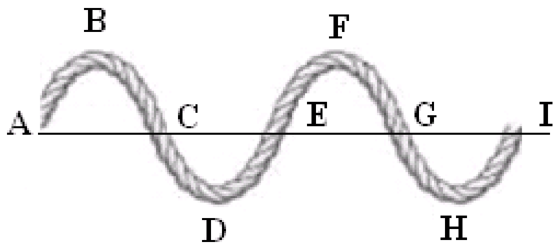
Wave Phenomena

IB 12

Phase: The phase of any particle is its position in its cycle of oscillation.



In phase: ____.

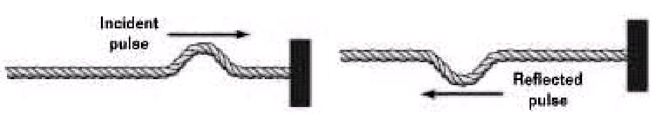
The **phase difference** between any points *in phase* is ____.

Completely out of phase: ________________________.

The **phase difference** between any points *completely out of phase* is _____________.

Reflection at a Boundary between Two Media

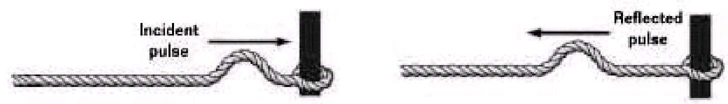
I. Fixed End Reflection (Hard Reflection)



Phase Difference: _____________.

Reason: Rope applies upward force on support (incident pulse). By Newtons 3rd law, support applies downward force on rope (reflected pulse).

II. Free End Reflection (Soft Reflection)



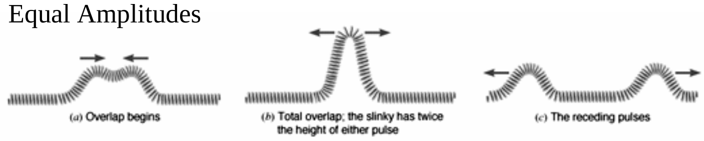
Phase Difference: _____________.

Superposition and Interference

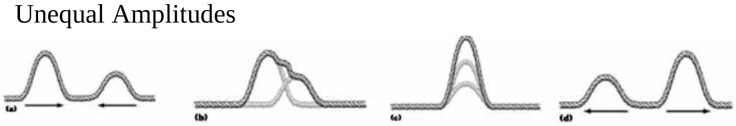
Principle of Linear Superposition: ____
____.

Constructive Interference: superposition of two or more pulses or waves in phase

Equal Amplitudes

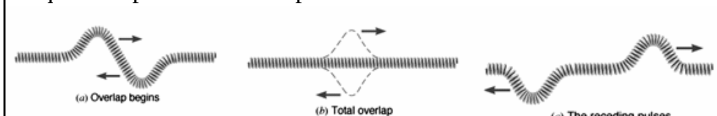


Unequal Amplitudes

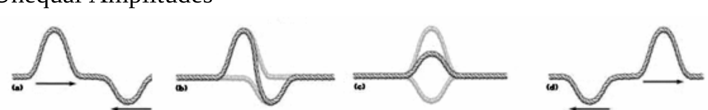


Destructive Interference: superposition of two or more pulses or waves out of phase

Equal Amplitudes – Complete destructive interference



Unequal Amplitudes



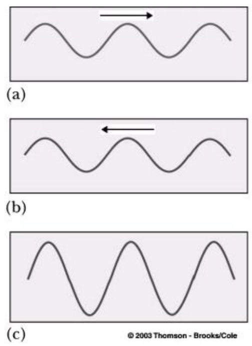
Standing (Stationary) Waves

How are standing waves formed?

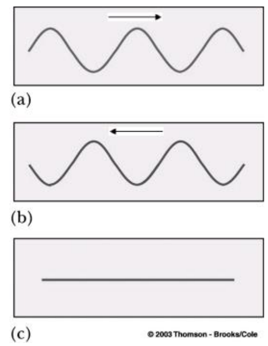
1. A traveling wave moving in one direction in a medium is reflected off the end of the medium.

2. This sends a reflected wave traveling in the opposite direction in the medium. This second wave is (nearly) identical with the first traveling wave. (same frequency, same wavelength, almost same amplitude)

3. The two identical waves traveling in opposite directions interfere with each other creating the standing wave whose amplitude at any point is the superposition of the components' amplitudes.

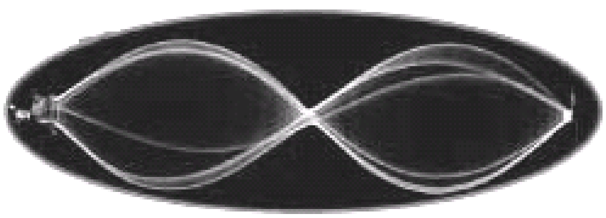


When the two component waves meet in phase, ______________ interference takes place.



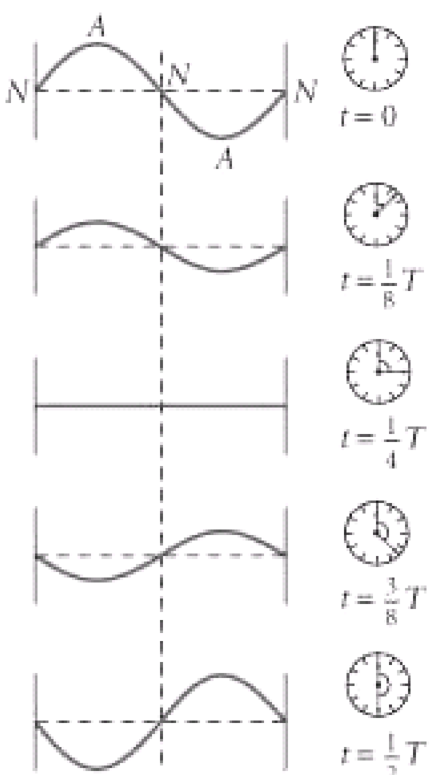
When the two component waves meet out of phase, ______________ interference takes place.

One possible standing wave on a string



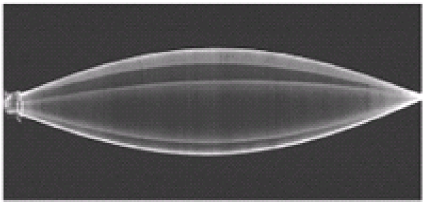
Node: ______________________________

Anti-Node: ______________________________



	Standing (Stationary) Wave	Traveling Wave
Energy		Energy is transferred by the wave.
Amplitude		All points on the wave have the same amplitude (= fixed amplitude) – provided energy is not dissipated.
Wavelength		Equal to the shortest distance along the wave between any two points that are in phase.
Frequency		All particles oscillate in SHM with the same frequency.
Phase		All points within one wavelength have a different phase. Thus, all phase differences are possible.

Transverse Standing Wave: String fixed at both ends



1st Harmonic (fundamental)

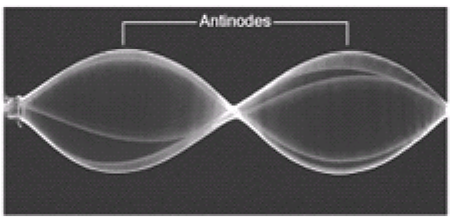
0 ------------------------------------ 6 m

v = 1200 m/s

L =

λ_1 =

f_1 =



2nd Harmonic (1st overtone)

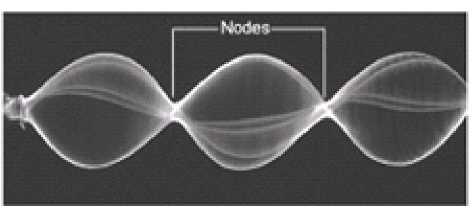
0 ------------------------------------ 6 m

v = 1200 m/s

L =

λ_2 =

f_2 =



3rd Harmonic (2nd overtone)

0 ------------------------------------ 6 m

v = 1200 m/s

L =

λ_3 =

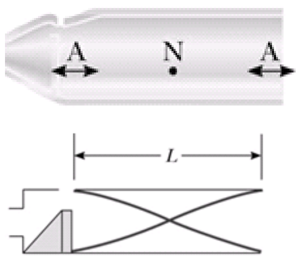
f_3 =

Boundary conditions for transverse standing waves on a string: ______________________

Fundamental wavelength
and frequency:

Other natural frequencies
(Resonant modes):

Longitudinal Standing Waves: Pipe open at both ends



1st Harmonic (fundamental)

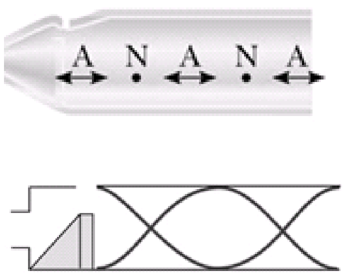
0 0.60 m

v = 340 m/s

L =

λ_1 =

f_1 =



2nd Harmonic (1st overtone)

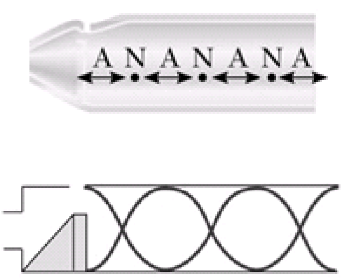
0 0.60 m

v = 340 m/s

L =

λ_2 =

f_2 =



3rd Harmonic (2nd overtone)

0 0.60 m

v = 340 m/s

L =

λ_3 =

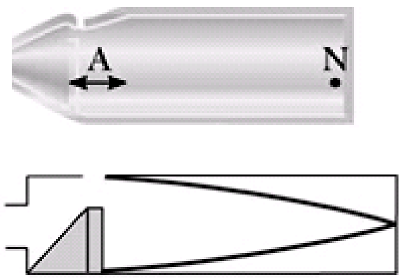
f_3 =

Boundary conditions for a pipe open at both ends: ______________________________

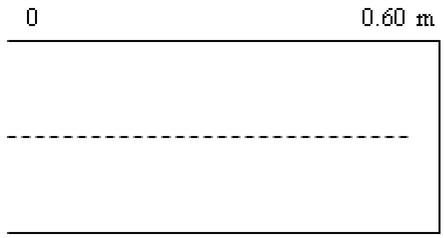
Fundamental wavelength
and frequency:

Other natural frequencies
(Resonant modes):

Longitudinal Standing Waves: Pipe closed at one end



1st Harmonic (fundamental)

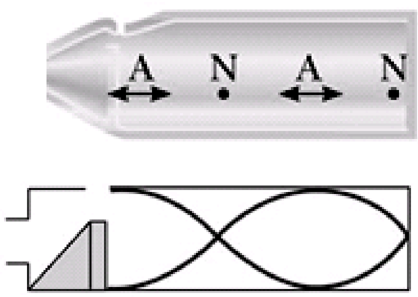


v = 340 m/s

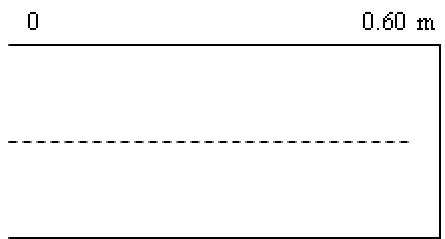
L =

λ_1 =

f_1 =



3rd Harmonic

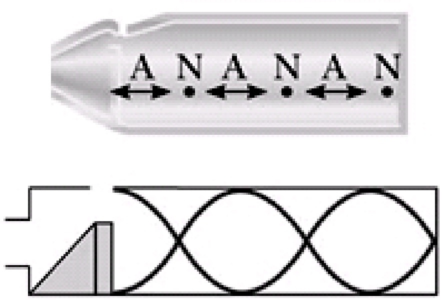


v = 340 m/s

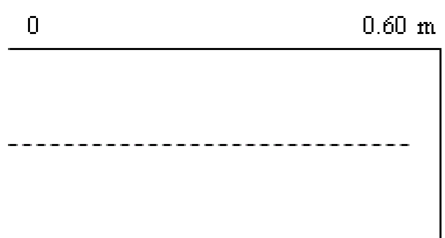
L =

λ_3 =

f_3 =



5th Harmonic



v = 340 m/s

L =

λ_5 =

f_5 =

Boundary conditions for a pipe closed at one end: ____

Fundamental wavelength
and frequency:

Other natural frequencies
(Resonant modes):

1. A violin string that is 40.0 cm long has a fundamental frequency of 440 Hz. What is the speed of the waves on this string?

2. A flute is essentially a pipe open at both ends. What are the first two harmonics of a 66.0 cm flute with all of its keys closed (making the vibrating column of air approximately equal to the length of the flute)? Assume the flute is at room temperature.

3. What is the fundamental frequency and wavelength of a 0.50 m organ pipe that is closed at one end, when the speed of sound in the pipe is 352 m/s?

Resonance Tube

4. A 256 Hz tuning fork is used in a resonance tube and the first two resonances of the fundamental frequency are found at 0.32 m and 0.98 m. What is the speed of sound under the present laboratory conditions?