CHAPTER 15
WAVES

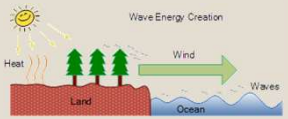
Waves are all around Us

- light from the stoplight
- ripples in a puddle of
- electricity flowing in wires
- radio and television and cell phone transmissions

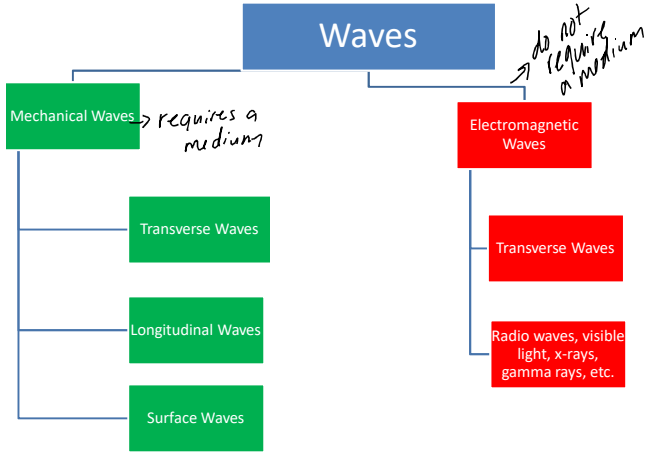
What is a wave?

- Wave- a disturbance that transmits energy through matter or space
  - Energy may spread out as a wave travels.
  - Kinetic theory explains differences in wave speed
- The speed of a wave depends on the medium
- Medium-matter through which a wave travels
  - Water, Air, Earth
  - Greatest in solids and least in gases

2 Types of Waves:
1. Mechanical
2. Electromagnetic



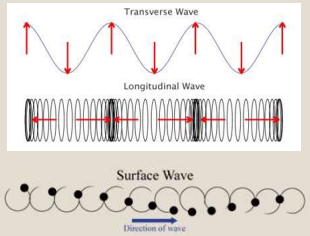
Intro to Waves Clip



Mechanical Waves

A wave that requires a medium through which to travel

- They are caused by the vibration of particles within the medium.

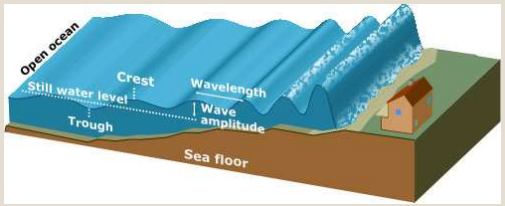


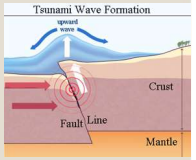
3 Types of Mechanical Waves:
1. **Transverse**
2. **Longitudinal**
3. **Surface Waves**

- **sound waves (air)**
- **water waves**
- **waves in a spring**

Mechanical Energy

A tsunami is a huge ocean wave caused by earthquakes.
- A tsunami can carry enough energy to damage coastal dwellings.



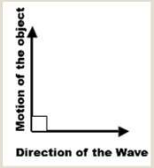


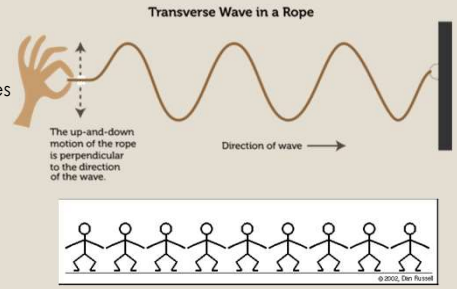
Animation

Transverse Waves

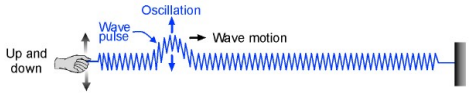
- Particles oscillate up and down about their equilibrium positions, perpendicular to the direction of wave propagation
- Its oscillations perpendicular to the direction the wave moves

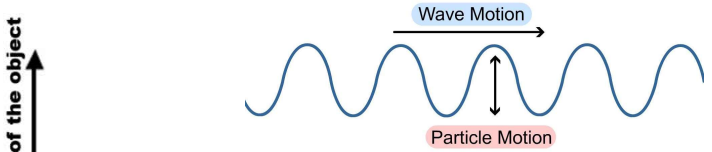
Examples:
- light waves
- electromagnetic waves

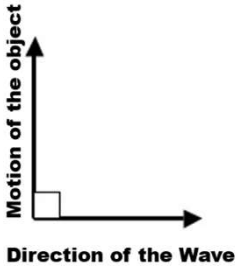




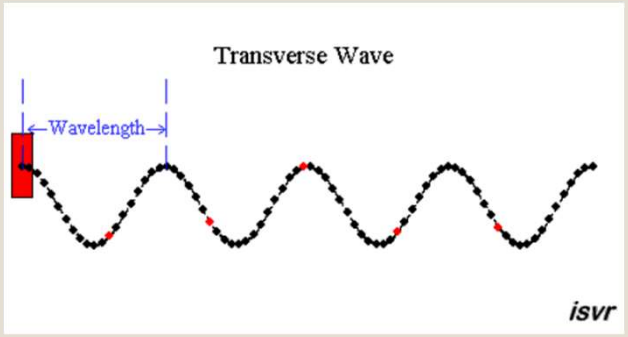
Transverse Waves







Transverse Wave

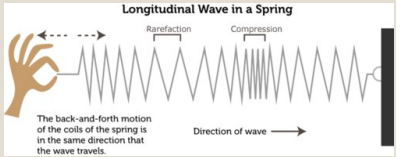


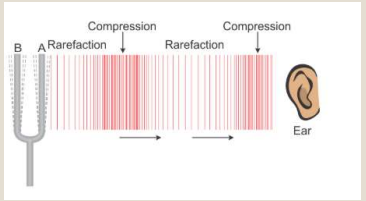
Longitudinal Waves

Compressions

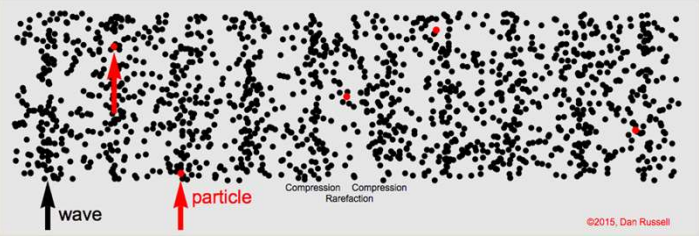
- Particles oscillate back and forth about their equilibrium positions, parallel to the direction of wave motion
- Oscillations in the same direction as the wave moves

Ex: Sound waves, seismic waves



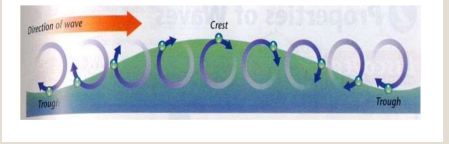


Longitudinal Wave



Surface Waves

- In a surface wave, particles move in circles.
- Combination of transverse and longitudinal
  - Ex: water waves



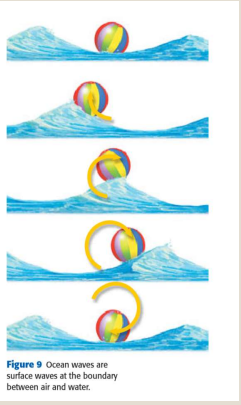
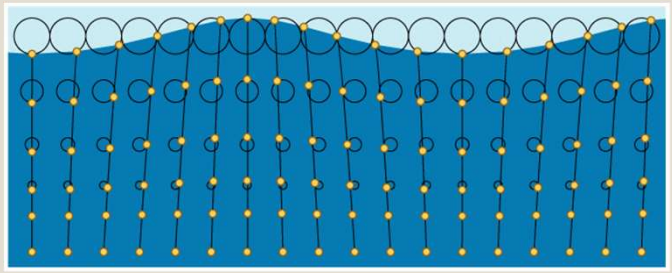


Figure 9 Ocean waves are surface waves at the boundary between air and water.

Surface Waves

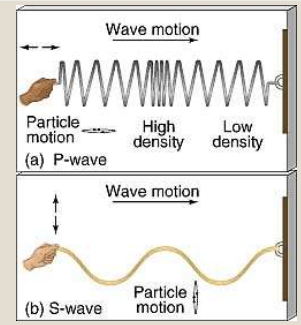


longitudinal wave

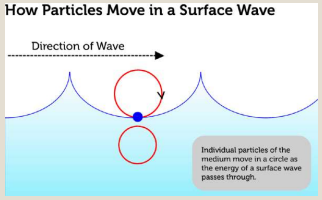
transverse wave

Surface Wave

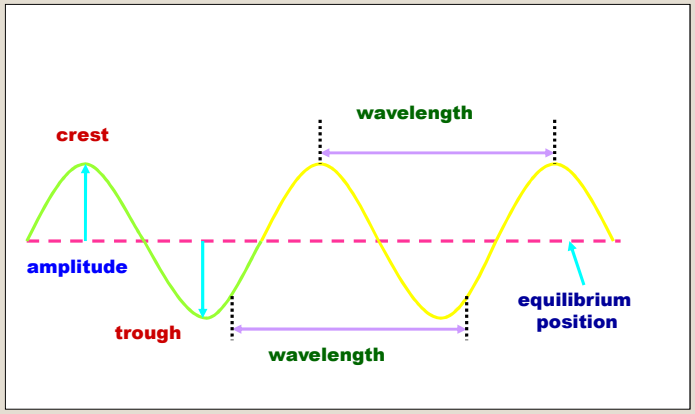
Clip



How Particles Move in a Surface Wave

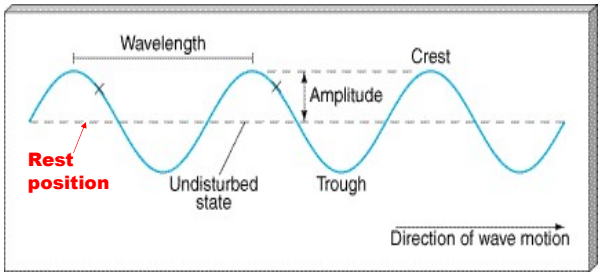


A Transverse Waveform



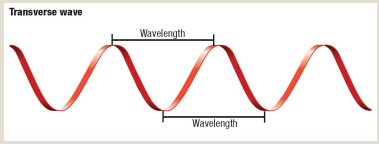
Wave Properties of a **Transverse Wave**

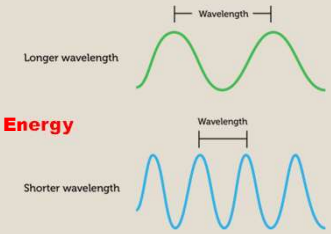
- **Crest**-the highest point of a transverse wave
- **Trough**-the lowest point of a transverse wave
- A cycle consists of one crest and one trough.
- **Amplitude**-the greatest distance that particles in a medium move from their normal position when a wave passes



Wavelength of a Transverse Wave

- **Wavelength**-the distance between any two successive identical parts of a wave
- Ex. Crest to Crest
- Ex. Trough to Trough

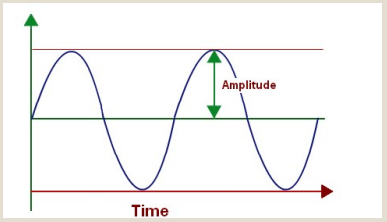


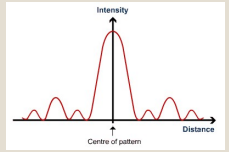


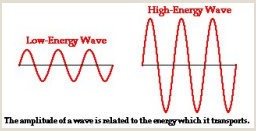
Shorter the Wavelength = More Energy

Amplitude of Transverse Wave

- The amount of energy carried by a wave.
- Larger the amplitude = more energy





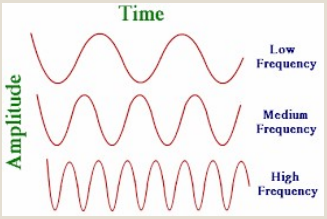


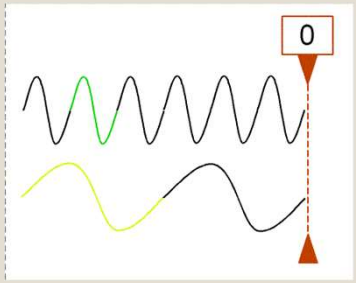
Frequency

The number of cycles or vibrations per unit of time.

The number of waves produced in a given amount of time.

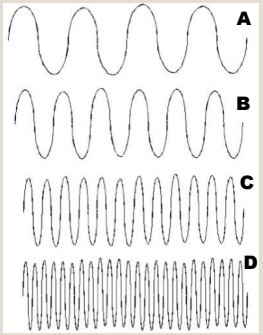
- unit hertz (Hz)





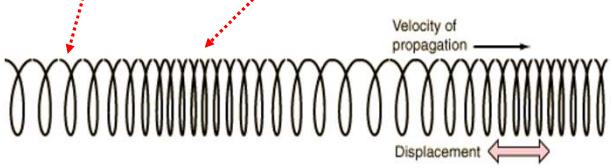
Frequency in Waves

Describe the relationship between frequency and energy for each example?



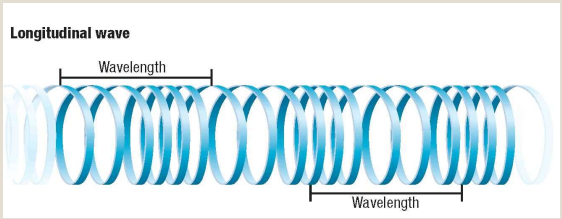
A Longitudinal Waveform

- A cycle consists of one compression and one expansion of the particles of the medium.



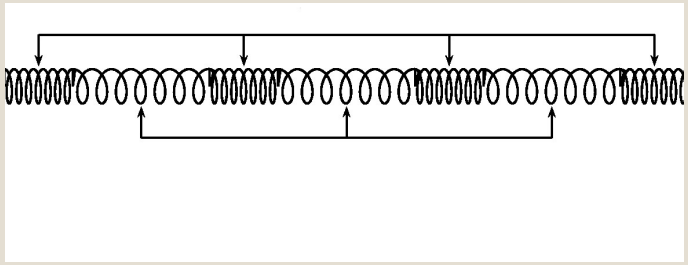
Wavelength of a Longitudinal Wave

- **Compressions**: the crowded areas of a longitudinal wave
- **Rarefactions:** the stretched-out areas of a longitudinal wave



Wave Properties of a **Longitudinal Wave**

Label the parts of the following wave.

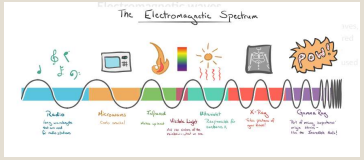


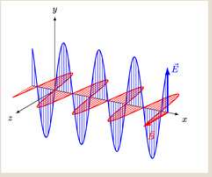
What type of wave is shown above?

Electromagnetic Waves

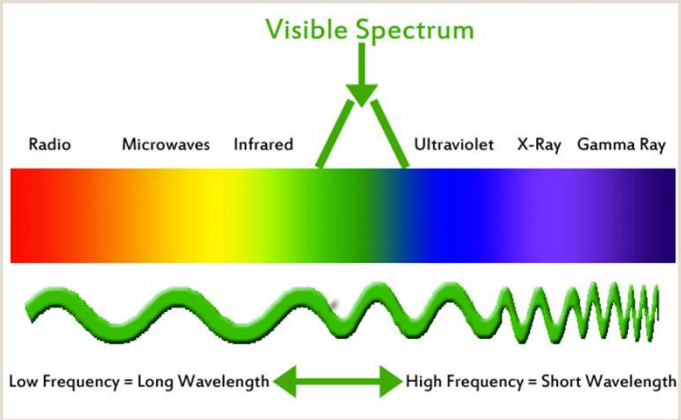
- Wave caused by a disturbance in electric and magnetic fields by vibrating charged particles.
  - Does not require a medium
  - Also called a light wave
  - Can transfer energy through a vacuum
  - Can also transfer energy through a material medium
  - Considered **transverse waves** because they have similar characteristics; therefore, they have the same parts.

Example: radio wave, gamma rays, x- rays, visible light



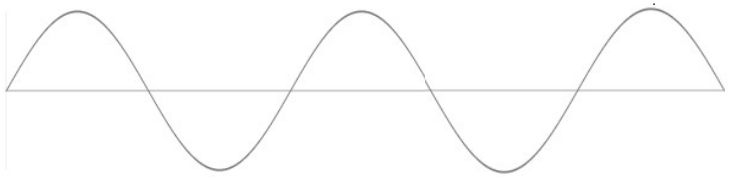


Electromagnetic Waves



Lets Practice Wave Properties

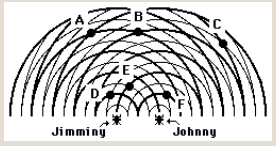
Label the parts of the following wave.

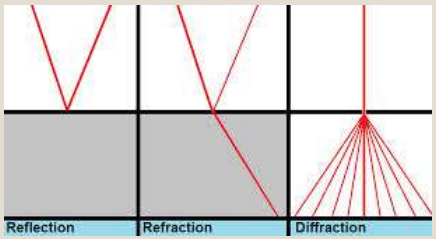


What type of wave is shown above?

Wave Interactions

- Waves bend when they pass from one medium to another at an angle.
- Waves will experience :
  - Reflection
  - Diffraction
  - Refraction
  - Interference

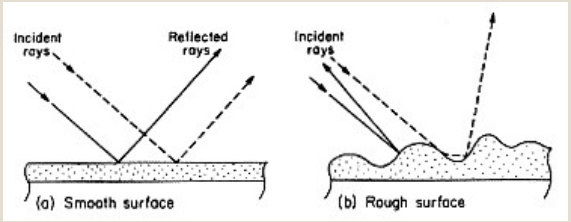




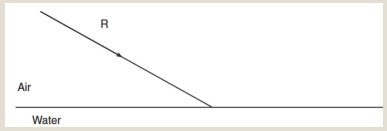
1. Reflection

The bouncing back of a wave as it meets a surface or boundary

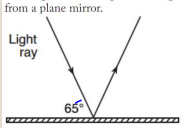
- Examples:
  - The reflection of light waves in a lake can create a mirror image of a landscape.
  - Water waves are reflected when they hit the side of a boat.



Reflection

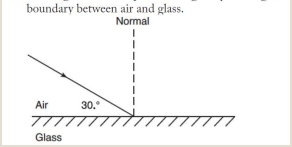


The diagram below represents a light ray reflecting from a plane mirror.

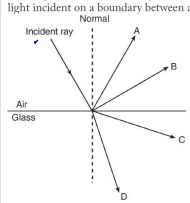


The angle of reflection for the light ray is

1. The diagram below represents a light ray striking the boundary between air and glass.



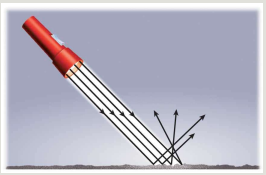
The diagram below shows a ray of monochromatic light incident on a boundary between air and glass.



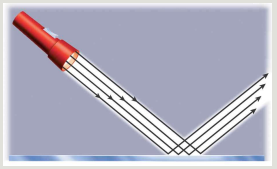
Which ray best represents the path of the reflected light ray?

Reflection

Rough surfaces reflect light rays in many directions.

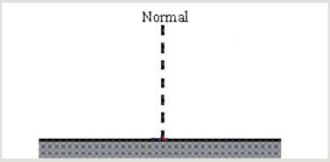


Smooth surfaces reflect light rays in one direction.

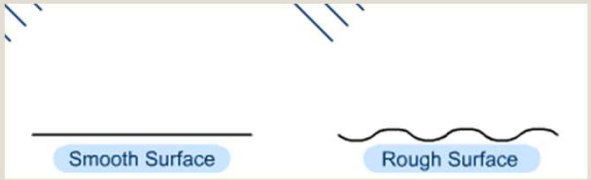


The ***angle of reflection*** is the light rays reflecting off the surface.

The ***angle of incidence*** is the light rays striking the surface



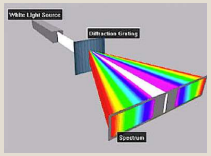
Reflection of Waves

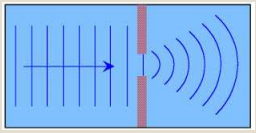


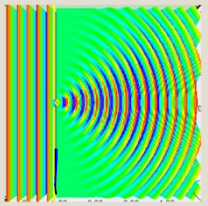
2. Diffraction

The bending of a wave as it passes an edge or an opening

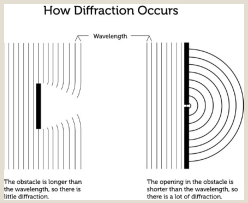
- Examples:
  - Water waves diffract around a block in a tank of water.
  - Sound waves passing through a door diffract.

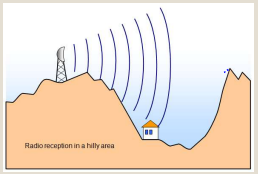


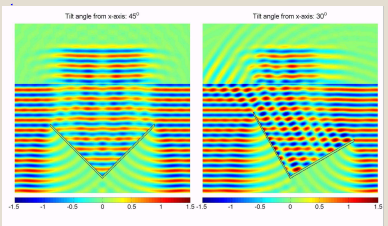


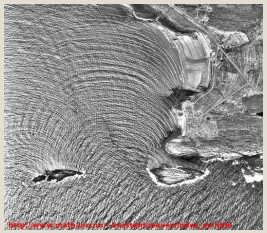


Diffraction



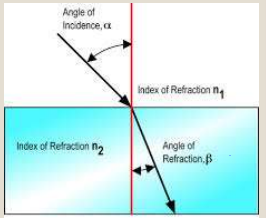


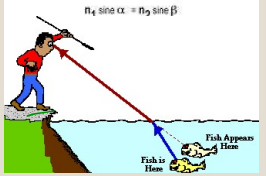


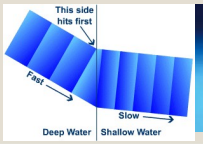


3. Refraction

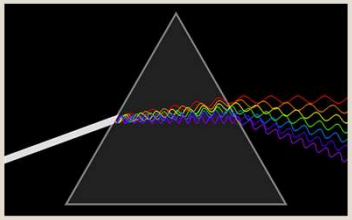
- The bending of waves as they pass from one medium to another
- All waves are refracted when they pass from one medium to another at an angle.
- Molecules slow down when then move from one medium to another

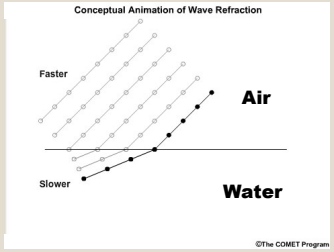






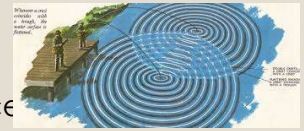
Refraction of Waves

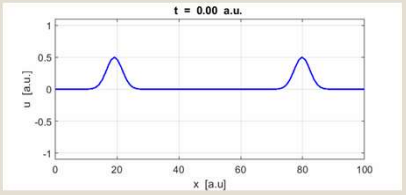


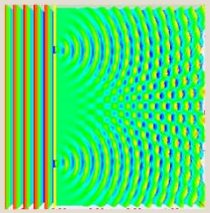


4. Interference

- The combination of two or more waves that exist in the same place at the same time
- Occurs in all waves
- Two types
  - Constructive interference
  - Destructive interference

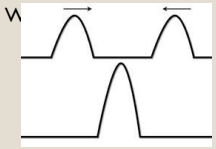


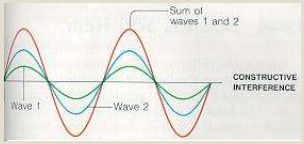


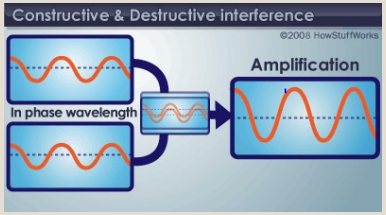


Type 1: Constructive Interference

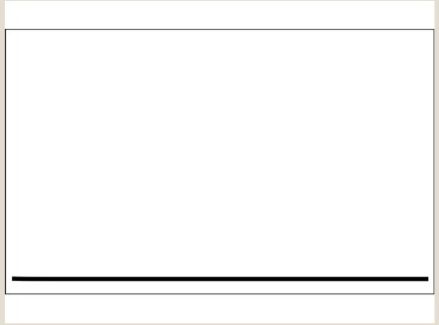
- Waves combine without any phase difference
- Waves combine to form a bigger w
- Increases amplitude







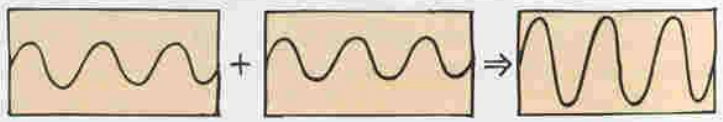
Constructive Interference



Wave Addition

Constructive Interference

Amplitude ~ Intensity

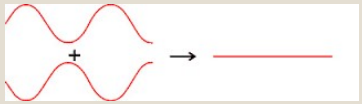


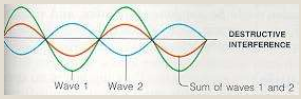
The superposition of two identical transverse waves in phase produces a wave of increased ampitude.

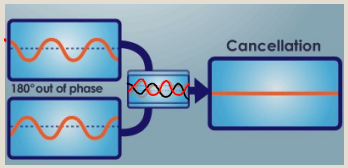
The superposition of two identical longitudinal waves in phase produces a wave of increased intensity.

Type 2: Destructive Interference

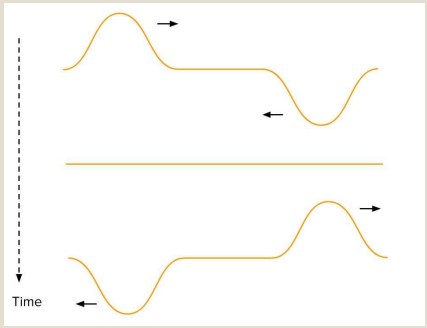
- Waves combine differing by multiples of 1/2 wavelength
- waves combine to form a wave smaller than the largest of the original waves
- Decreases amplitude



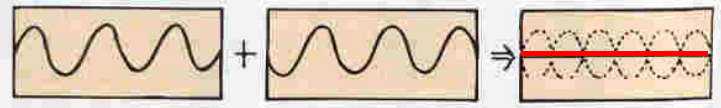




Destructive Interference



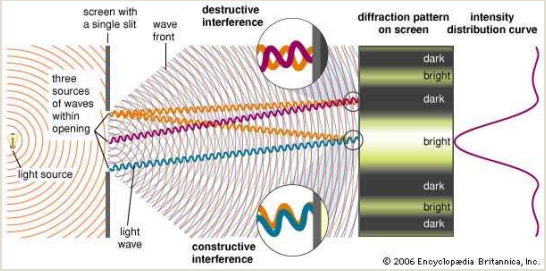
Wave Subtraction Destructive Interference



Two identical transverse waves that are out of phase destroy each otherwhen they are superimposed.

Two identical longitudinal waves that are out of phase destroy each other when they are superimposed.

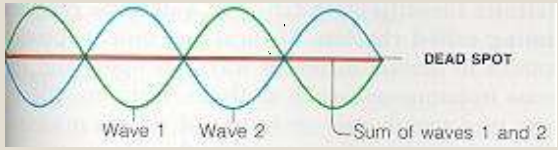
Interference Waves (Dead Spots)



Destructive Interferences- creates a dark area
- **Both waves cancel each other out**

Constructive interference-creates a bright area
- **Both waves overlap and increase**

Dead Spots



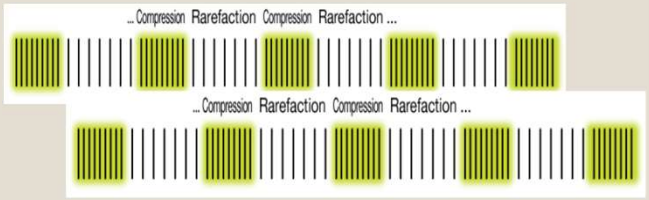
Waves can interfere so destructively with one another that they produce **dead spots**, or places where no sound at all can be heard.

Happens in both transverse waves and longitudinal waves.

Speakers Video

Warm Up!

Draw a model of two sound waves meeting to form a dead spot.



The compression of one sound wave overlaps with the rarefaction of another sound wave and cancel each other out. **No Sound is produced**

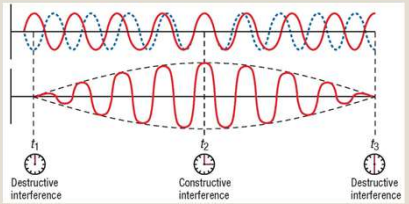
Interference

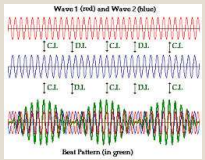
- Interference of light waves creates colorful displays
  - Ex. Rainbows, oil in water, soap bubbles

The colors seen in a soap bubble or an oil film on water are a common example of interference. Light reflecting off the front and back surfaces of the thin soap film interferes, resulting in different colors being enhanced.

Interference

- Interference of sound waves produces beats





Which statement best explains why the music is quieter in some spots?

A. Sound waves reflect off the walls of the theater. Then, the compression of one sound wave meets the compression of another sound wave resulting in destructive interference.
B. Sound waves reflect off the walls of the theater. Then, the compression of one sound wave meets the rarefaction of another sound wave resulting in destructive interference.
C. Sound waves reflect off the walls of the theater. Then, the rarefaction of one sound wave meets the rarefaction of another sound wave resulting in constructive interference.
D. Sound waves reflect off the walls of the theater. Then, the compression of one sound wave meets the rarefaction of another sound wave resulting in constructive interference.

Answer: B

When light waves interfere the result is often a pattern of light and dark areas, like those seen in the image below. The dark areas are caused by _____ interference and the light areas are caused by _____ interference.

A. Constructive; destructive
B. Longitudinal; transverse
C. Destructive; constructive
D. Transverse; longitudinal

Answer: C