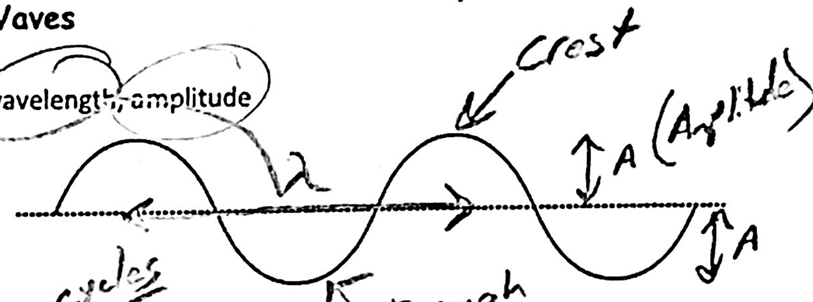
Unit 11 Handout, Part 1 — Name: B7/8 — ①

Part 1: Wave Terminology and Standing Waves

Show these parts of a transverse wave: crest, trough, wavelength, amplitude



Wavelength Symbol: λ (lambda)

Frequency: waves per second

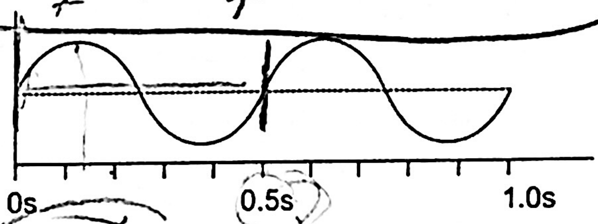
Frequency Symbol: f Units: Hz (Hertz) cycles/sec Frequency Formula: # of waves / time

Period (T) = seconds per wave
$T = \frac{1}{f}$ $f = \frac{1}{T}$

Wave speed Formula: v = λf

Calculate the frequency of the series of waves on the right.

$f = \frac{1 \text{ wave}}{0.5 s} = 2 Hz$



Assuming that λ=10m for the waves on the right, what is the wave speed?

$v = 10m(2 Hz) = 20 m/s$

Transverse and Longitudinal Waves

A. A transverse wave (a.k.a. shear wave, sinusoidal wave) is a disturbance perpendicular to the direction of propagation.

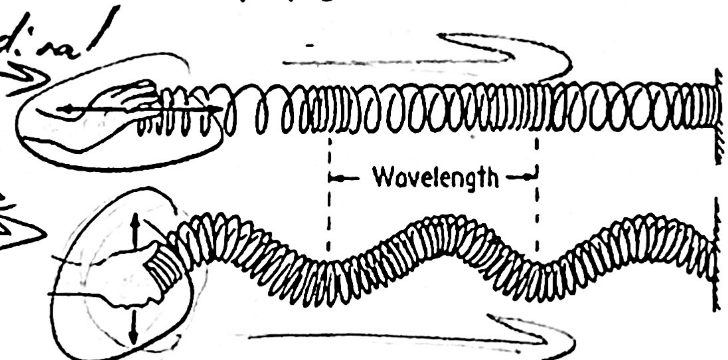
B. A longitudinal wave (or compressional wave) is a disturbance parallel to the direction of propagation.

Types and parts of waves:

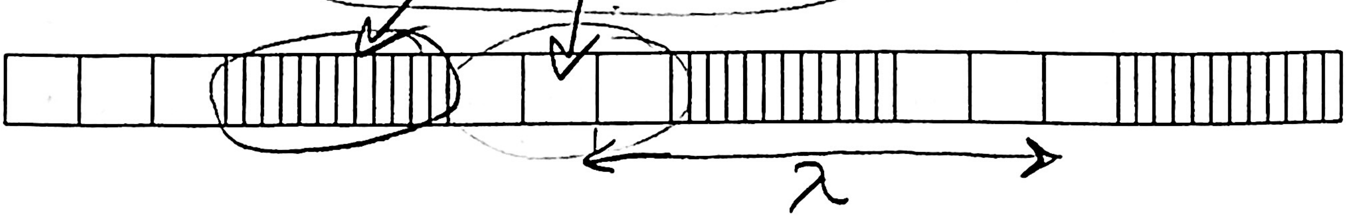
Identify the two different types of waves on the right.

(a) longitudinal

(b) Transverse



Parts of a longitudinal wave: compression, rarefaction, wavelength

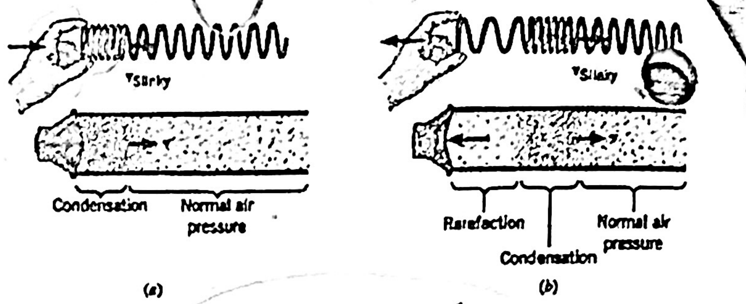


ΔX

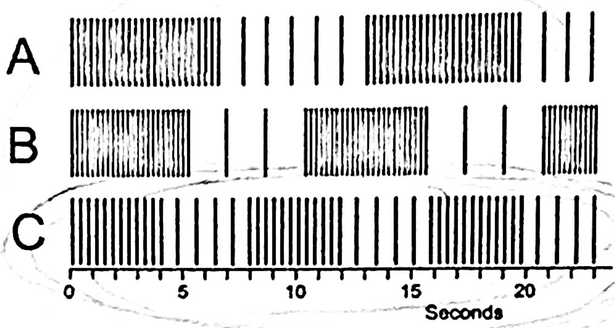
What determines the amplitude of a longitudinal wave?

density of the compressions

Formation of a sound wave (longitudinal wave, a.k.a. compression wave)



Which of the series of waves on the right shows the greatest amplitude? B



Period (T) is the duration of one wave. What is the period of Wave C? $T = 8\,s$

What is the relationship between period (T) and frequency (f)? $f = \frac{1}{T}$ $\quad T = \frac{1}{f}$

What is the frequency of wave C?

$f = \frac{1}{8s} = \frac{1}{8}\,Hz$

Sound waves are longitudinal, but they can be represented as transverse waves:

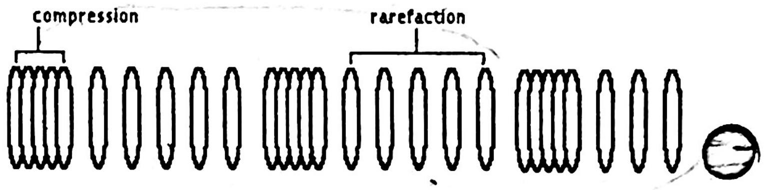


Figure 1: Longitudinal Wave

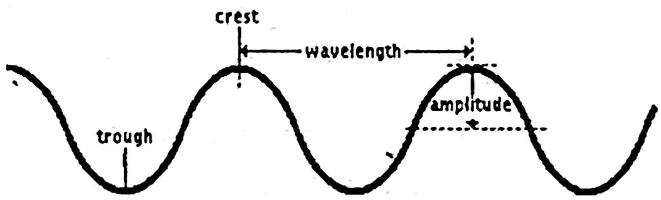
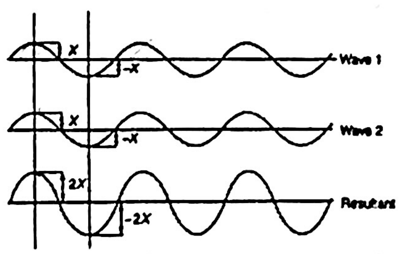


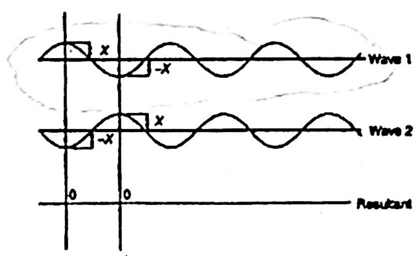
Figure 2: Transverse Wave

Wave Interference:

2. When two or more waves arrive at the same point, the resulting wave is the __Sum__ of the individual waves. This is a phenomenon called __interference__. If the disturbance corresponds to a force, then the forces add. Whatever the disturbance, the resulting wave is a simple addition of the disturbances of the individual waves. That is, their amplitudes add.

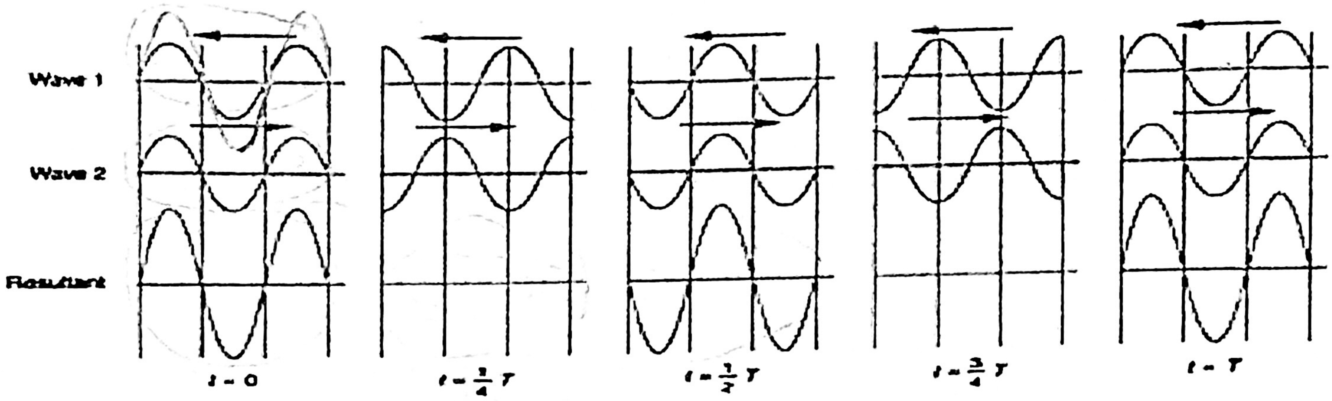


Pure __constructive__ Interference



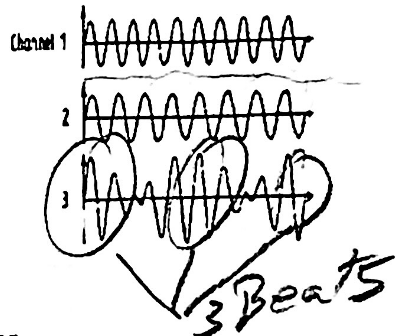
Pure __destructive__ Interference

3. In the diagram below, two waves pass through each other moving in opposite directions, and their disturbances add as they go by. Since the two waves have the same frequency and amplitude, then they alternate between constructive and destructive interference. The resultant looks like a wave standing in place. This is called a standing wave.



Beats:

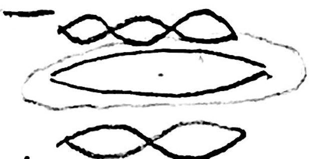
Wave Interference can cause "**beats**". When two waves have slightly different frequencies, their interference alternates between constructive and destructive. The diagram below shows transverse representations of two sound waves (channels 1 and 2) and their resultant sound (channel 3).



- In the diagram, label the channel with the highest frequency (1 or 2).
- Then label regions of constructive and destructive interference. Channel 3 is the "sum" of channels 1 and 2.
- Label the "beats" that will be heard

Beat frequency =difference in frequencies of two notes that are played together

Example: What is the beat frequency when 220Hz and 216Hz are played at the same time? 4Hz



Standing Waves:

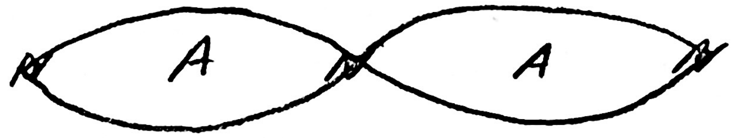
What are the rules for drawing standing waves?

1. Antinodes + nodes alternate

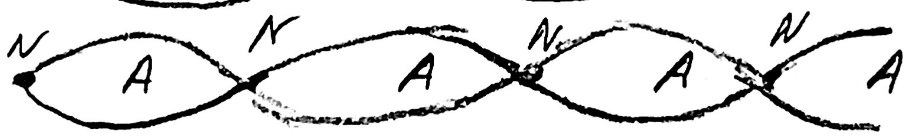
2. If an end is free to move, it is a(n) Antinode. If an end is fixed, it is a(n) node.

Draw a vibrating string with the combinations of nodes and antinodes below. Label the free and fixed ends.

- 3 nodes, 2 antinodes



- 4 nodes, 4 antinodes



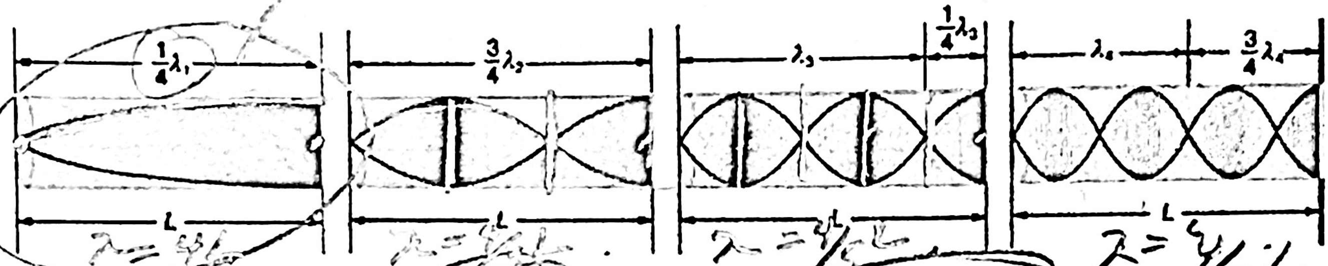
- 2 nodes, 3 antinodes

Fundamental

Standing Sound Waves in a Tube

4

Wavelengths and Harmonics in a tube open at one end (e.g. an organ pipe)



$\lambda = 4L$ $\lambda = \frac{4}{3}L$ $\lambda = \frac{4}{5}L$ $\lambda = \frac{4}{7}L$

1. How are waves in an organ pipe different than waves on a string?

   longitudinal (compression)   transverse

2. The diagram above represents the organ pipe waves as transverse waves. In reality, they are longitudinal. What is really happening to air molecules at the antinodes?

   Moving with maximum displacement

3. At the nodes, what are the air molecules doing?

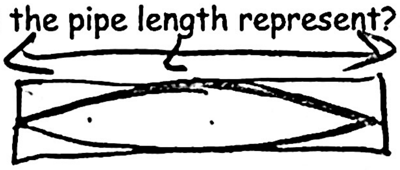
   Not moving (but pressure is changing)

4. For the fundamental explain why there is a node at the left end and an antinode at the right?

   lowest possible standing wave (lowest possible frequency)

   The wall prevents particles from moving   No wall to prevent movement

5. Draw the fundamental for a pipe that is closed at both ends. How much of a wavelength does the pipe length represent?



$\lambda = 2L$

$L = \frac{\lambda}{2}$

6. For each harmonic above, write an equation for wavelength in terms of tube length.

7. Label any harmonics according to the order of the harmonic (i.e. 1st harmonic, 2nd harmonic, 3rd harmonic...). The lowest frequency harmonic is the **1st harmonic (a.k.a fundamental)**. The **nth harmonic** has a wavelength that is equal to the fundamental wavelength/n.

8. Label the harmonics using the term "overtone," rather than the term harmonic.