WAVES & SOUND

NOTES TO BE POSTED ON MY WEBSITE

Wave Properties

Additional Source
http://www.physicsclassroom.com/Class/waves/U10l2a.cfm

Wave

- Transfer of energy with no net displacement of matter.
- Example: Drop a rock in a pond ripples move out from the rock, if there was a leaf on the water you would see it move up and down not across the water. The leaf shows the motion of the water particles.

Types of Waves

- Mechanical Waves – require a **medium.**
  - Examples of mechanical waves:
    - Sound
    - Pressure wave
  - Examples of mediums:
    - Water
    - Air
    - Spring/rope
- Medium – The material through which a disturbance travels

Types of Waves Electromagnetic Wave

- Electromagnetic Wave – no medium needed
  - Examples of Electromagnetic Waves:
    - Light
    - Microwaves
    - Radio
    - X-rays
    - Ultraviolet
    - Infrared
- Oscillating electric and magnetic fields make an electromagnetic wave.

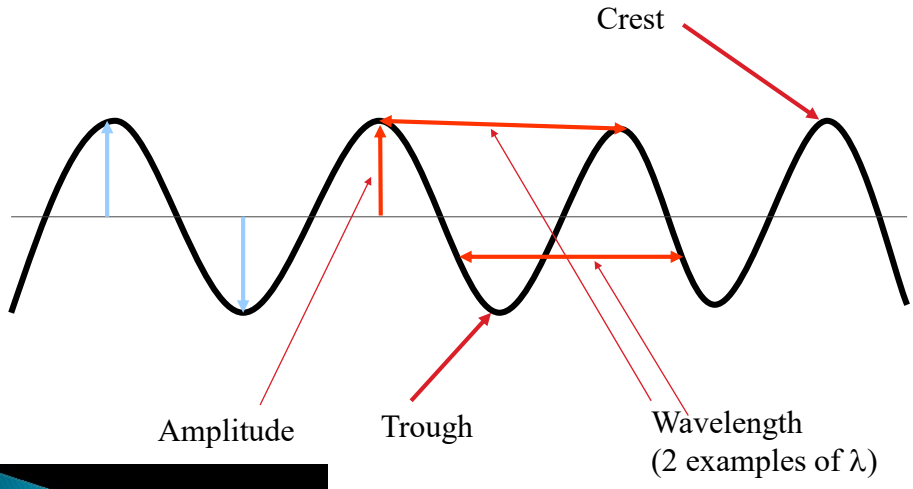
Production of Waves

- Wave pulse – a single, non-periodic disturbance.
  - For example the rock dropped in a pond.
- Traveling Wave/Periodic Wave – a wave whose source is some form of periodic motion thus creating a continuous traveling wave.

How waves travel

- Transverse wave – particles of the medium vibrate perpendicularly to the direction of the wave.
  - The wave may move from right to left, but the medium is displaced at a right angles to the direction
    - Example: Electromagnetic waves, String on a violin.

Transverse Wave



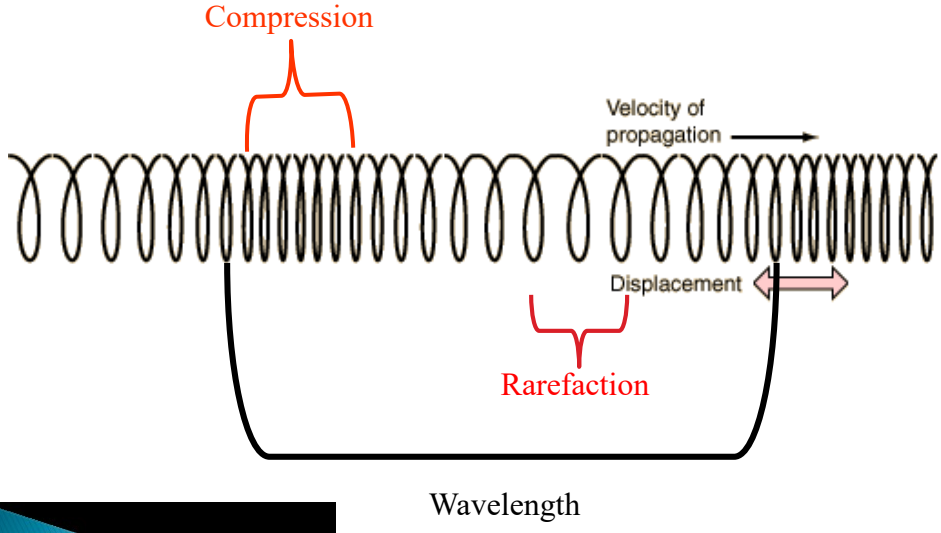
Wave Facts

- All periodic waves can be represented graphically with a sine wave.
- Wavelength (λ) – the shortest distance between points where the wave pattern repeats itself.
- Crest – the high point of a wave. Maximum positive displacement from the equilibrium point.
  - There is one wavelength between each crest.
- Trough – the low point of a wave. Maximum negative displacement from the equilibrium point.
  - avelength between each trough

Longitudinal Wave

- Longitudinal Wave – causes the particles of a medium to move parallel to the direction of the wave
  - The displacement of the medium is in the same direction as the motion of the wave
  - Example: Sound
  - Also called a pressure wave because where the wave is compressed is an area of pressure.

Longitudinal Wave



Period & Frequency

- Period (T) – the shortest time interval during which the motion of a wave repeats itself
- Frequency (*f*) – the number of complete vibrations per second measure at a fixed location
  - Hertz – unit of frequency
  - 1 Hz = 1 vibration per second.
- T and *f* are reciprocals of one another.

More about Frequency

- Waves passing from one medium to another – no matter what the density of the mediums – will have the same frequency in both media.
- Frequency is caused by the SOURCE not the medium!!!!

Velocity

$$v = \lambda f$$

- Is determined by the medium.
- Velocity of a wave is given by the wavelength times the frequency.
  - Velocity – meters per second - m/s
  - Wavelength (λ) – meters - m
  - Frequency – cycles per second – Hz – s^{-1}

Frequency, velocity, and wavelength

- If frequency depends on the source, and velocity depends on the medium, wavelength must change whenever the source or medium changes!!!!
- *f* and v are independent variables, λ is a dependent variable.

A wave's frequency depends on its source (how much energy it is given to start with)

A wave's velocity depends on the medium it is traveling through

Ex: will a wave travel faster through water or ketchup? Why?

Amplitude

- The maximum displacement of a wave from rest or equilibrium position
  - Two waves can have the same frequency, but different amplitudes (amplitude is an independent variable).
  - The greater the amplitude, the greater the energy transfer of the wave.
  - In sound, volume is a measure of amplitude.

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- $v = \lambda f$
- Read Sections 25.1 – 25.6
- Pg 388
  - **Write Questions & Answers**
  - **Problems: 3, 6 – 11**

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WAVE INTERACTIONS

Part II of wave properties

Superposition

- When two bumper cars collide, they bounce off of each other and are forced to change the direction of their motion.
- Two particles can NOT occupy the same space at the same time. This is a fundamental property of particles.

Superposition

- When two waves come together they do not bounce off of each other.
- For example, if you listen to a concert you can distinguish the sounds of each different instrument. This means that the sound wave of each instrument are unaffected by the other sound waves passing through it.

Superposition

- Waves are not matter but rather the displacement of matter, two waves can occupy the same space at the same time.
- **Superposition** is the overlapping of two waves or more.

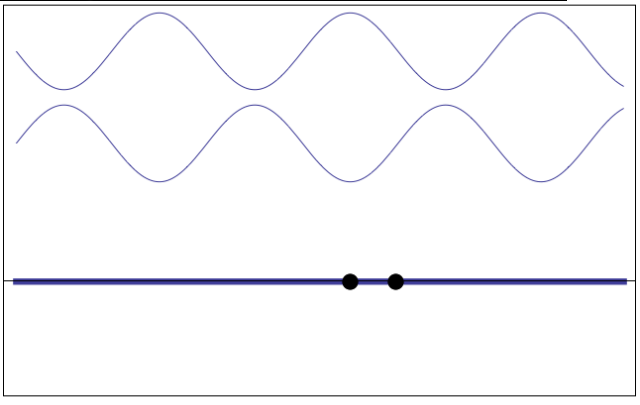
Vocabulary

- Principle of superposition – the displacement of a medium caused by two or more waves is the algebraic sum of the displacements caused by the individual waves.
- Interference – the result of the superposition of two or more waves.

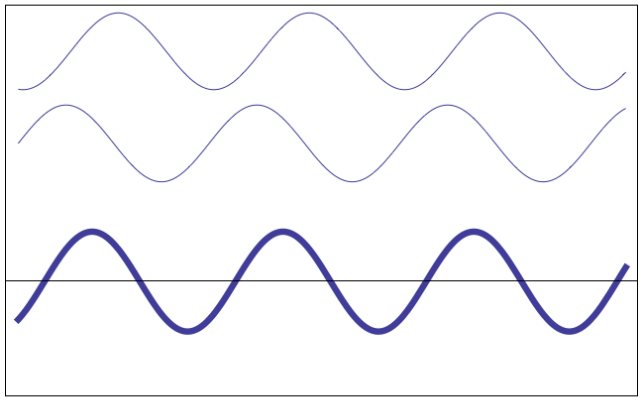
All animated gifs courtesy of Dr. Dan Russell, Grad. Prog. Acoustics, Penn State

Superposition of two opposite direction wave pulses
http://www.acs.psu.edu/drussell/Demos/superposition/pulses.gif

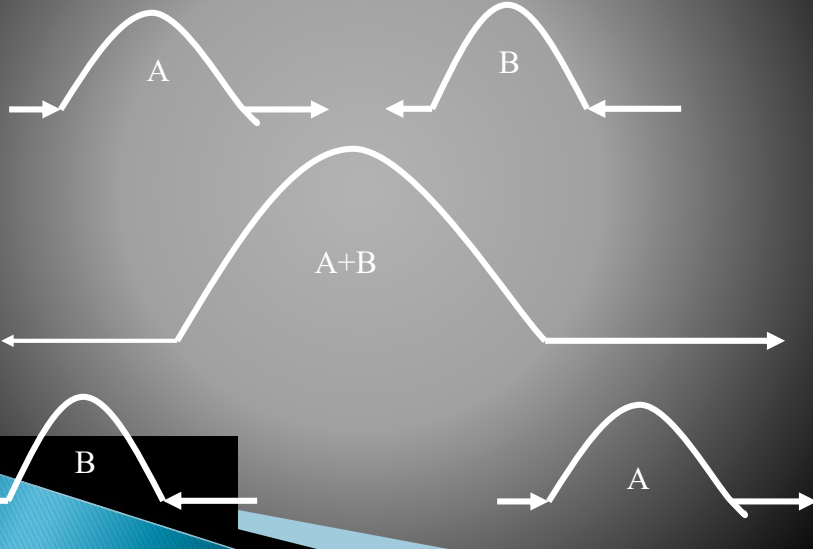
Two sine waves travelling in opposite directions create a standing wave



Constructive and Destructive Interference

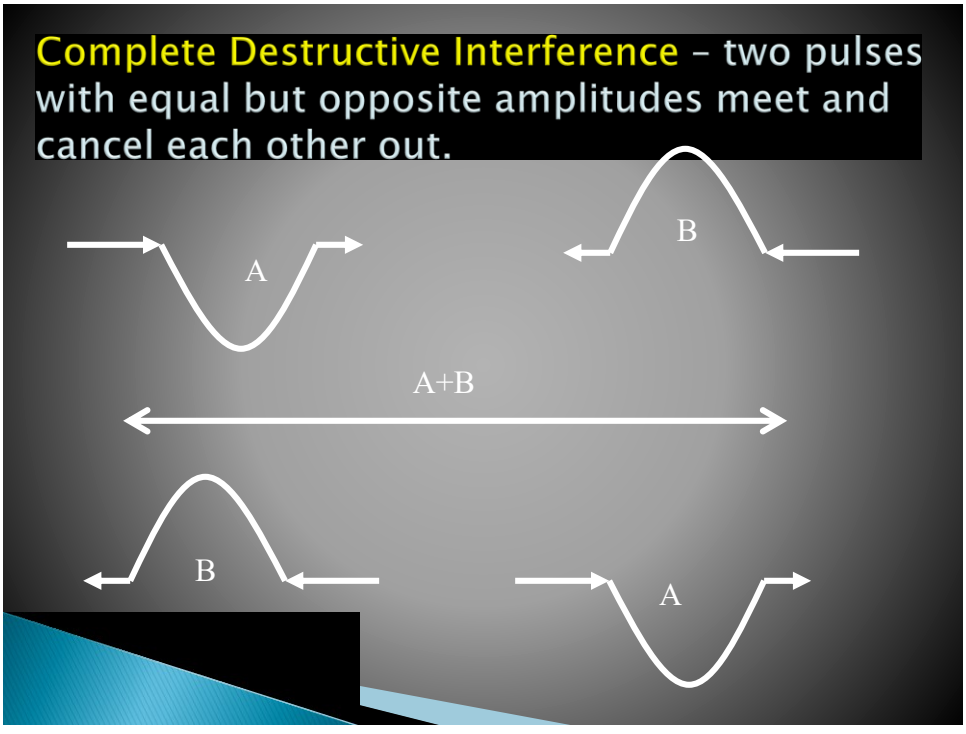


Constructive Interference – the wave displacements are in the same direction.



Constructive Interference

- A single wave pulse with a larger amplitude is the result.
- Once the pulses have passed through each other, they return to their original size and shape.



- There is zero displacement when the two pulses meet for equal and opposite displacements.
- Once the pulses have passed each other they return to their original size and shape
- If the pulses have unequal amplitudes, there is not complete destructive interference

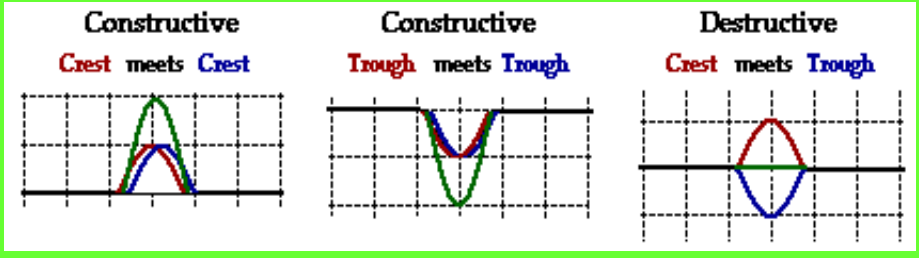
Types of Interference

Constructive

results in a larger amplitude

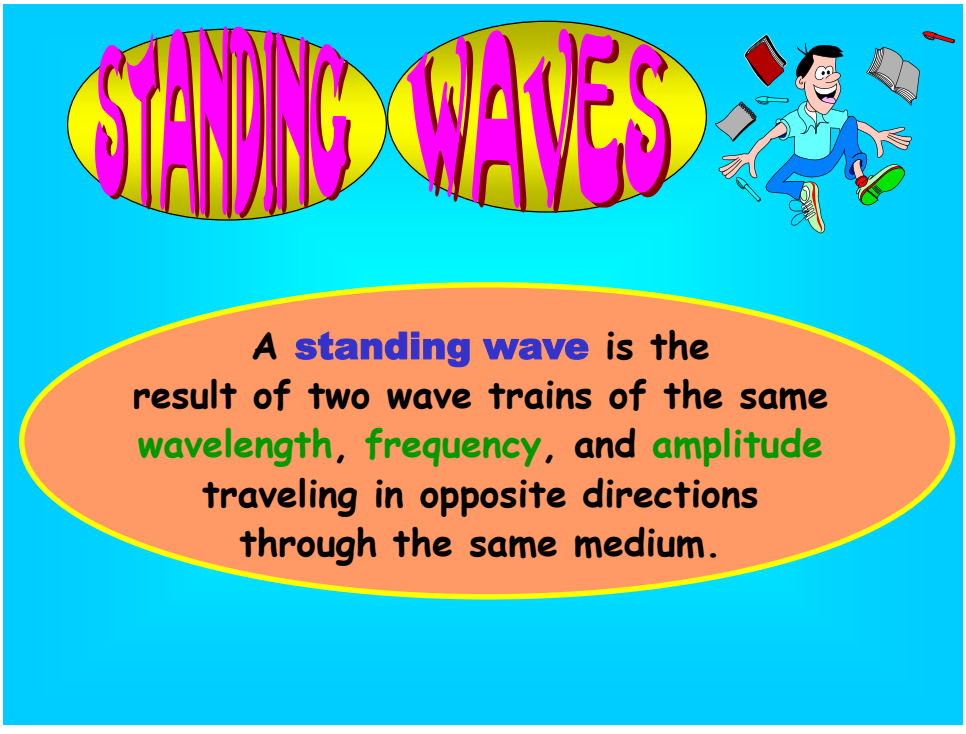
Destructive

results in a smaller amplitude

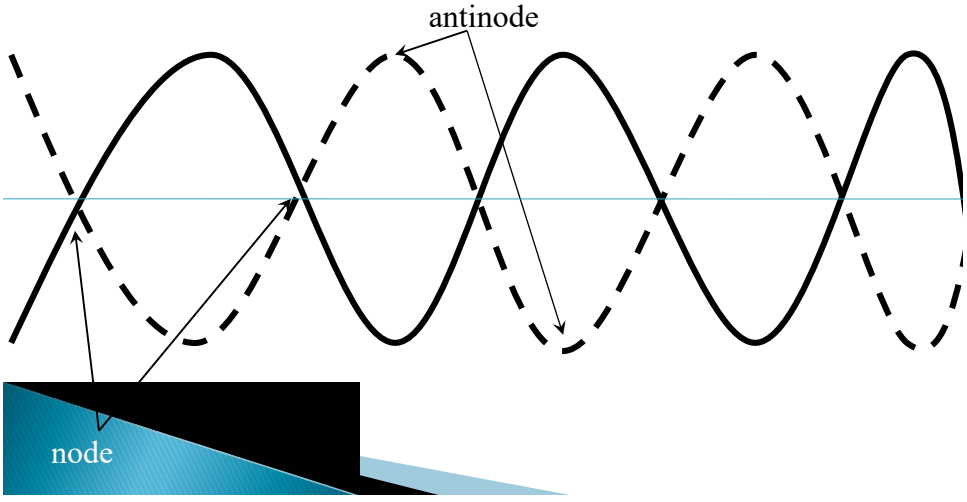


Standing Waves

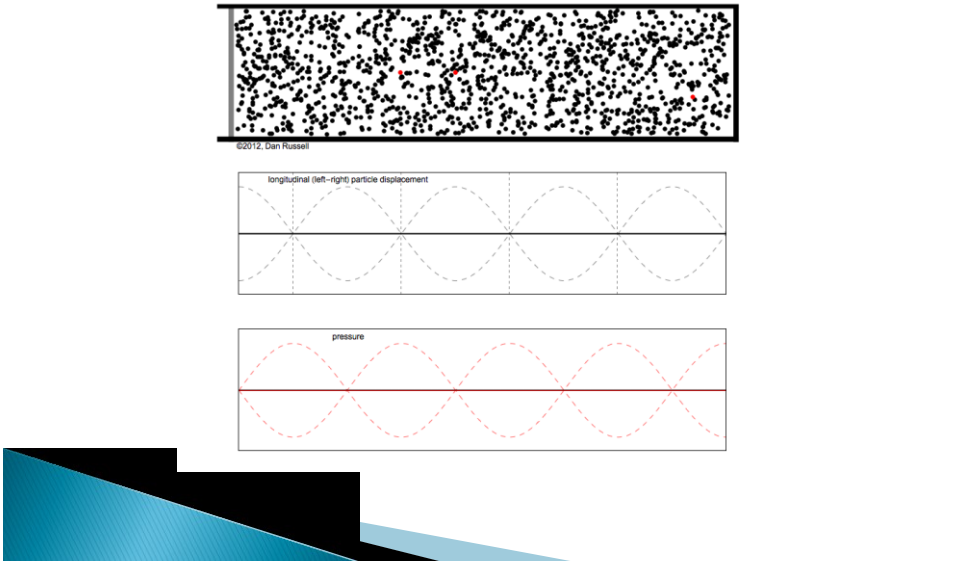
- Interference pattern is such that it looks like the wave is standing still.
- Node – a point on the wave that is completely undisturbed at all times
  - Caused by destructive interference
- Antinode – the point of maximum displacement when two "like" waves meet
  - Caused by constructive interference



- When a medium is vibrating at just the right frequency a pattern of constructive and destructive interference develops that magnifies the amplitude of the wave.



Standing wave in an air column



Standing Waves in a String

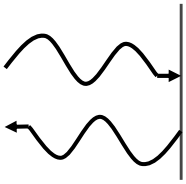
- Only certain frequencies of vibrations produce standing waves for a given string length.
- The ends must be nodes so that a standing wave can be produce for any wavelength that allows both ends to be nodes. (λ = 2L, L, 2/3 L, ½ L, etc.)

Waves at Boundaries

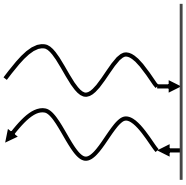
- The speed of a wave is dependent only on the properties of the medium!!!
- Where two different media meet is called a **boundary**.
- Reflected Wave – the energy that moves back from the boundary
- Transmitted Wave – the energy that travels into the new medium
- Incident Wave – the original wave.

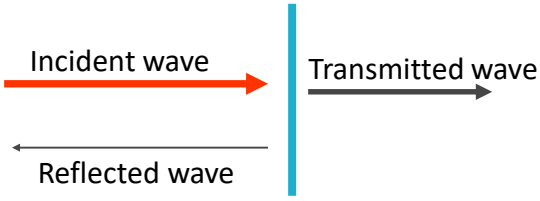
Reflected waves

- When a wave passes into a more dense material or if the end is fixed the reflected wave is inverted.



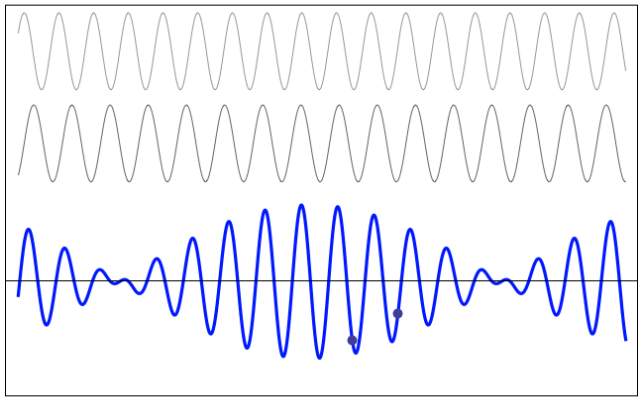
- When a wave passes into a less dense material or if the end is free to oscillate the reflected wave is not inverted.





- If there is a small difference in media the amplitude of the transmitted wave will be almost as large as that of the incident wave.
- Most of the energy is transmitted
- If the media is very different, most of the wave will be reflected and the amplitude of the transmitted wave will be very small.

Two sine waves with different frequencies: Beats



Surface Wave

- Surface Wave – a mixture of transverse and longitudinal waves.
  - The particle makes a circular pattern – both up and down and side to side.
  - Example: Ocean waves

Movie showing different traveling waves

http://www.acs.psu.edu/drussell/demos/waves/wavemotion.html

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- Write the questions on a sheet of paper that you can turn in.
- Write the answers in complete sentences
- Monday questions to answer: 3, 6 – 11
- Tuesday questions to answer: 12 – 16, 23 – 26

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