Waves

1. _____ the material through which the wave (energy) is traveling
2. _____ a single oscillation or disturbance of the medium
3. _____ a series of pulses or oscillations that move through a medium

Energy Transfer

Particle – transfers both _____ and _____

Wave – transfers _____ without transferring _____

Electromagnetic – a wave that _____
to transfer energy
Examples:

Mechanical – a wave that _____
to transfer energy

Examples:

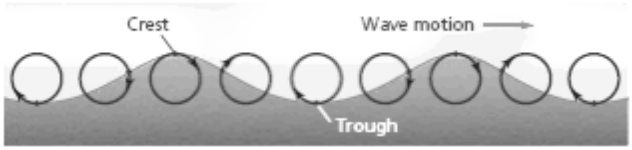
Transverse – the particles of the medium move _____
to the direction of the wave energy

Longitudinal – the particles of the medium move _____
to the direction of the wave energy

4. Other types of mechanical waves

Elliptical wave (surface wave):

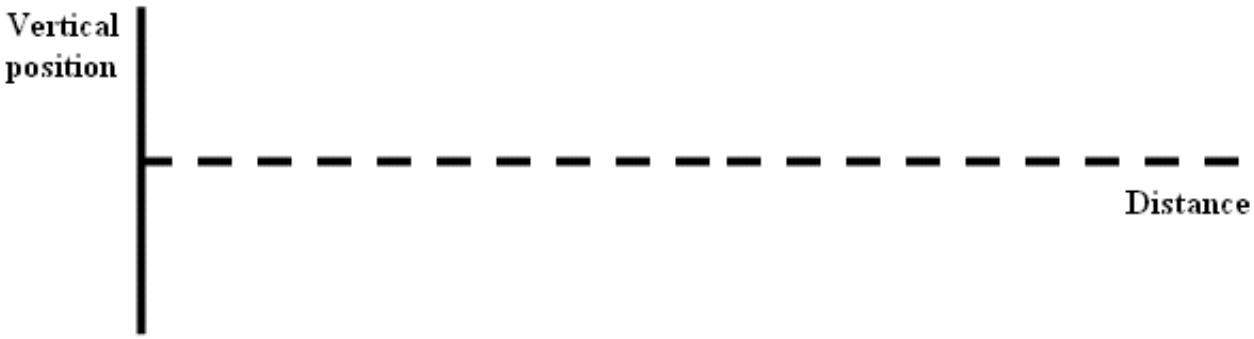
Torsional wave:



Wave Characteristics

Cycle:

5. On the axes at right, sketch two cycles of a transverse wave.



6. Label the following parts of the wave you drew: **equilibrium position, crest, trough, amplitude, wavelength**

7. Identify each of the following terms:

a) _____ maximum displacement from the equilibrium position

b) _____ shortest distance along the wave between two points that are in phase

c) _____ time taken for one cycle

d) _____ number of cycles per second

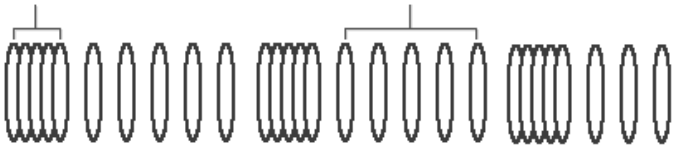
Symbol	Units

8. What is the relationship between period and frequency?

Period **Relationship** **Examples:**

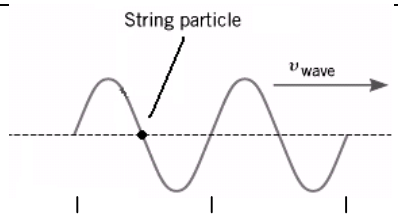
Frequency

9. Name each part of the longitudinal wave shown at right. Indicate the amplitude and wavelength of the wave.



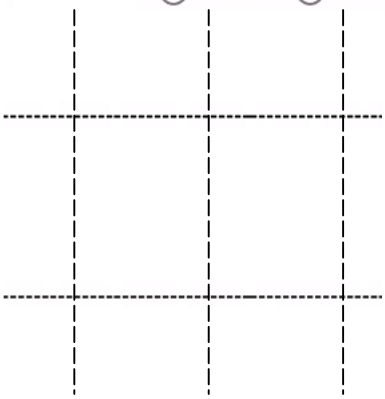
Wave Motion vs. Particle Motion

a) In which direction is the string particle moving at this instant?



b) Sketch the wave and particle after ¼ of a period from the time shown in a).

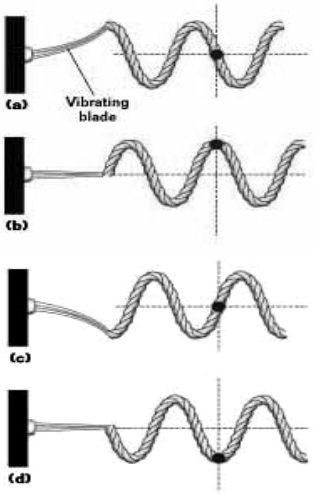
c) Sketch the wave and particle after ½ of a period from the time shown in a).



d) How far will the wave energy travel in one period?

e) How long does it take one complete cycle to pass a given point?

Compare the motion of the wave with the motion of a single particle of the medium.



Wave (energy) motion

Particle motion

Determining the Speed of a Wave

The Wave Equation

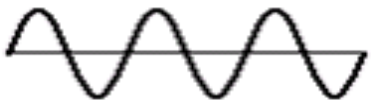
Derivation

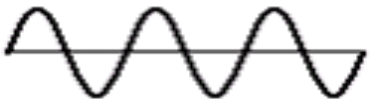
Variable:			
Quantity:			
Units:			
Type:			

1. A buoy moored off-shore bobs up and down as waves pass by. A nearby boater notices that it takes 1.6 seconds for the buoy to move from its lowest position to its highest position, a distance of 0.80 meters. She also notices that the crests of the waves are approximately 2.8 meters apart.

   a) What is the average speed of the buoy?

   b) What is the average speed of the wave?





2. a) On the bottom, sketch a wave that has the same wavelength as the wave on top but a higher amplitude.

   b) A mechanical wave with a higher amplitude has more . . .

   c) Will increasing the amplitude change the speed of the wave?

3. a) On the bottom, sketch a wave that has the same amplitude as the wave on top but a higher frequency.

   b) A wave with a higher frequency has a . . .

   c) Will increasing the frequency change the speed of the wave?

4. How can the speed of a wave be changed?

Sound Waves

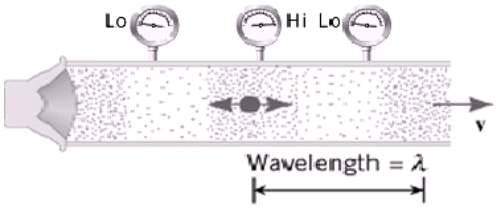
1. How are sound waves produced?

2. What type of a wave is sound?

   a)

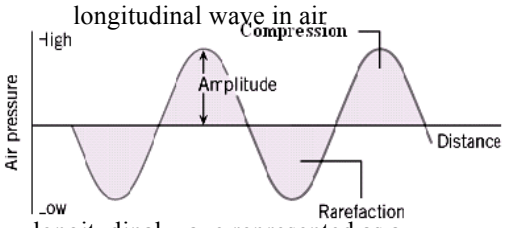
   b)

longitudinal wave in a Slinky



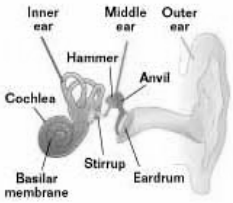
longitudinal wave in air

3. How can a longitudinal wave be represented as a transverse wave?



longitudinal wave represented as a transverse wave

4. What happens when this wave of varying air pressure reaches your ear?



5. Can sound be heard in outer space? Explain.

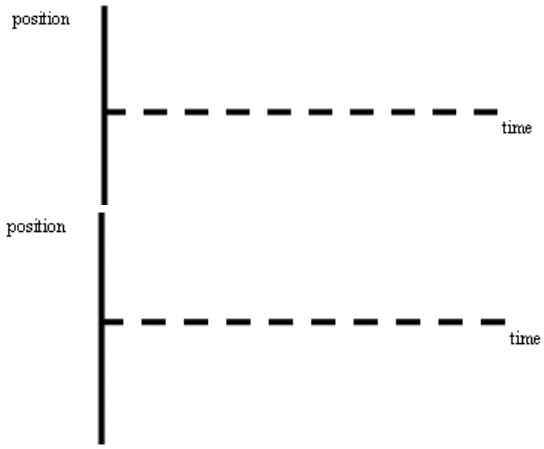
6. Speed of sound in air at STP:

7. Speed of sound in air at room temp:

8. How is the speed of sound related to air temperature? Explain.

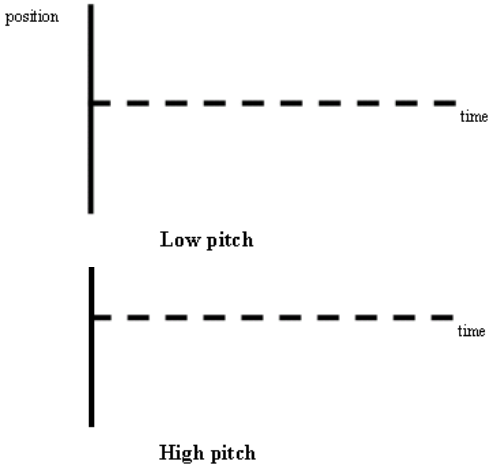
9. Does sound travel fastest in a solid, a liquid, or a gas?

10. As you increase the loudness (volume) of a sound, you increase its . . .



Loud

11. As you increase the pitch of a sound, you …



Low pitch

High pitch

12. In a classroom experiment, a student strikes first a 256 hertz tuning fork and then a 394 hertz one.

a) Which fork plays a note with a higher pitch?

b) Which fork has a greater period?

c) Which note has a longer wavelength?

d) Which note is traveling fastest?

e) Calculate the wavelength and period of the 256 Hz tuning fork.

f) How long would it take a second student to hear a note from the 256 Hz tuning fork if they are sitting 7.5 meters away?

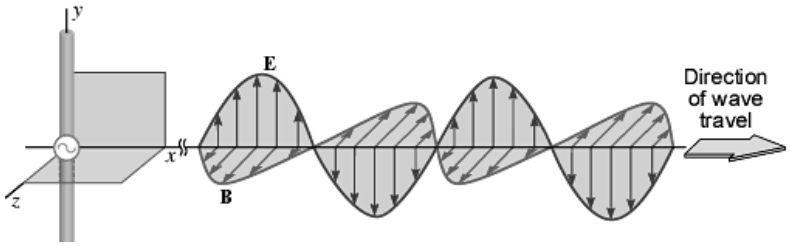
Light Waves

1. How are light waves (and all electromagnetic waves) produced

2. What type of a wave is light?

a)

b)

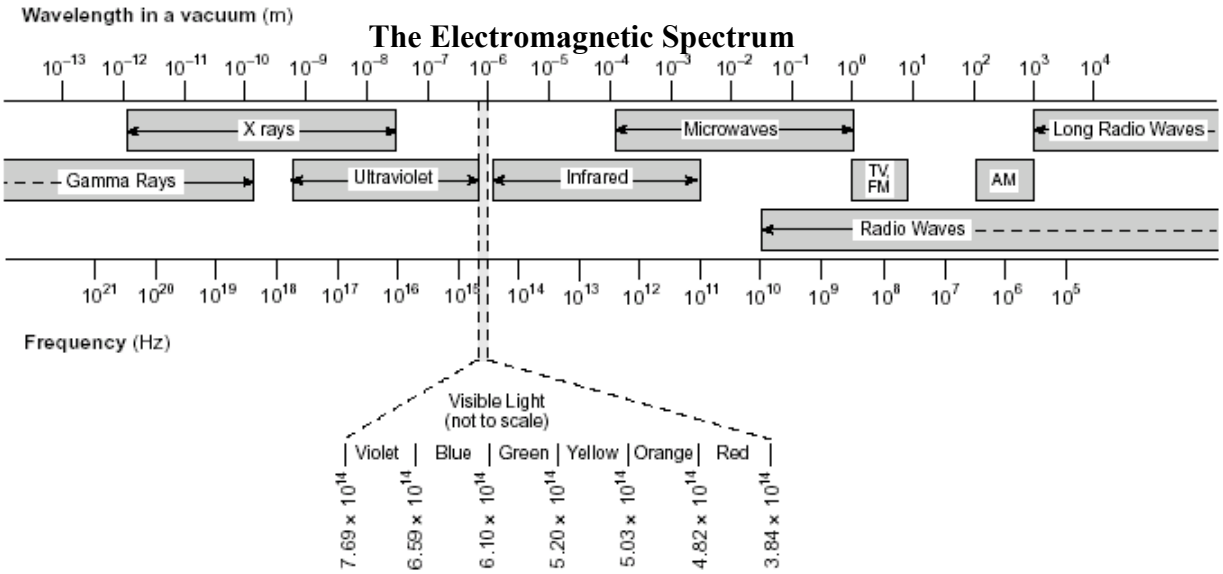


3. How fast does light travel?

in a vacuum:

in air:

in other materials:



4. What is the difference between an X-ray and a microwave?

5. What is the difference between a radio wave and a sound wave?

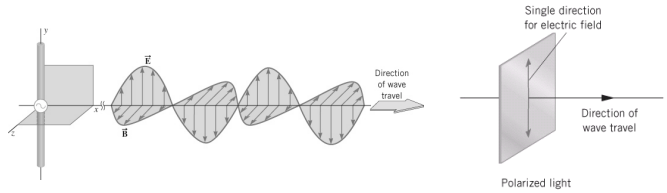
6. Which type of electromagnetic radiation has the highest frequency? Longest wavelength? Highest speed?

7. What range of frequencies is considered to be green light?

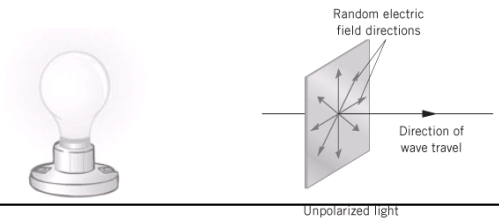
8. Which color of visible light has the highest frequency? Longest wavelength?

Polarization

Polarized Light –



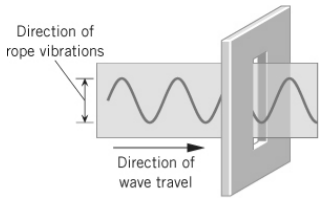
Unpolarized Light



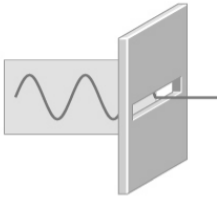
Polarizer –

Transmission axis –

A simple model of a polarizer using a wave on a rope



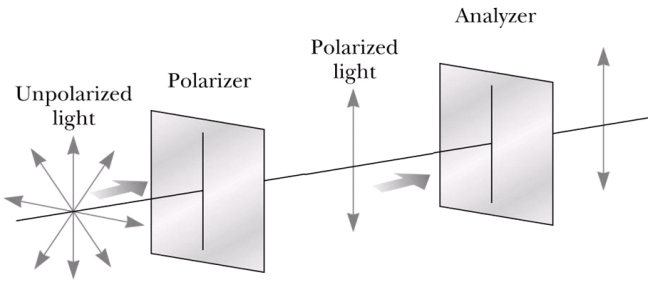
Transmission axis of polarizer is parallel to the plane of polarization of the wave.



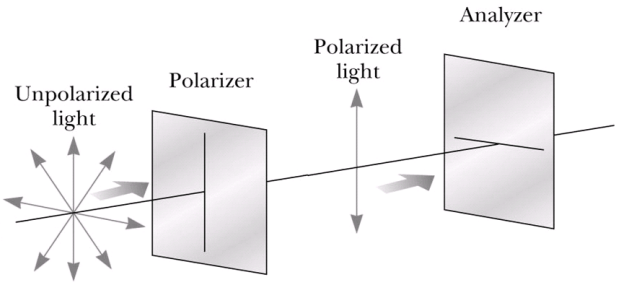
Transmission axis of polarizer is perpendicular to the plane of polarization of the wave.

NOTE:

Analyzer –



When the transmission axis of the analyzer is parallel to that of the polarizer . . .



When the transmission axis of the analyzer is perpendicular to that of the polarizer . . .

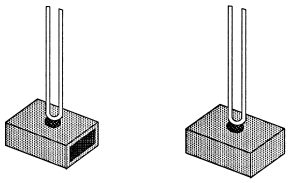
How do polarized sunglasses reduce glare?

Natural Frequency and Resonance

Natural frequency:

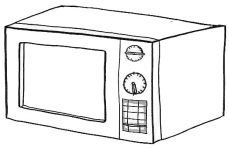
Resonance:

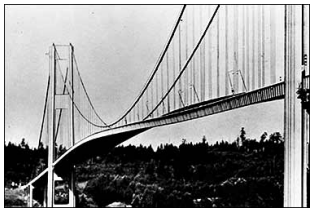
Explain the results of the tuning fork demonstration

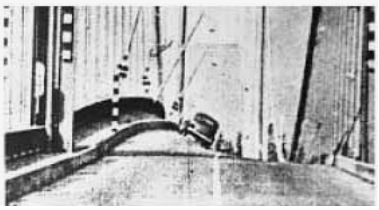


Other examples of resonance:

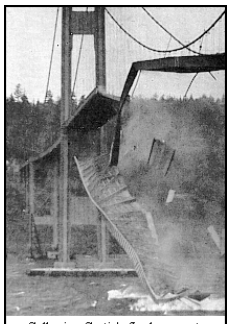
1. Two instruments
2. Swings
3. Wine glasses
4. Bridges
5. Buildings in earthquakes
6. Microwave ovens
7. MRI (Magnetic Resonance Imaging)







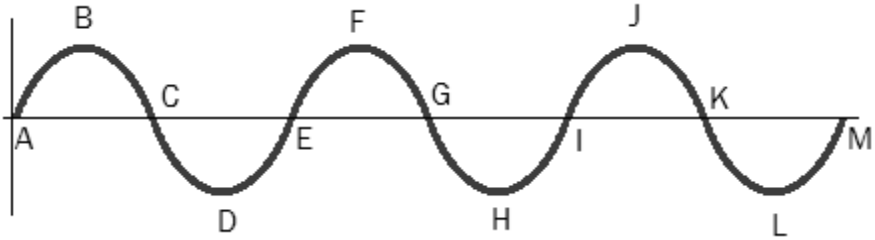
The Tacoma Narrows Bridge (Nov. 7, 1940)



Galloping Gertie's final moments

Phase and Reflections

Phase:



Inspect the labeled graph at right and name points that are:

a) in phase

b) out of phase by 180^0

c) out of phase by 90^0

Fixed End Reflection (Hard Reflection): Reflected pulse is . . .

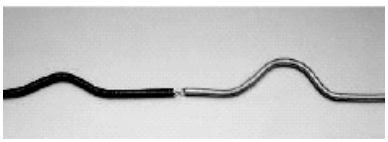
Free End Reflection (Soft Reflection): Reflected pulse is . . .

Waves Crossing Boundaries

In general, whenever a wave (or pulse) reaches a boundary between two media . . .

Before

After



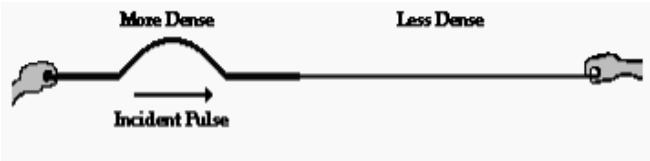
1. When a pulse travels from a less dense to a more dense medium

Before

After

2. When a pulse travels from a more dense to a less dense medium

Before



http://surendranath.tripod.com/Applets.html

3. When a wave crosses a boundary

What characteristic(s) of a wave must remain the same as the wave crosses a boundary between two different media? Explain.

Compare the characteristics of the wave in the two media

Thick rope

Thin rope

Light Crossing a Boundary

A swimmer underwater looks up to see the Sun.
Compare the light wave in air and water.

Sound Crossing a Boundary

A swimmer underwater hears a boat's engine.
Compare the sound wave in air and water.

One Medium

When a wave travels in a single medium, what is the control variable?

Two Media

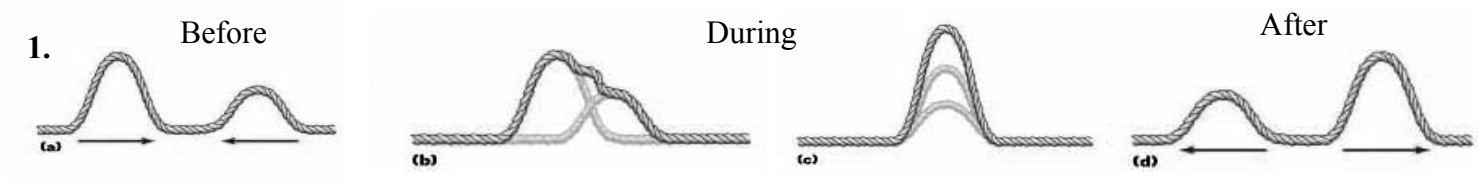
When a wave crosses a boundary between two media, what is the control variable?

Superposition and Interference

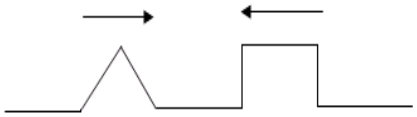
The Principle of Superposition:

Constructive Interference:

1.

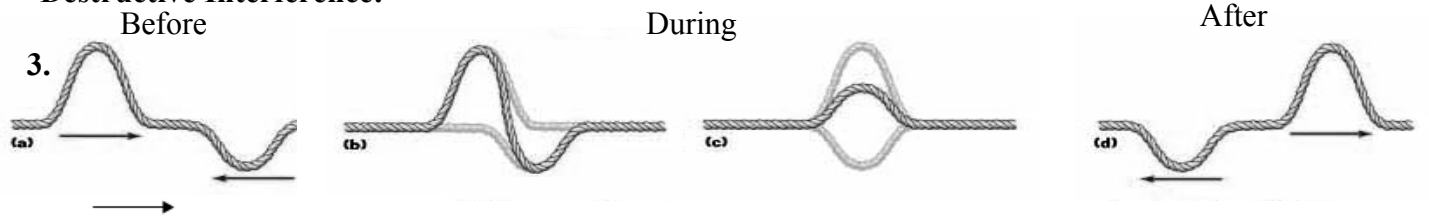


2.

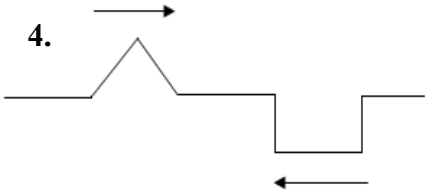


Destructive Interference:

3.



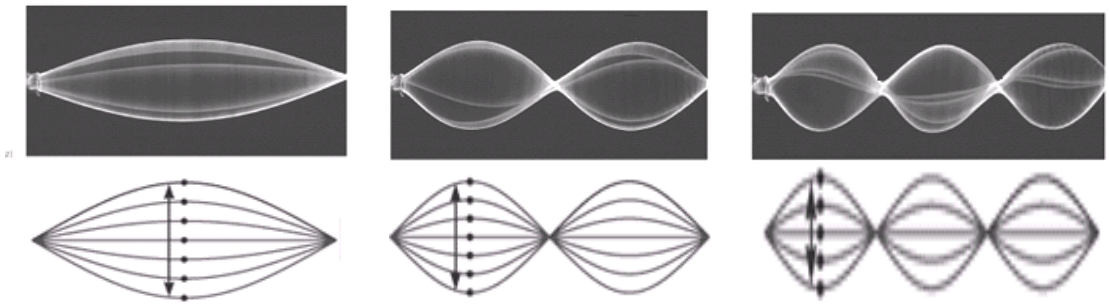
4.



Standing Waves

Traveling Wave: a series of pulses or oscillations that move through a medium

Standing Wave:



Time elapsed photographs of three possible standing waves on a string

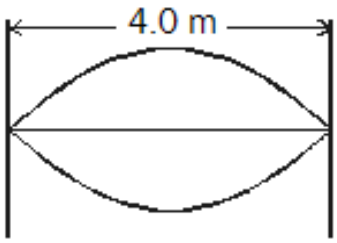
Node:

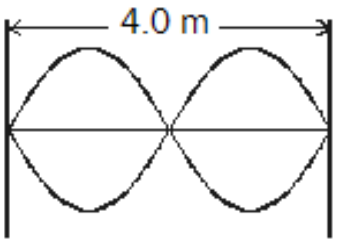
Anti-node:

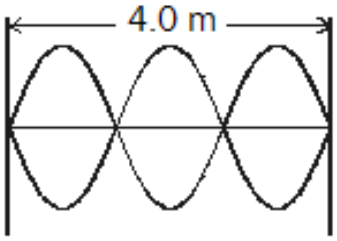
	Sound	**Light**
Node		
Anti-node		

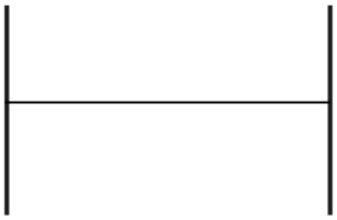
For the standing waves shown below, sketch them in the spaces provided and determine their characteristics. The speed of the component waves making up these standing waves is 12 m/s.

Name: Name: Name:









Wavelength	
Node(s)	
Antinode(s)	
Frequency	

Wavelength	
Node(s)	
Antinode(s)	
Frequency	

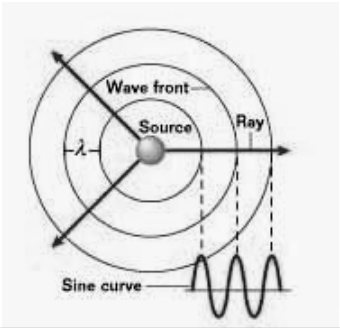
Wavelength	
Node(s)	
Antinode(s)	
Frequency	

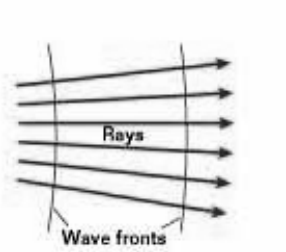
How do the frequencies of the harmonic waves compare to the frequency of the fundamental wave?

What wave phenomena are responsible for the occurrence of standing waves?

Waves in Two or Three Dimensions

Point Source –





Very far from point source

Two-Dimensional Wave Phenomena

Reflection:

Sketch in the reflected ray and wavefronts

Normal line:

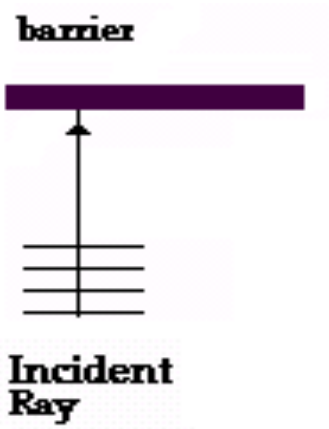
Angle of incidence:

Angle of reflection:

Law of Reflection:

When a wave reflects from a barrier, are there any changes in

a) direction? b) speed? c) wavelength? d) frequency? e) phase?



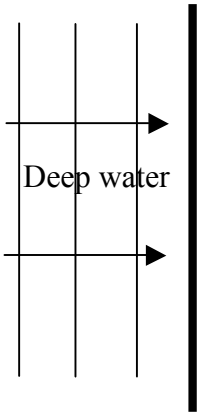
Sketch in the reflected ray and wavefronts.

What is the angle of incidence?

What is the angle of reflection?

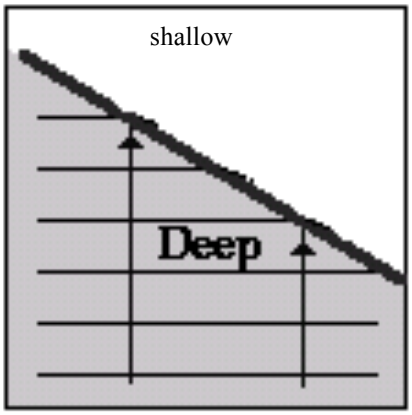
Sketch and label the wavelength of a standing wave.

Complete the diagram below showing the wave moving into shallow water.



When a wave travels from deep water to shallow water, how do its characteristics change?

Refraction:



Complete the diagram showing the refraction of the wave.

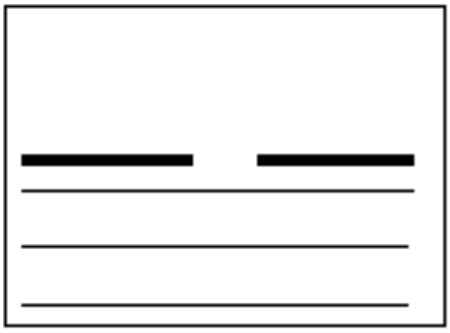
When a wave refracts, are there any changes in

a) direction? b) speed? c) wavelength? d) frequency? e) phase?

Diffraction:

Complete the diagram showing the diffraction of a wave around the edge of a barrier.

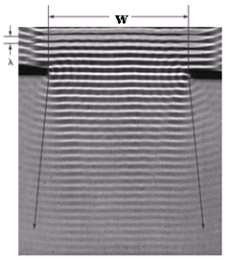
Complete the diagram above showing diffraction through a wide opening.

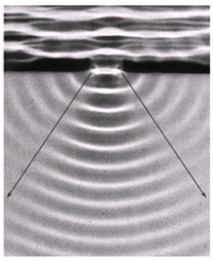


Complete the diagram above showing diffraction through a narrow opening.

1. When a wave diffracts, are there any changes in

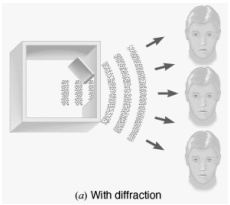
   a) direction? b) speed? c) wavelength? d) frequency? e) phase?

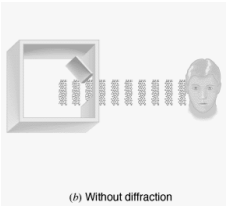




2. What happens to the diffraction pattern as the width of the opening decreases?

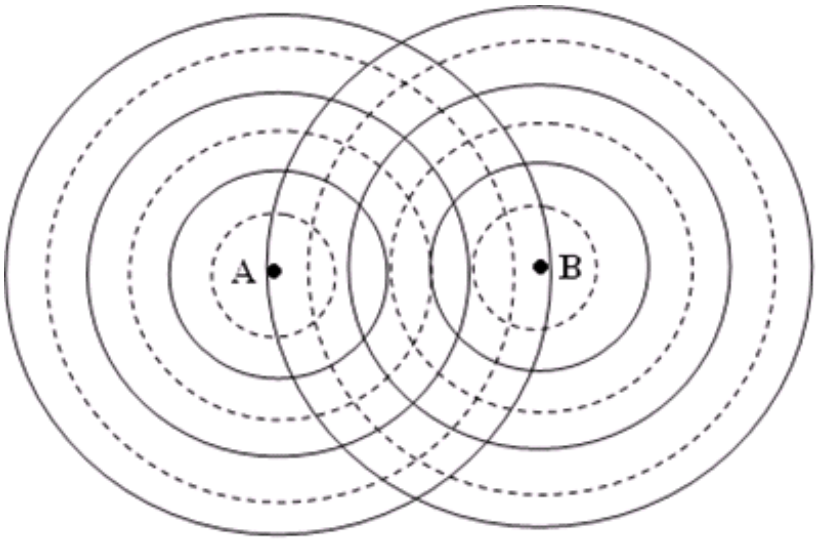
3. Condition for noticeable diffraction to occur:

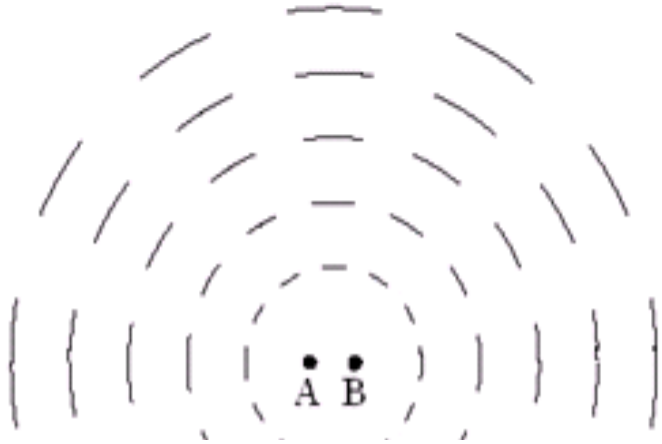




4. Why can you hear around a corner but can't see around a corner?

Two-Source Interference of Waves





Path Length (ℓ) – distance traveled by a wave from source to a location
Path Difference (Δℓ) – difference in path lengths between two waves = $|\ \ell_1 - \ell_2\ |$

Anti-nodal Line:

Nodal Line:

Conditions for Anti-nodal Line

Phase difference:

Path difference: …

Conditions for Nodal Line

Phase difference:

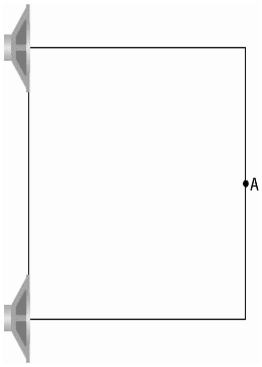
Path difference

Conditions for a stable interference pattern:

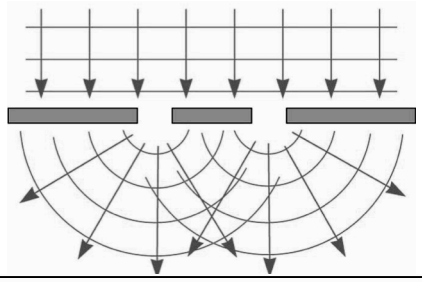
1) waves have approximately same amplitude/intensity and frequency/wavelength

2) sources are coherent

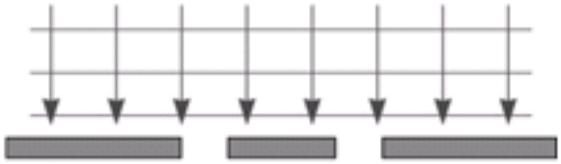
1. A square is 3.5 m on a side, and point A is the midpoint of one of its sides. On the side opposite this spot, two in-phase loudspeakers are located at adjacent corners. Standing at point A, you hear a loud sound and as you walk along the side of the square toward either empty corner, the loudness diminishes gradually but does not entirely disappear until you reach either empty corner, where you hear no sound at all. Find the wavelength of the sound waves.



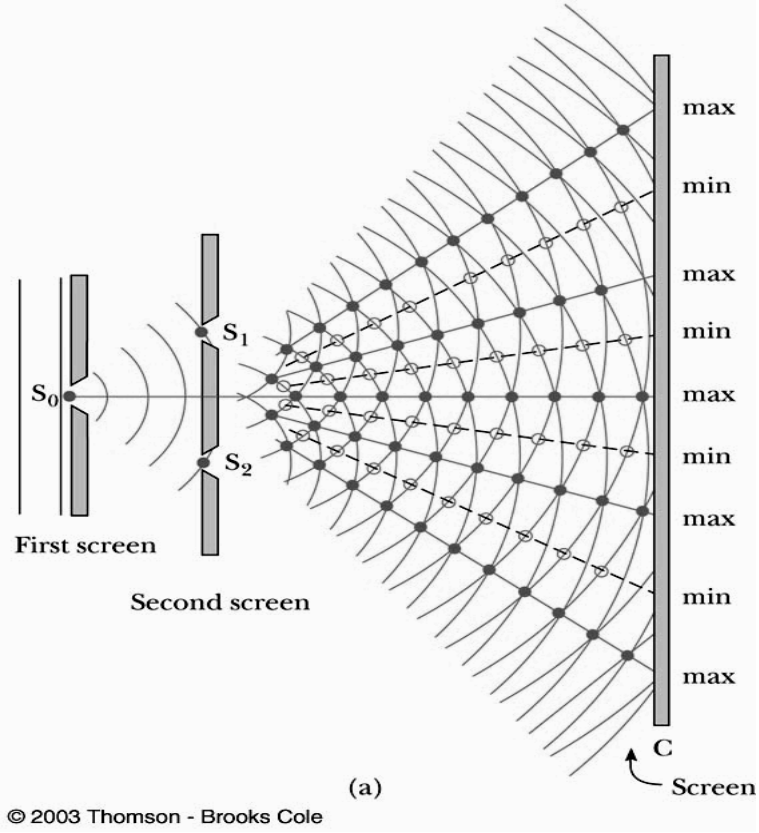
Double Slit Diffraction and Interference



Component Waves



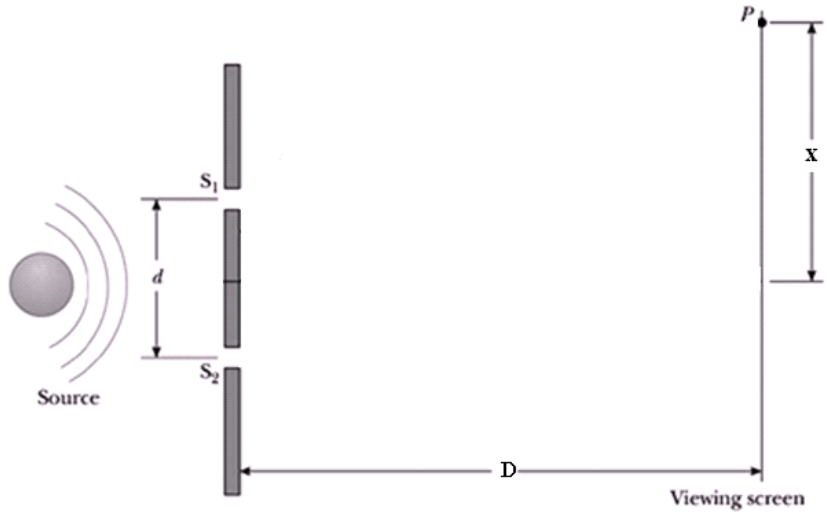
Resultant Wave



Interference Formulas

Bright Fringes:

Dark Fringes:



The Fringe Equations

Constructive Interference **Destructive Interference**

Variable:					
Quantity:					
Units:					

Thomas Young's Double Slit Diffraction

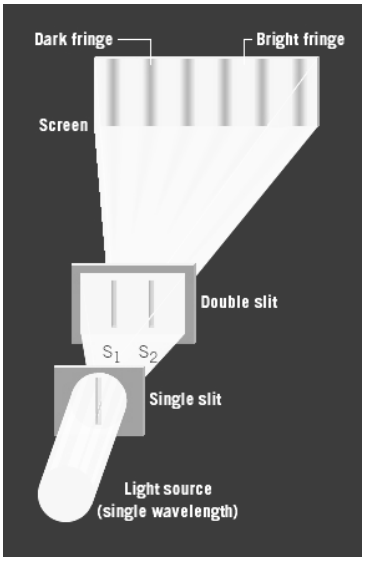
In 1801 the English scientist Thomas Young (1773–1829) performed an historic experiment that demonstrated the wave nature of light by showing that two overlapping light waves interfered with each other.

Importance of experiment:

1.

2.

What is the reason for first having a single and then a double slit?



In a double slit experiment, light whose wavelength is 6.0×10^{-7} m is shone through two slits that are 0.10 mm apart onto a screen that is 2.5 m away. What is the distance between the central maximum and the first bright band?