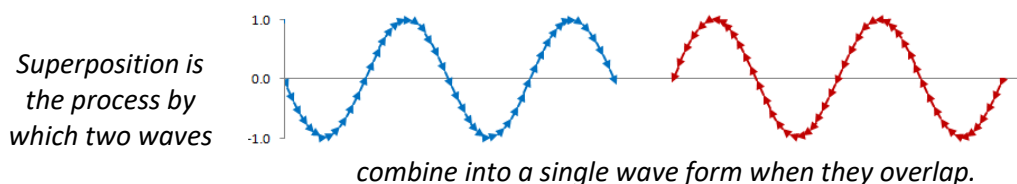
To know and be able to explain what standing waves are and how they are formed

To know what nodes and antinodes are

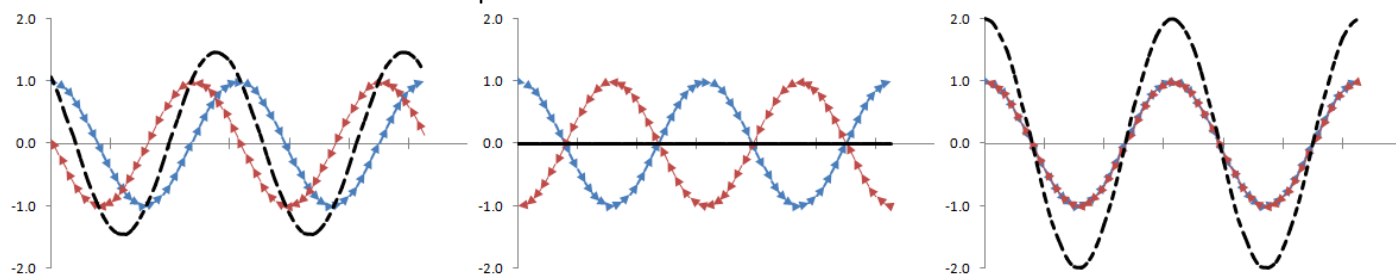
To be able to sketch the standing wave produced at different frequencies

Superposition

Here are two waves that have amplitudes of 1.0 travelling in opposite directions:



If we add these waves together the resultant depends on where the peaks of the waves are compared to each other. Here are three examples of what the resultant could be: a wave with an amplitude of 1.5, no resultant wave at all and a wave with an amplitude of 2.0

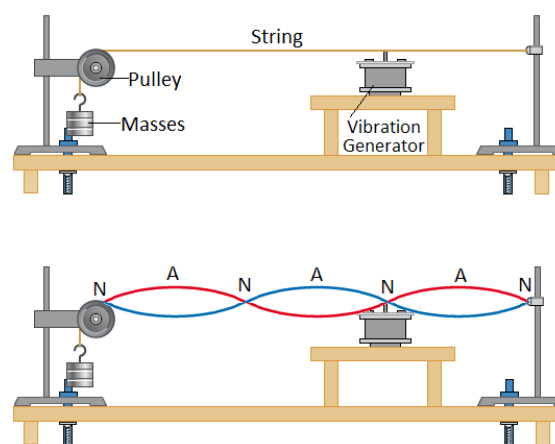


Stationary/Standing Waves

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 will 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

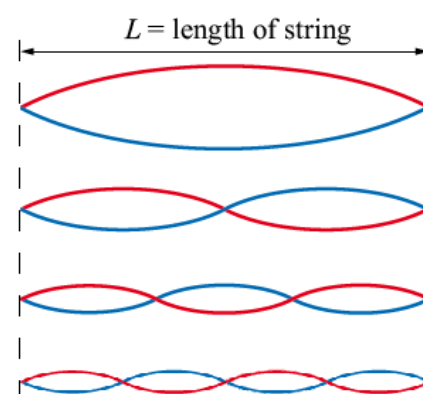
2 nodes and 1 antinode

$$f = f_0 \quad \lambda = 2L$$

Second Harmonic

$$f = 2f_0 \quad \lambda = L$$

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3 nodes and 2 antinodes

Third Harmonic

4 nodes and 3 antinodes

Forth Harmonic

5 nodes and 4 antinodes

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

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