Standing Wave Math

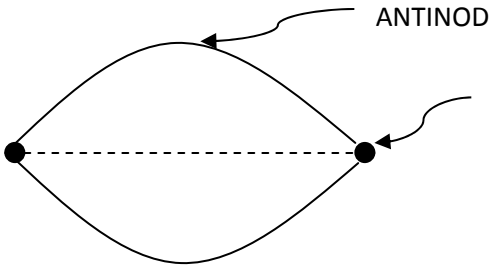
Standing waves vibrate at a certain frequency and wavelength. A given frequency is heard as a given note. Standing waves are the basis for music! You can make music by vibrating a string or by vibrating the air in a column.

(vibrating) string instruments = guitar, violin, banjo, piano, harp etc.

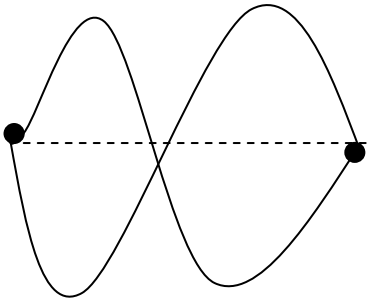
(vibrating air) column instruments = trumpet, clarinet, flute, saxophone etc.

STRING – both ends the same

If the string is attached, it is said to be FIXED. This will create a NODE.
If the string is free to move, it is said to be FREE. This will create an ANTINODE.

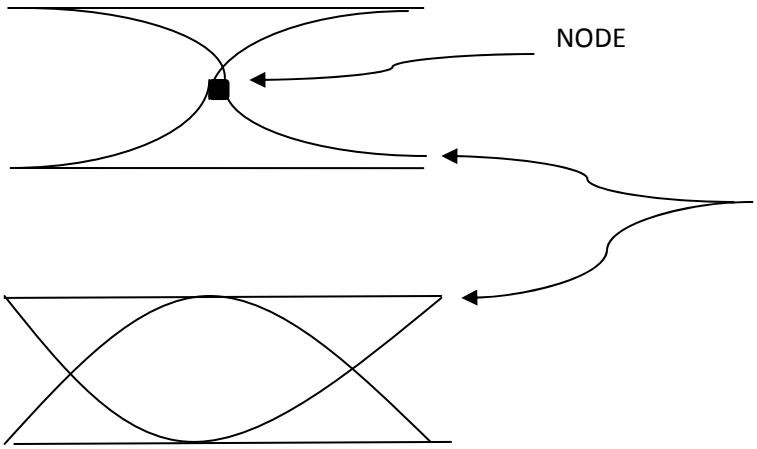


1^{st} harmonic (1^{st} simplest pattern)



2^{nd} harmonic (2^{nd} simplest pattern)

AIR COLUMNS - both ends the same
Open air columns are considered free and thus form an antinode on a standing wave.



1^{st} harmonic (1^{st} simplest pattern)

2^{nd} harmonic (2^{nd} simplest pattern)

Formula: When BOTH ends are open ….or….. BOTH ends are fixed, you can use the following formula to help determine length of the vibrating medium or the the frequency of the note created.

$$L_n = \frac{n\lambda}{2}$$

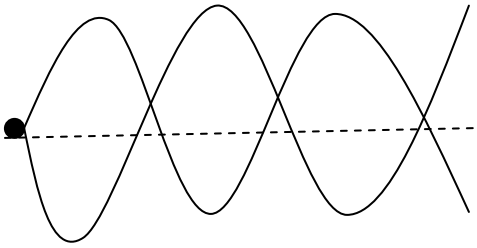
where L_n = length of string/air column (m)

n = harmonic # (1,2,3 etc)

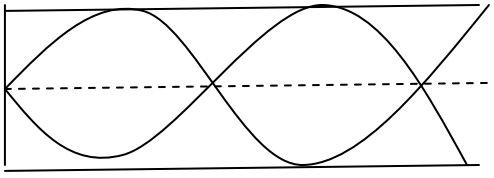
λ = wavelength (m)

String & Air Columns – ends are different

Strings and air columns sometimes have one end free/open (ANTINODE) and one end fixed/closed (NODE)



Free & Fixed end **string** vibrating in 4th harmonic (4th simplest pattern)



Free & Fixed end **air column** vibrating in 3rd harmonic (3rd simplest pattern)

Formula - When one end is fixed and one is free, the following formula is used to help determine lengths or wavelengths.

$$L_n = \frac{(2n-1)\ \lambda}{4}$$

where L_n = length of string/air column (m)

n = harmonic # (1,2,3 etc)

λ = wavelength (m)

HINT: Often these problems require you to use the universal wave equation too!

Remember:

$$V = f\lambda$$