FLIPPED around PHYSICS

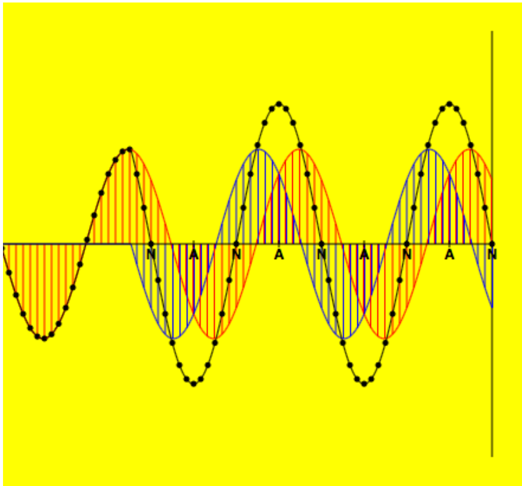
3.3.2 Standing (or stationary) waves

When two waves, with the same frequency and similar amplitudes move through each other in opposite directions, they superpose and produce a standing (or stationary) wave.

videos

Take a look at the following simulation:
http://www.walter-fendt.de/html5/phen/standingwavereflection_en.htm

In this simulation the two waves moving in opposite directions is achieved by reflection.

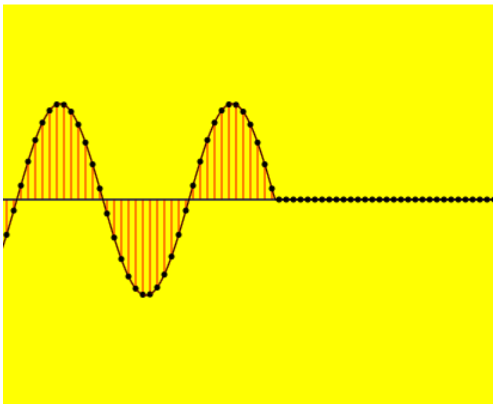


The red wave is the incident wave and the blue wave is the reflected wave. The black line shows the wave produced when the two superpose.

(1) Look closely at points on the standing wave (black dots). What do you notice about their amplitudes?

(2) What do you notice about the phase relationship of the different points in the standing wave?

Now start the simulation again and look at the points in the initial progressive wave.

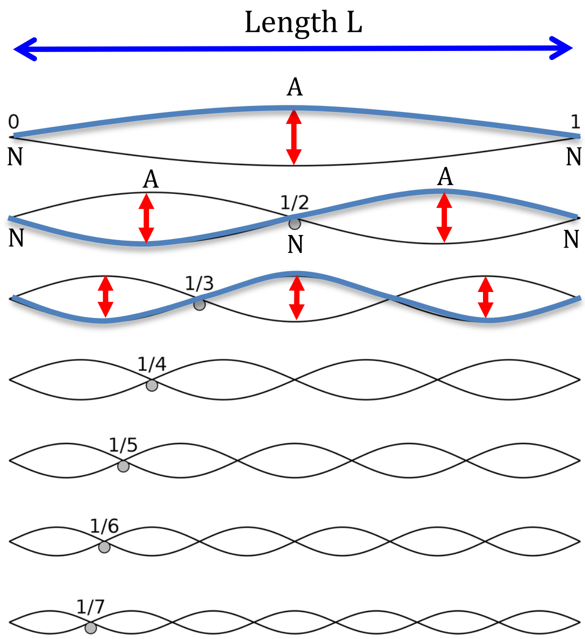


(3) Look closely at points on the progressive wave. What do you notice about their amplitudes?

(4) What do you notice about the phase relationship of the different points?

Standing waves on strings

Standing waves are used to produce notes on stringed instruments. When the string is plucked vibrations travel up and down the string in opposite directions, leading to the formation of standing waves. The simplest standing wave is called the <u>first harmonic</u> (or fundamental). The length of the string is half a wavelength $\left(\frac{\lambda}{2}\right)$.



1st harmonic. $length = \frac{\lambda}{2}$

2nd harmonic. $length = \lambda$

3rd harmonic. $length = \frac{3\lambda}{2}$

4th harmonic. $length = 2\lambda$

The string moves up and down between the two extremes. The part where the string moves most is called an antinode (A), and the part where the string doesn't move is called a node (N).

(5) Complete the diagram, above, drawing on the nodes and antinodes, and indicating how many wavelengths fit into the length.

A pitch of the vibrating spring is determined by the speed (c) that the waves travel along the string.

Looking at the first harmonic we see that the wavelength=2 x length:

$$\lambda = 2L$$

(6) Using the wave equation ($v=f\lambda$), substitute c for wave speed and 2L for the wavelength. Rearrange to get and expression for the first harmonic frequency f_1.

(7) In a similar manner, write expressions for the frequencies of the 2nd and 3rd harmonics.

(8) How do the 2nd and 3rd harmonic frequencies compare to the 1st harmonic frequency?

The speed of waves on a string

The speed of waves on a string is given by the expression:

$$c = \sqrt{\frac{T}{\mu}}$$

where T is the tension in the string and μ is the mass per unit length of the string.

(9)✐What will the speed be if the tension of the string is 15N and the mass per unit length μ=0.01kgm^{-1}?

(10)✐If the length of the string is 0.5m, what is the first harmonic frequency?

The first harmonic frequency is usually the dominant frequency for a stringed instrument.

(11)✐Describe 3 things you can do to change the frequency of note produced by a stringed instrument.