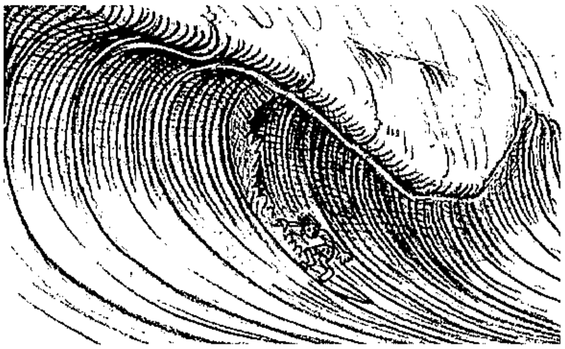
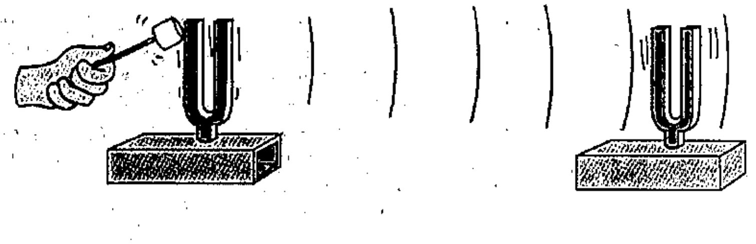
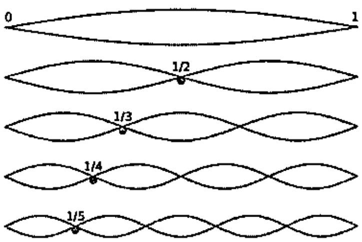
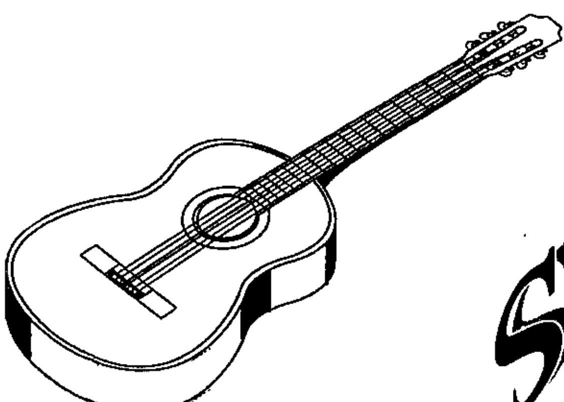


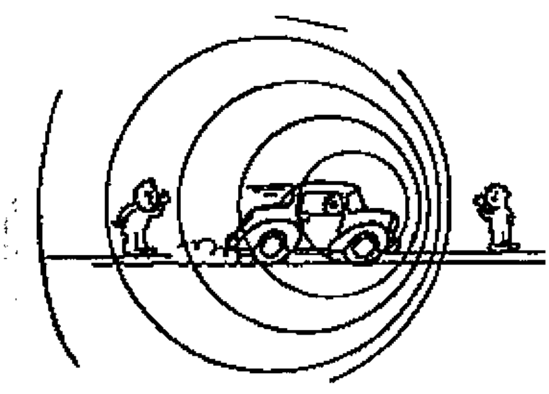


Unit 1: Physics 1



WAVES and SOUND





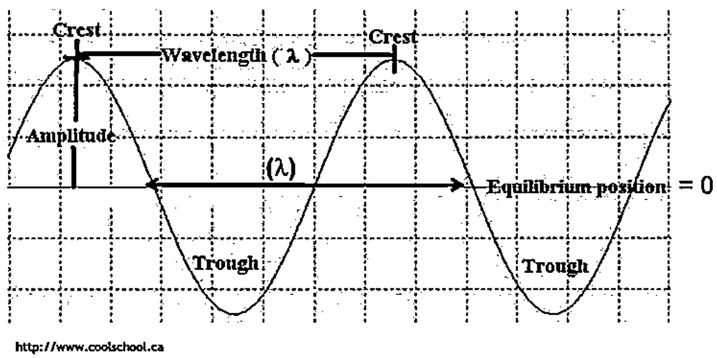
Name________________

Period______

Waves Notes

Wave: a transfer of __________ from one place to another. It does NOT transfer ____________.

Wave Anatomy



Wave terms

Amplitude (A) = height of a wave from baseline (________________ position).

Crest = highest point of a wave.

Trough = lowest point of a wave.

Wavelength (λ) = the length of one __________________ (crest to crest, trough to trough, etc.). λ is pronounced Lambda

2

More wave terms

Frequency (f) = number of waves per unit time.

f = # waves/time

Units: 1/sec = Hertz (Hz)

Period (T)= the time it takes for 1 wave cycle (1 wavelength) to pass a point.

T = time/wave

Units: sec/# waves = sec

Notice that...
$f = 1/T$ and $T = 1/f$.
(_____________ relationship)

Wave Velocity = wavelength x frequency
v = λ x f

Medium: material that transmits the wave. All waves except ____________________________ waves require a medium

Plural of medium = media

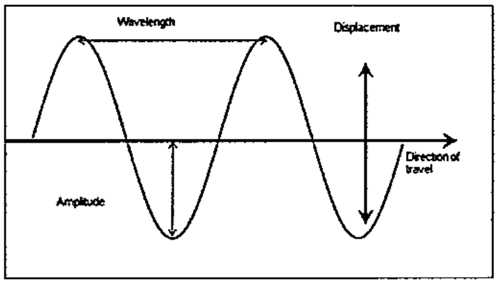
Wave velocity will be the same in any single medium, given identical conditions. For example, the speed of sound in dry air at 20°C is 343 m/sec (~768 mi/hr)

Since velocity stays constant, if wavelength is increased, frequency will decrease and vice versa (__________ relationship): λ↑, then f↓

Two Types of Waves

1. Transverse: particle movement (oscillation) is ________________ to direction of wave movement (energy).

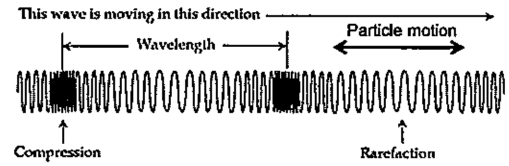
Examples: the surface of ________ waves, ________ in earthquakes and ________________ waves (3-D).



Two Types of Waves

2. Longitudinal: particle movement (oscillation) is ________ to the direction of wave movement (energy).

Examples: ________, __________ in earthquakes.

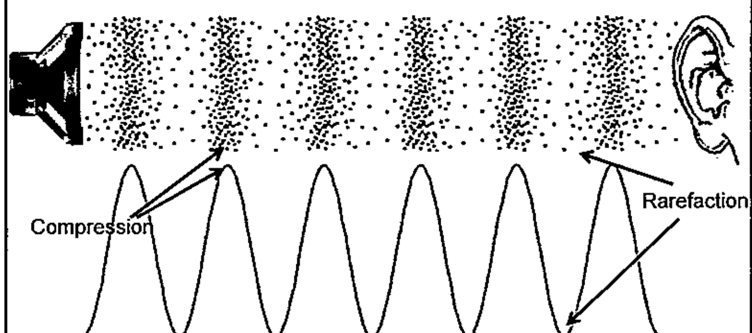


Compression: particles are squished together

__________: particles are stretched apart

Since longitudinal waves are hard to draw, we often represent them as transverse waves.

- Compressions are drawn as __________.
- Rarefactions are drawn as ___________.

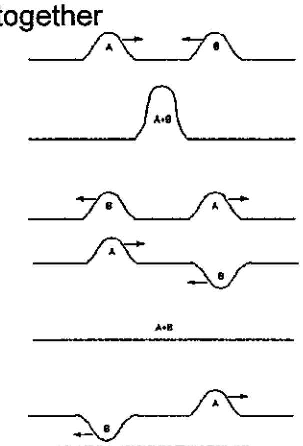


Interference

Law of ______________: When 2 waves meet, their magnitudes will ______ together

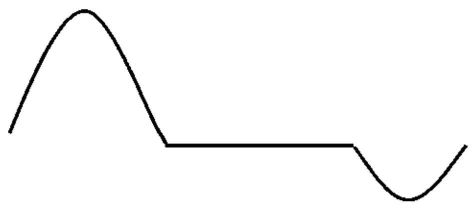
______________ Interference: when 2 or more waves interact to make a bigger wave.

______________ Interference: when 2 or more waves interact to make a smaller wave.



Waves Notes

Interference

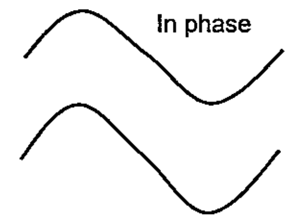


Draw what it will look like when these 2 waves meet:

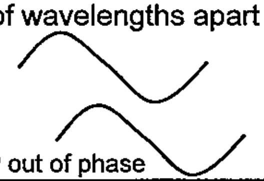
Is this constructive or destructive interference?

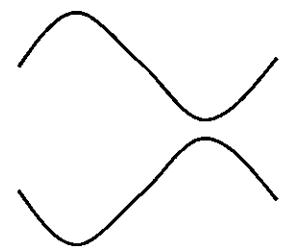
Phase

In Phase: two waves are in phase when any 2 points on the waves are one or more ________ apart



Out of phase: when waves are an uneven (non-whole) number of wavelengths apart





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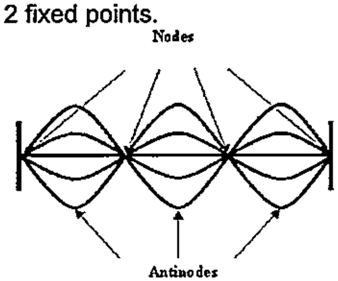
Standing Waves

A stable pattern of ________________________
in waves oscillating between 2 fixed points.

________ wave = incoming wave

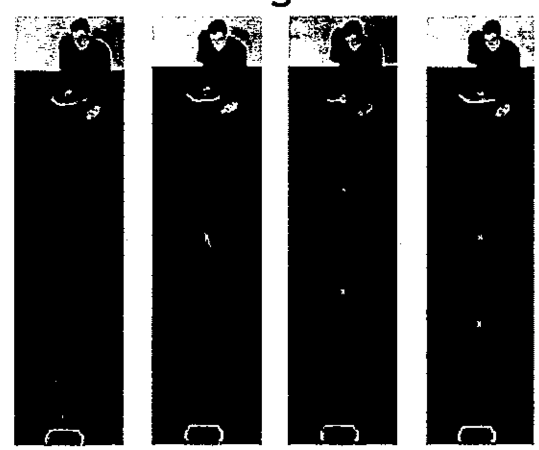
________ wave = wave bouncing off some surface



__________: a place of maximum movement (where __________ interference happens).

_______: a place of minimum movement (where __________ interference happens)

Standing Waves



Water Waves

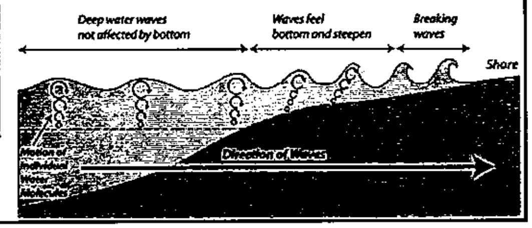
- Water waves are an example of waves that involve a combination of both longitudinal and transverse motions.
- As a wave travels through the waver, the particles travel in *clockwise* __________. The radius of the circles ______________ as the depth into the water increases.
- Things that affect wave height: _____ (distance over which wind blows), Wind_________, Wind ____________

5

Water Waves

- The ________________ of wind-generated waves decreases with depth
- Waves "break" when the sea bottom shallows and causes friction or drag on the bottom of the wave. A walking person who trips is similar.

Breaking Waves



Tsunamis

Tsunami waves carry energy throughout the entire ocean's depth, since they are generated on the ocean ___________

v is approximately 500-600 mi/hr

λ is approximately 100 miles

Calculate the frequency (f) of the wave using the equation

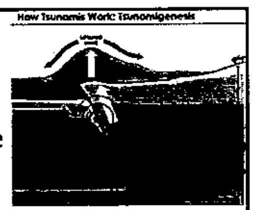
$v = \lambda \times f$

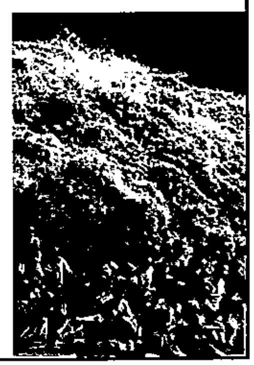
How often will wave crests reach shore?

______________________________.

Amplitude = 1-2 meters in open water.

Why do they do so much damage on land?





Tsunamis

v is approximately 500-600 mi/hr!

λ Is approximately 100 miles!

Calculate the frequency (f) of the wave using the equation

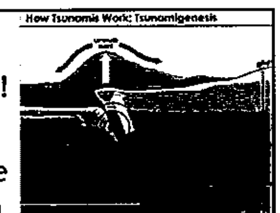
$v = \lambda \times f$

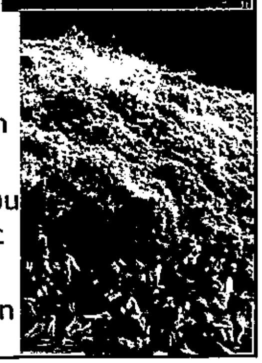
f = ________per hour

How often will wave crests reach shore?

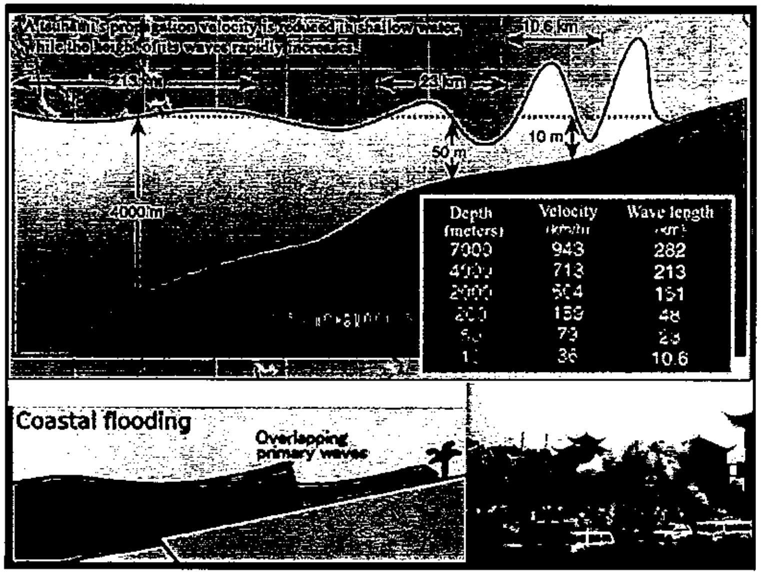
Amplitude = 1 to 2 meters. Can you detect one if you're on a boat at sea? _________

Why do they do so much damage on land?



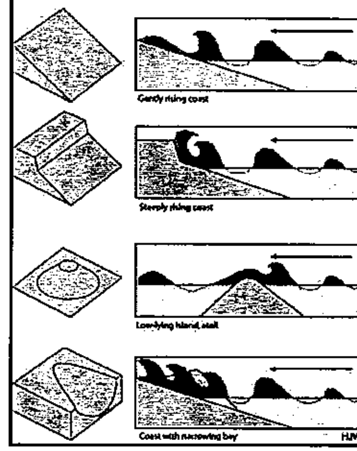


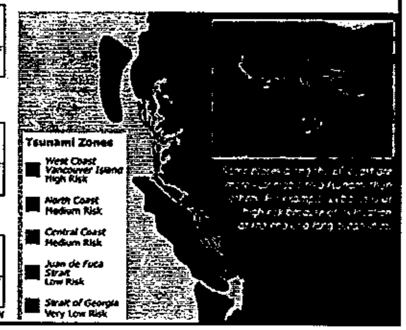
Waves Notes



Tsunamis

Height and distance tsunami travels depends on shape and steepness of the coastline





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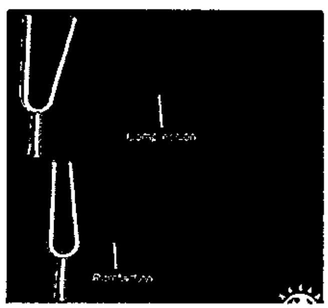
Medium

Medium (plural is media) = any material substances which can propagate (transmit) waves or energy. Most waves need a medium. Light waves are an exception.

As the medium increases in density, the waves will

- Travel ___________
- Travel ___________
- Be higher _____________



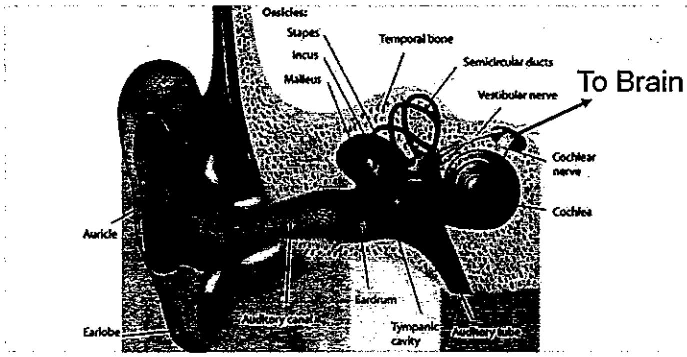
Sound traveling through air needs the a molecules to transmit the wave (energy)

Sound waves in different media

- Sound waves are_________________Waves
- Any object that vibrates can create sound
- Air: 343 m/s (at STP) ~ 767 mi/hr
- Water: 1450-1500 meters per second in distilled water (depending on Temp) and 1531 m/s in sea water at room temperatures (20 to 25 ° C).
- Cork: 366-518 m/s
- Steel: 4880-5050 m/s
- Diamond: 12,000 m/s
- _______________Sounds higher than the human hearing range.
- _______________Sounds lower than the human hearing range.

Waves Notes

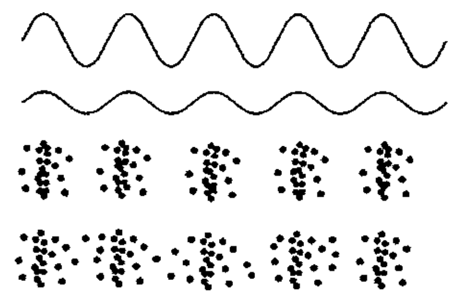
Human Hearing



- Vibrations in the form of longitudinal waves can reach your __________ (hearing center) different ways
- Hearing damage can be caused in different ways.

Wave Energy and Amplitude

- Amplitude is the measure of wave ____________. (Exception: light waves have more than one measure of energy).
- Note the wavelength (l) doesn't change.
- What also doesn't change if λ is constant?

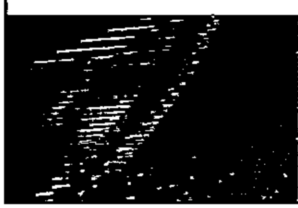


Resonance

Natural Frequency: the frequency something vibrates at when struck. This is also its ________________ resonant frequency.

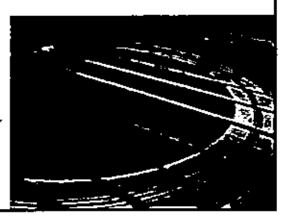
Depends on

1. _____________ of the vibrating object (density, tension or stiffness)
2. The ________ of what is vibrating



Piano

Guitar

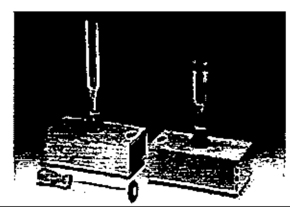


Resonance

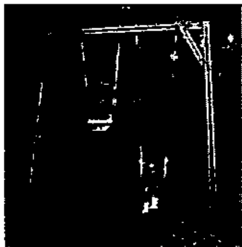
Forced Frequency: when an object is forced to vibrate at a frequency ________________ on it from another object.

Resonance: when the frequency of a vibrating object _____________ the natural frequency of another object, the second object will _____________(in "sympathy" or with "sympathetic vibrations".

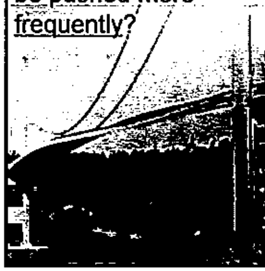
If the vibrating continues, constructive interference causes an increase in _______________ over time.



Examples of Resonance



Which swing must be pushed more frequently?

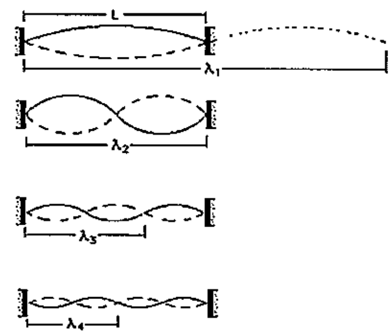


Who must bounce their ball more frequently?

What else was needed besides a fairly strong wind?

Harmonics and Resonance

Harmonics: standing waves created on an instrument or object (string, tube, etc). For the pictures below, assume L = 1 inch and the fundamental is a C note.



1st harmonic = fundamental

λ_1 = __________. (Low C)

2nd harmonic

λ_2 = __________. (______)

3rd harmonic

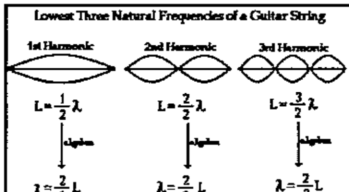
λ_3 = __________. (______)

4th harmonic

λ_4 = __________. (______)

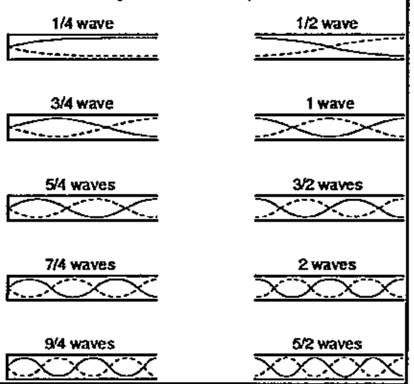
Any instrument plays multiple harmonics when struck (plucked, blown into). These are also called ____________.

8



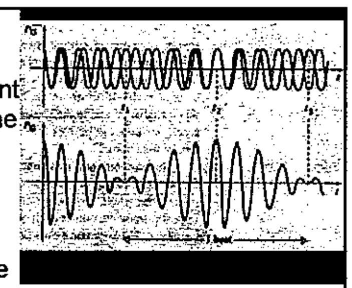
Harmonics and Resonance in Strings and Tubes

- Strings will always have ___________ at the ends because they are fixed (no movement of string)
- Tubes will have a displacement node on _________ ends (no air movement), and anti-nodes on the ______ ends (lots of air movement)

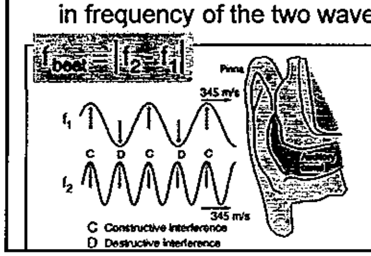


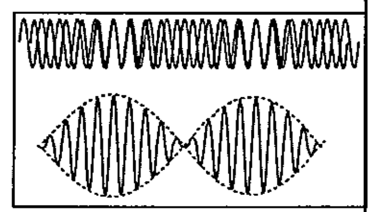
Beats

When two sound waves of different frequency approach your ear, the alternating constructive and destructive interference causes the sound to be alternatively ____________________.



The beat frequency is equal to the absolute value of the difference in frequency of the two waves





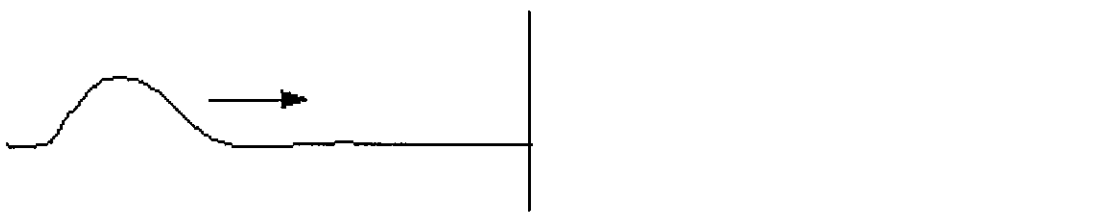
WAVES ON SPRINGS

Name ______________________ Per. _____

Follow the demonstration by your teacher for making pulses on your springs. Use the **slinky** unless it says to use the skinny spring (#5 and #6). Always **keep the springs on the floor** and make sure that each end is held still. Do several trials of each experiment to make sure you get it right. For each question below, draw what happens to each of the waves you make. Be sure to draw **arrows** showing the direction the waves are traveling.

1. **Reflection:** One person makes a pulse while the other person holds their end still.

Original Wave | Reflected Wave



What happened to the **location** of the pulse?

What happened to the **shape** of the pulse?

2. **Interference:** What happens when 2 waves collide? Each person makes a pulse on the **same side** of the spring.
   a. **Waves that are the same size:**

Original Waves

Waves at collision:

Waves after the collision

Do you think the waves are bouncing off each other or passing through each other? How can you tell?

2. **Interference continued:**

b. Waves of different sizes: One person makes a large wave, the other makes a small wave.

Waves at beginning:

Waves **after** the collision (after they have met in the middle)

Did these waves bounce off each other or pass through each other? How can you tell?

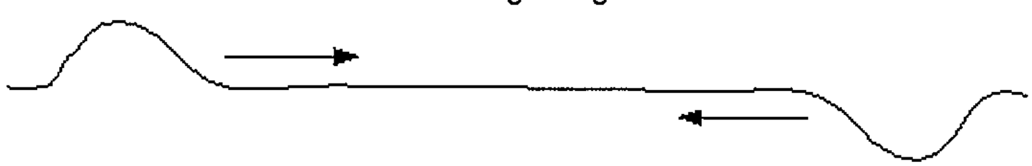
How do waves traveling on the same side of a spring affect each other when they collide?

What kind of interference is this called? ______________________________

How do waves traveling on the same side of a spring affect each other **after** they have collided?

c. Waves on opposite side of the spring: now create 2 waves on opposite sides of the spring. Have a third person stand close to where they meet and observe carefully.

Waves at beginning:



Waves at collision:

Waves after collision:

2. **Interference cont'd:**

   c. **waves of different sizes cont'd**

   How do the waves traveling on opposite sides of the spring affect each other when they collide?

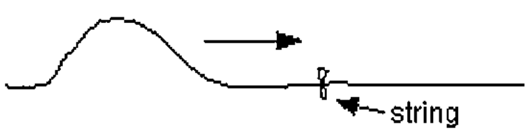
   What type of interference is this called? ______________________________

   How are the waves affected by each other after the collision?

3. **Types of Waves:**

   a. **Transverse:** (also called side-to-side or S-waves) These are the waves you have already been making. Attach a string somewhere in the middle of the slinky. Make a pulse and observe the motion of the string as the wave moves through it. Draw the motion of the string only.

   Transverse Wave — Motion of String

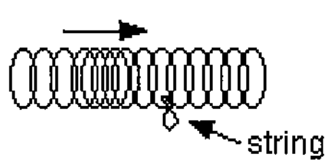


   How does the direction of motion of the string compare to the wave direction?

   What is the string's location after the wave has fully passed it by?

   b. **Longitudinal:** (also called push-pull or compressional) These waves are made by squishing the slinky together (compressing it) and then letting go. Make a pulse and observe the motion of the string. Draw the motion of the string only.

   Longitudinal Wave — Motion of String



   How does the direction of motion of the string compare to the wave direction?

3b. Longitudinal Waves continued:

What is the string's location after the wave has fully passed it by?

What does the wave do to the slinky as is travels down the length of it?

How would you make a longitudinal wave with a larger amplitude (a stronger wave)?

4. Energy: Make side-to-side pulses using different amounts of energy. Draw a low energy and a high energy pulse. (Hint: a high energy pulse is **not** faster).

Low energy pulse | High energy pulse

What do you have to do to create a pulse that has more energy?

Besides measuring how much energy you are exerting on the spring, what measurement can you make of the spring to indicate its energy level?

Measure the time it takes for the wave to travel down the spring, and then measure the time it takes for the wave to return to its origin. Does the returning wave travel faster, slower, or at the same speed as the outgoing wave?

What happens to the amplitude of the wave as it travels back and forth? Why?

How can you create a higher energy longitudinal (push-pull) wave?

How would you measure the amplitude of a longitudinal wave?

5. **Speed:** Use a **skinny spring** for this section (except for 5d). Predict which of the following actions will make a side-to-side wave move faster. Then test your predictions by trying each one. You should have a control wave time (using your basic pulse) for comparison. Time your waves carefully!

Control wave time for one round-trip: ________________

Round trip Time (sec)

	Prediction	**Trial 1**	**Trial 2**	**Trial 3**	**Avg.**
a. Make a larger amplitude pulse					
b. Make a quicker motion to the side					
c. Stretch the spring more tightly (gather many coils together in your hands)					
d. Use a looser spring (a slinky)					

What conclusions can you make about what determines the speed of a wave on a spring?

6. **Standing Waves:** Use a **skinny spring** for this section. One person generates a standing wave by making regular pulses while the other person holds their end still. It might take some practice to get a standing wave going. Draw the standing wave you create below, carefully noting all the anti-nodes you make.

How many anti-nodes does your standing wave have? _________

Try making a standing wave with more or less anti-nodes than the one you have. Draw your new standing wave below and record its number of anti-nodes.

Anti-nodes: ______

What did you have to do to get the different standing wave?

Name________________________________Per.______

Physics Cinema Classics Laserdisc Questions: Waves

Chapter 12: Energy Transfer

1. What type of waves are water waves at the surface? ______________________________

2. What happens to individual portions of water as waves pass through the water?

3. A slinky can knock down a bowling pin because it transfers _____________. Waves do not transfer

_________________.

Chapter 13: Various Media

4. What happens to the speed of a pulse after it is reflected?

5. How does the speed of the slinky that is stretched more compare to the less stretched slinky?

6. What is another difference with the slinky that has more tension in it compared to the looser slinky?

7. How does using a denser medium affect the speed of a wave pulse?

8. How does using a denser medium affect how long a wave pulse will last?

Chapter 14: Wave Machine

9. Which of these things affects the speed of a pulse? (Write yes or no)

   A. Shape of the pulse: ______

   B. Amplitude of pulse: ______

   C. Using different media: ______

Chapter 15: Longitudinal Waves

10. Define rarefaction:

11. Define compression:

Chapters 31 and 32: Computer Animations of interference:

12. Draw what happens when 2 wave crests meet:

13. What is superposition?

14. Draw what happens when a crest and a trough meet:

15. What is the size and shape of the waves after they pass through each other?

Chapter 33: Standing Waves in Sound Waves (or chapter 46)

16. When the amplitude is at a minimum, what part of a standing wave is located at this point? _______

17. What part of a standing wave is located where the current is at maximum amplitude? ___________

Chapter 41: Standing Waves in Wires:

18. What is the relationship between wavelength and the distance between nodes?

19. What happens to the pitch as the number of nodes increases in a circular wire?

Chapter 42: Standing Wave Machine

16. Standing waves are created when reflected waves interfere with _____________________.

17. Define Node:

18. Define Antinode:

Chapter 43: Standing waves in slinkies:

19. What do antinodes look like in longitudinal slinky waves?

Chapter 52: Wave machines and different media

20. At the boundary between 2 different media, part of the wave is ______________________

and part of it is _____________________________.

Chapter 53: Water: Plane Surfaces

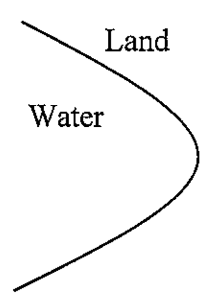
21. The angle of incidence __________________ the angle of reflection.

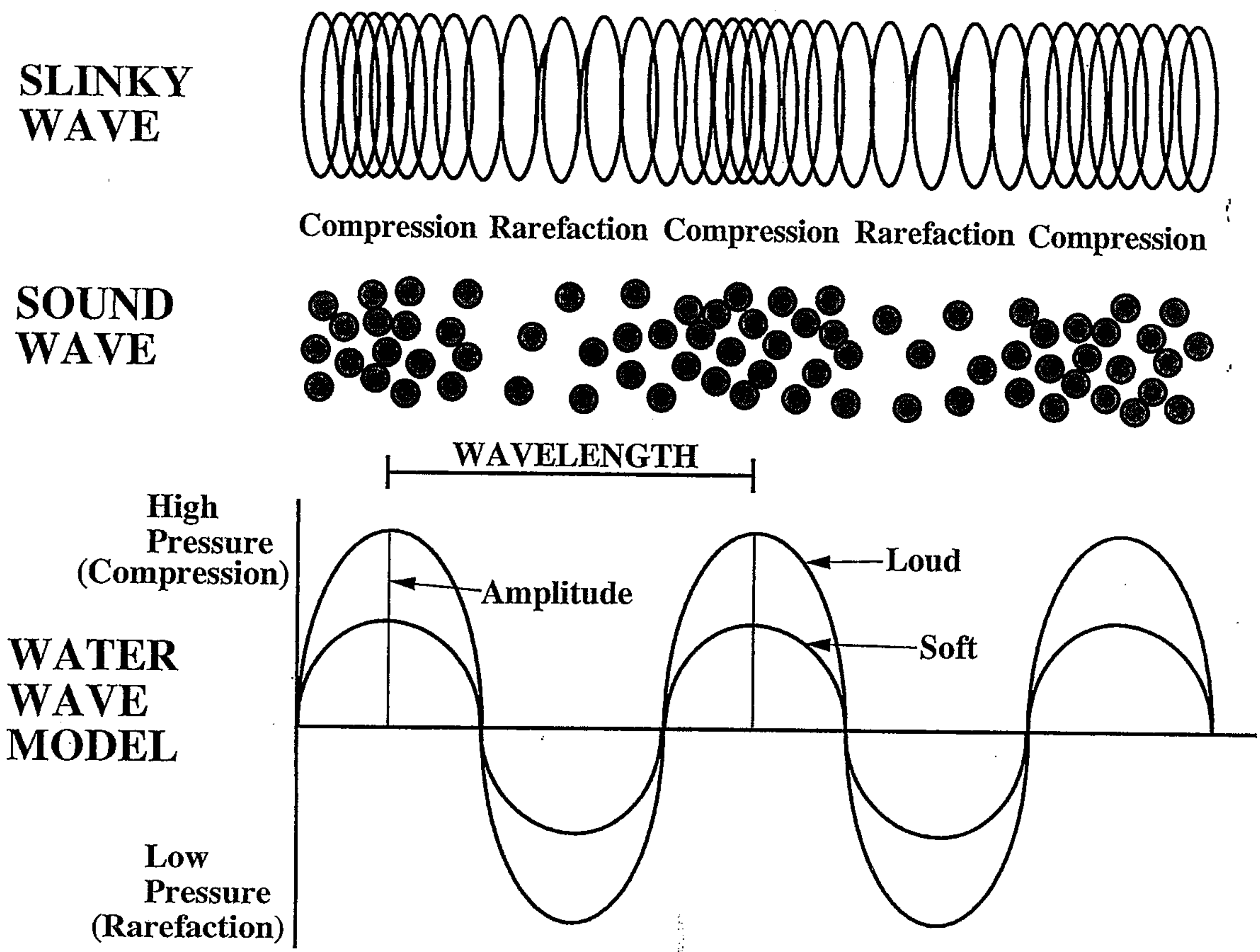
Chapter 54: Curved Surfaces

22. Where will a wave generated at one focal point of an ellipse converge?

23. Where will waves generated at the center of a circle or semi-circle converge?

24. Label the part of a harbor shown at the right where the wave energy will be greatest.




SLINKY WAVE
Compression Rarefaction Compression Rarefaction Compression
SOUND WAVE
WAVELENGTH
High Pressure (Compression)
Amplitude
Loud
Soft
WATER WAVE MODEL
Low Pressure (Rarefaction)

Name ____________________________ Per. ______

Cheap Music-Makers: Rulers, Straws, and Bottles

Rulers and Meter sticks:

1. Hold a ruler flat on a table with some of the ruler extending over the edge of the table. Pluck the ruler. Why is the ruler making a sound? Explain in terms what makes a longitudinal wave.

2. Draw a picture of the vibrating ruler and the longitudinal sound waves coming off of it.

3. Try varying the amount of ruler that is extended over the table edge. What makes a higher sound? Why?

4. Practice with this until you can play "Mary had a Little Lamb." For the first 3 notes of the song ("Mary had a"), how far do you have to move the ruler each time to get the new note?

5. Pluck a meter stick. Keep extending more of the meter stick out until you cannot hear the sounds it makes anymore. You now have a frequency that is beyond the hearing capabilities of the human ear. This is called **infrasound**. Female elephants use infrasound to attract male elephants, who can hear the sound several miles away. What is sound higher than the human range called? ________________ Dolphins, who can hear each other up to 500 miles away in the ocean, can make notes that are up to 100 times higher than sounds people can hear.

Straws:

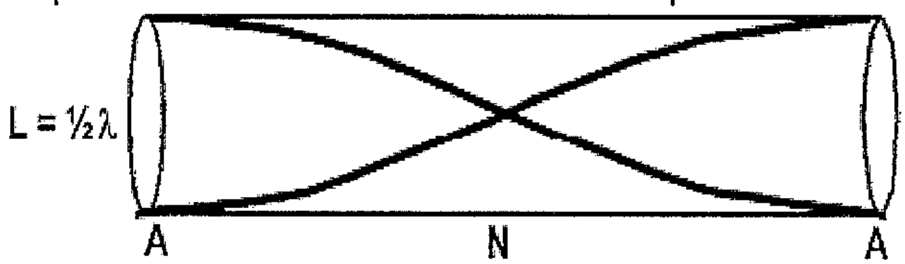
5. Grab 2 straws, some scissors, and some tape. Cut one straw in half, then cut one of the halves in half. You should now have three straws, each of which is double the length of the next shorter straw. Tape the 3 cut straws together, leaving about 1 cm in between the straws. Blow across the tops of the straws. What is vibrating?

6. How does the length of the straw affect the pitch of the sound you make?

7. How is the wave changed by shortening a straw? (i.e. what happens to its wavelength and frequency?)

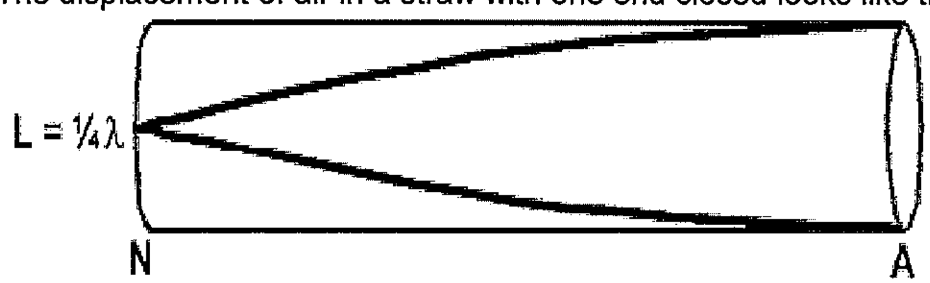
8. Now plug the end of one of your straws with your finger and blow until you get a clear sound. There are two changes to the sound you hear. What are they?

9. The displacement of air in a straw with both ends open looks like this:



A transverse wave is used to represent the standing sound wave within the tube. The wave represents movement of air back and forth between the two ends of the open pipe. Air can move freely through the open ends, so these are anti-nodes.

The displacement of air in a straw with one end closed looks like this:



Since air cannot move back and forth through the closed end, there is a node located there. L represents the length of the straw. How does the wavelength of the air vibrating within the straw change when one end is closed change compared to when both ends are open?

In musical terms, how are the 2 notes you hear (end open and end closed) related?

Straws continued:

9. Take an uncut straw and cut the top of it so that it is tapered or pointed. Flatten this tapered end and put this end in your mouth and blow.
   a. Why is this sound different than the sounds you were making before?

b. Cut off small amounts of straw while you are blowing. How does this affect the sounds you make? Why?

Bottles:

10. Grab 3 flasks and fill them up with varying amounts of water. Strike the bottles with a pencil.
    a. Which bottle makes the lowest sound? Why?

    b. Now blow across the tops of your bottles. Which bottle makes the lowest sound? Why?

    c. How can you explain this using what you learned with the rulers and straws? Think about what is vibrating in each case.

Big Idea: Think about what affects the pitch in each of the cheap instruments you made today.
How does wavelength affect pitch?

Why does wavelength affect pitch?

NAME________________________Period_____

Fishing Line Guitar

Purpose: To see how length and tension on a string can be manipulated to create sounds of different pitches.

Materials:

C-clamp	1-meter length of a thick monofilament (fishing line)
Dowel	1-meter length of a thin monofilament line
Ruler	500g mass

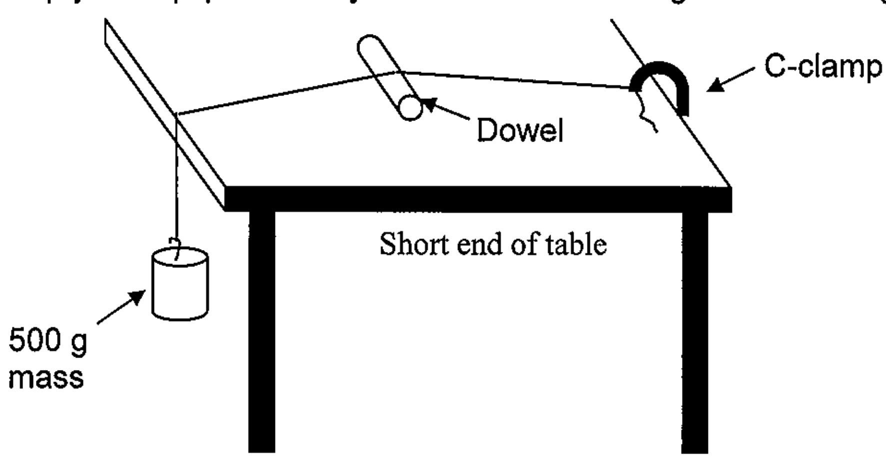
Background:

1. What is the relationship between wavelength, frequency, and velocity?

2. What is the relationship between frequency and pitch?

Procedure:

3. Set up your equipment on your lab table according to the drawing below:



Note: This is similar in some ways to a violin or guitar. The dowel acts like the bridge or frets of the instrument.

Length:

4. With a 500 gram mass on the fishing line and the dowel exactly half-way between where the C-clamp holds the line and the opposite edge of the desk, pluck the line gently with your finger and listen to the pitch. Now move the dowel so that the distance between it and the C-clamp is half as large as before and pluck the line again.

How does the pitch change on the long side?

How does the pitch change on the short side?

You should hear a relationship between the first note you played, and the note played on a string that is half as long. What is it?

Why does the pitch (frequency) change? Are you changing wavelength, wave velocity, or both?

What does a guitarist do to change the pitch of a string while she or he is playing a tune?

How many different notes can you play on a guitar or violin by changing the length of a string?

Tension:

5. Put the dowel back in the center, pluck the string, and listen to the note. Now hang a 1 kg mass on your line to double the mass. Pluck the string again and listen to the pitch.

How does the pitch change as additional mass is added?

Mathematically, here is how tension affects wave velocity:

$$v = \sqrt{\frac{T}{\mu}}$$

T = Tension
μ = linear density

Why does increasing the tension cause the pitch to change? Relate your answer to the relationship among wavelength, wave velocity, and frequency.

Thickness:

6. Replace the 500 gram mass on your string, pluck, and listen to the frequency. Now replace the string with the thinner fishing line. Keep the dowel in the same place.

How does the thickness of the string (fishing line) affect the pitch?

Why does a thinner string affect the pitch? Hint: Look at the equation above that relates tension and linear density to wave velocity.

Big Idea:

7. Length, tension, and thickness of a string can all be manipulated to change pitch. Which of these manipulate wave velocity, and which manipulate wavelength to change pitch?

Loudness:

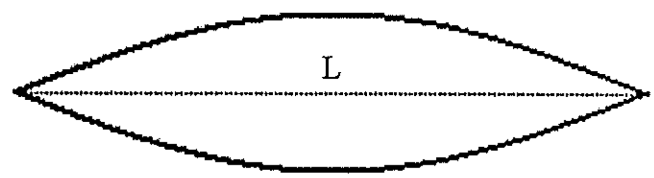
8. Describe why plucking the line harder makes it play a louder note in terms of the longitudinal waves created.

Describe a design change you could make to the fishing line guitar to make it sound louder without plucking it harder.

Standing waves, Wavelength, and Frequency:

9. When you pluck a guitar string, the fundamental frequency is the lowest frequency created by the longest possible standing wave in the string. It looks like this:

The fundamental frequency of a vibrating guitar string will have a wavelength = 2L, where L is the length of the part of the string that is vibrating. Pluck the line and listen to the frequency.



Measure the length between the table and the bridge for the portion of the string you plucked. How long is one full wavelength?

_______________ m

10. Gently hold the fishing line in the exact middle with your index finger and thumb. Pluck the string on either side of where you are holding it.

How long is one wavelength now? _____________ m

Compare and contrast this pitch to the one you heard when you did not hold the string in the middle (Question #9). What is the same, and what is different?

11. **Big idea:** How are you changing the frequency each time you cut the wavelength in half?

12. What are these notes that are related by cutting the wavelength in half called in musical terms?

Name________________________________Per.______

Physics Cinema Classics Laserdisc Questions: Sound

Chapter 11: Wave Vocabulary (Sound)

1. What happens to the wavelength as the frequency is increased?

2. What is the difference in pitch between a guitar vibrating at 55 Hz, and a piano vibrating at 1568 Hz?

3. How many full wavelengths do you see on the screen when a low A note is played? ______

4. How many full wavelengths do you see on the screen when a middle A note is played? ______

5. How many full wavelengths do you see on the screen when a high A note is played? ______

6. What is the relationship between octaves and the number of wavelengths for those notes?

7. How does the wave of a louder sound look different on an oscilloscope compared to a softer sound?

Chapter 16: Sound

8. What type of waves are sound waves?

9. When the air is pumped out of a container with a ringing bell in it, what happens to the sound of the bell? Why?

Chapter 17: Ultrasound

10. Define ultrasonic:

11. What are sounds too low for humans to hear called? ______________________

Chapter 22: Sound

12. Why is there a delay in when you see the woodcutter hit the wood and when you hear it?

13. Why is sound traveling through the railroad tracks faster than sound traveling through air?

14. What happens to a wave when the frequency is increased?

15. What happens to the pitch when the frequency is increased?

Chapter 26: Sound and Light:

16. How far away is the lightning in the video?
    To calculate: Distance in km ~ Time delay/3 =
    Distance in miles ~ Time delay/5 =

Tacoma Narrows Bridge Questions

Name________________________

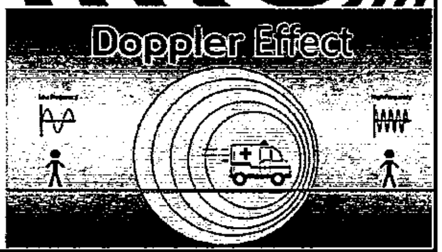
1. When did the Tacoma Narrows Bridge open, and how long did it last? ________________________
2. What was noticed almost immediately after the bridge opened, and why was it called 'Galloping Gertie'?
3. Did the oscillation of the bridge increase when the wind speed increased? ____________
4. What happened to Tubby? Why was Tubby's owner driving on the bridge just before it went down?
5. How high was the wind during the collapse?_____________________
6. During experiments with a model bridge, a fan, and a wooden board which could create a pulsing wind on the bridge, which combination of factors (fan speed, pulsing speed, etc) produced the largest oscillations in the model bridge?
7. Define Fundamental Frequency
8. Draw a standing wave produced when the fundamental frequency is doubled. Which harmonic is this?
9. In order to get a standing wave, what is the relationship that the wave must have to the fundamental frequency?
10. Which harmonic was produced at mid-span immediately before the bridge collapsed? ___________
11. Why did the bridge collapse, according to the laser disc? Hint: it WASN'T due to gusts of wind or high wind speed, but related to pulsing wind, resonance, and shedding of vortices. Write your explanation in words below, and illustrate it with a labeled diagram.
12. Why do flags flutter in the wind?
13. Give a few other examples of resonance listed at the end of the laserdisc.

25

Doppler Effect

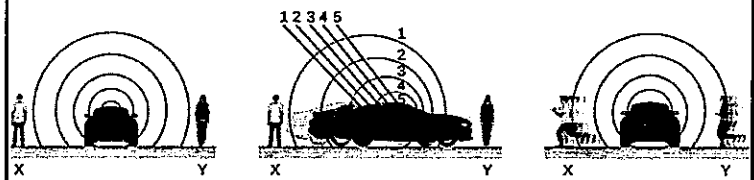
- The ____________ change in frequency due to a moving wave source, or due to the observer moving relative to a stationary wave source
- Object moving toward you: frequency will be __________

Object moving away from you: frequency will be ____________



Doppler Effect

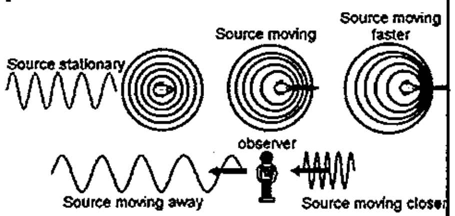
- If the observer moves towards a stationary wave source, the frequency will be __________
- If the observer moves away from a stationary wave source, the frequency will be __________

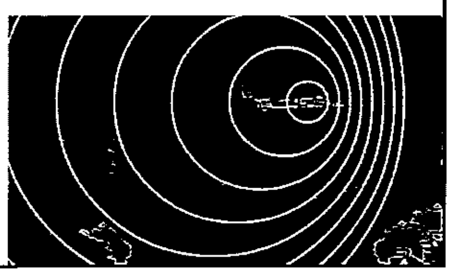


(a) Stationary source and observers
(b) Moving source, stationary observers
(c) Stationary source, moving observers

Doppler Effect

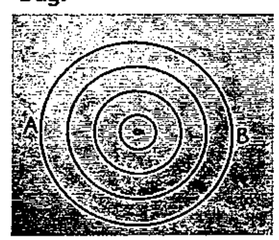
- As the source moves faster, the amount of frequency change gets __________
- Passenger aircraft travel slower than the speed of sound (~740 mi/hr). What happens if they exceed the "Sound barrier"?

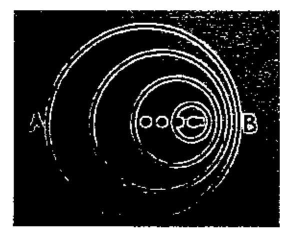




Doppler Effect

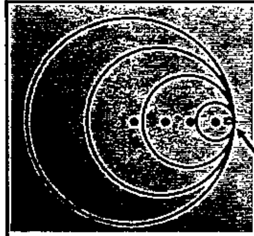
- Picture a bug swimming in water increases.
- The lines represent wave crests.
- The dots on the second picture show where the bug was when it made each of the circles.
- Label what is happening to the speed of the bug relative to the speed of the water waves moving outwards from the bug.



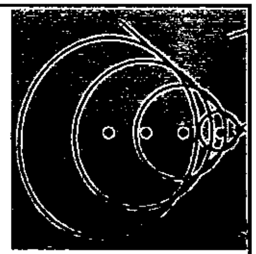


Bug is __________ Speed of bug___Speed of water wave

Doppler Effect



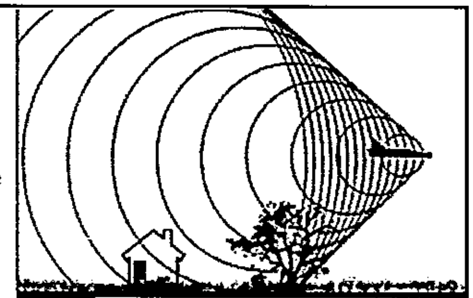
Wave Barrier

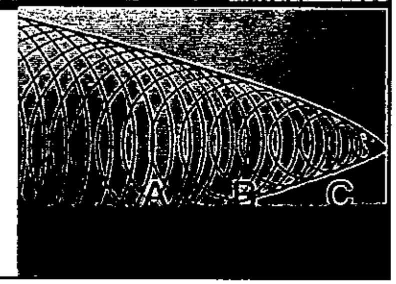


Speed of bug ___Speed of wave   Speed of bug ___Speed of wave

- What happens to the distance between blue dots as the bug swims faster and faster? ____________________
- The pile up of waves in front of the bug when his speed matches the wave speed is called a _____________
- The "V" behind the bug when it exceeds the speed of the wave is called a _____________(bow wave in water).
- If the bug swims even faster than the last picture, what will happen to the shape of the "V" ____________________

Sonic Boom

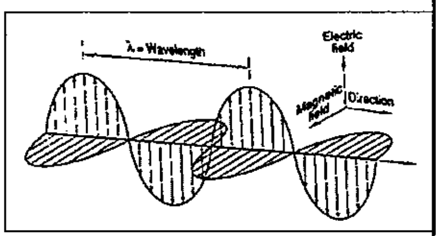




- For sound waves, the pile up of waves on the cone of ___________ ____________creates a very loud sound.
- This is the sonic boom
- What would you hear at....
- Point A (inside the cone): ______________
- Point B (on the cone): ______________
- Point C (in front of the cone): ______________

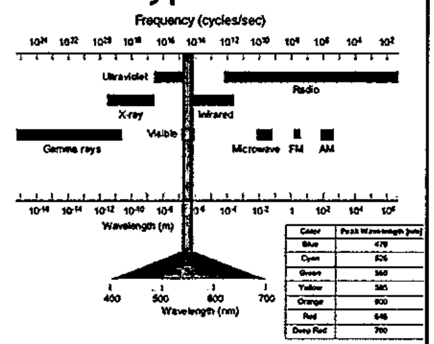
26

Light Energy



- Light is energy that is emitted by vibrating electric charges in ___________
- The energy travels in a wave that is partly electric and partly magnetic, and is called the electromagnetic spectrum
- _______________ light is only a small part of the entire spectrum

Light Waves vs. other types of Waves

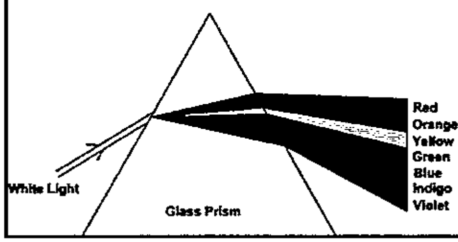


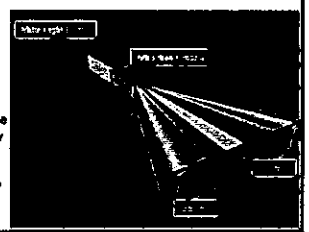
- Light does not need a medium to travel through
- Light waves are ____________ waves vibrate in more direction
- The energy of a wave is related to its____________(and therefore wavelength) – High frequency/short wavelength waves are more energetic than low frequency (long wavelength) waves

27

How do prisms and diffraction gratings separate white light?

- White light is ____________ (bent) when it passes through a prism (or diffraction gratings)
- Different _______________ are refracted different amounts (long λ gets refracted the least in a prism; i.e. red)

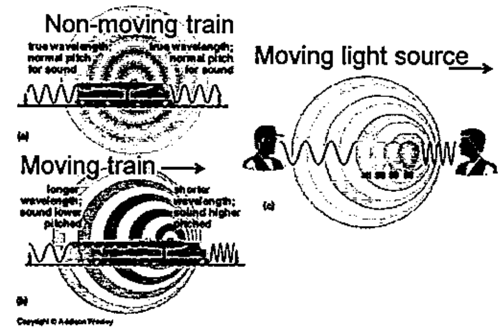




Doppler Effect and Light

High f = violet/blue

Low f = red

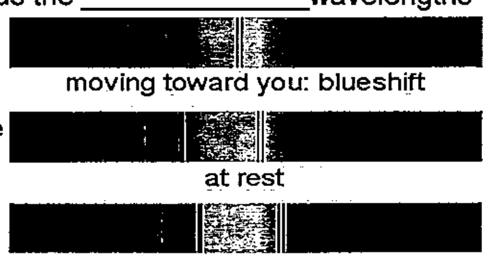


Doppler Effect and Light

- Light source moving __________ us: A Blue shift means that emission spectra coming from stars or galaxies will be shifted towards the blue end of the spectrum, not that the light will appear blue
- Light source moving ________: A red shift is a shift towards the _____________wavelengths

High f = Short λ = violet/blue

Low f = Long λ = red



Doppler Effect and Light

- Most objects we observe in space are _____-shifted
- The greater the shift, the greater the _______ at which the object is moving away from us
- Often, the more __________ the object, the greater the red shift we see

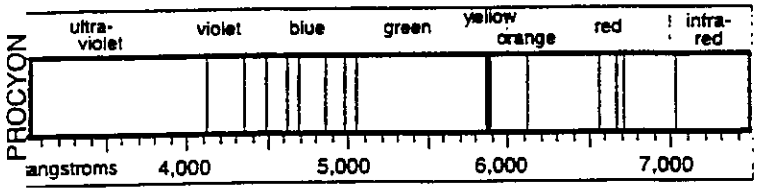
Evidence for the Big Bang:

- Most stars, galaxies, etc. in space show a red shift
- Red shift increases proportionately with distance
- Universe is currently ______________
- It appears that the expansion all comes from the same starting point

Emission Spectra of Stars Activity

Adapted from Project Haystack: The Search for Life in the Galaxy

Identify the elements you see in each of the stars below by comparing their emission spectra to the spectra for individual elements.



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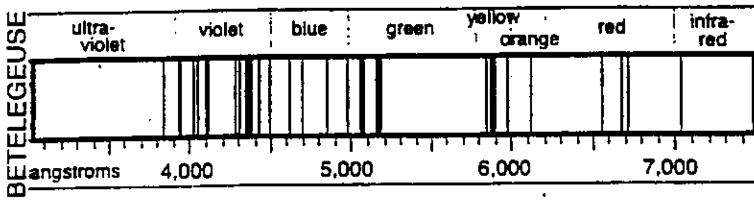
ELEMENTS IN PROCYON



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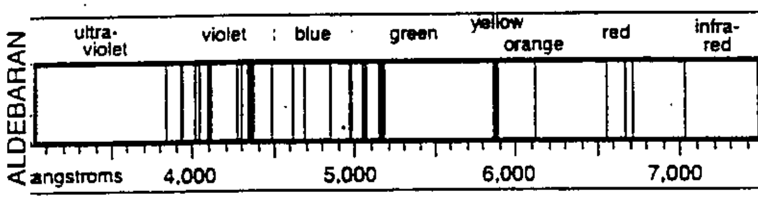
ELEMENTS IN BETELGEUSE



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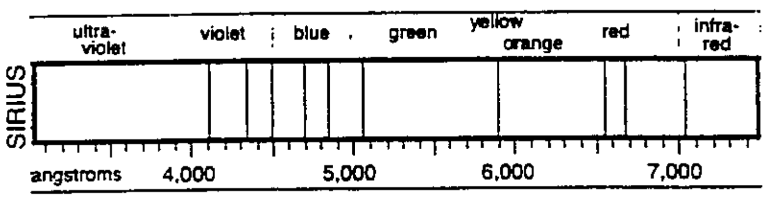
ELEMENTS IN ALDEBARAN



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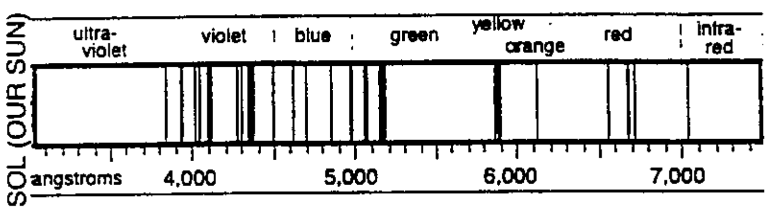
ELEMENTS IN SIRIUS



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ELEMENTS IN SOL

Questions:

1. What elements are on the **Emission spectra of Elements in Stars** sheet that you didn't see in class?

2. What do all the elements that you saw in class have in common?

3. Why do you think we couldn't show you some of the stars' elements in class?

4. Which of the 7 elements can be found in all 5 stars? ______________________________

5. What do you think "extra" spectral lines in some stars are?

6. Why do you think some lines are thicker than other lines?

Waves and Sound Review

Name________________________

Waves-General

Vocabulary: crest, trough, wavelength, period, frequency, pitch, amplitude, node, anti-node, transverse wave, longitudinal wave, standing wave, compression, rarefaction, infrasonic, ultrasonic, resonance, harmonics, Doppler Effect, red shift, shock wave, constructive interference, destructive interference

Frequency (f) = # waves/time (unit = 1/sec = hertz)

Period (T) = time for one wave cycle (unit = seconds) T = 1/f

Types of waves: Transverse: water waves, S-waves in earthquakes
Longitudinal: sound waves, P-waves in earthquakes

Law of Superposition: During interference, the amplitudes of 2 or more waves add together
Constructive Interference: crests add to crests, and troughs add to troughs, increasing the amplitude
Destructive Interference: crests add to troughs, decreasing the amplitude

Energy of a wave: amplitude measures the amount of energy in a wave

Wave Speed = wavelength x frequency = λf (unit = m/sec)
velocity = $\Delta p/\Delta t$ (distance traveled/travel time) (unit = m/sec).
Denser media = faster wave speed
Tension: increasing the tension in a medium will increase the wave speed (i.e. guitar string)

Standing Waves: created when incident and reflected waves interfere to make stable patterns of constructive and destructive interference. The higher the frequency, the more nodes will be created (shorter wavelength)
In strings: Nodes must be located at the end points.
In tubes: displacement anti-nodes will be at open ends of the tube, nodes will be at closed ends.

Speed of waves in various media

- Waves need a medium.
- Waves travel at a measurable speed (speed is fixed for a specific medium).
- Waves travel fastest and best (lose less energy) through denser media

Doppler Effect: the change in frequency caused by moving wave source or an observer moving relative to a wave source. The frequency of a wave is increased in front of a moving wave source, and decreased behind the wave source.
Example: The sound of a car engine passing you sounds higher as it approaches you, and lower as it moves away from you. The actual pitch of the car engine is in between the high and low pitch (you hear this pitch for the very brief time that the car is right alongside you).

Sound Waves

Sound -- General

- Sound sources are vibrating objects.
- Standing waves create continuous sounds (vibrating tuning fork, wine glass, etc)
- Sound travels away from source.
- Sound waves are longitudinal waves and create a series of compressions and rarefactions (expansions)
- The size and properties of the vibrating object affect the sound produced.
- While sound is a longitudinal wave, it's often represented as a transverse wave because it's easier to draw.
- Our perception of sound is related to the sound waves properties: frequency ~ pitch, amplitude ~ loudness, complexity ~ quality/tone

Frequency and Pitch

- The faster the frequency, the lower the wavelength, the higher the pitch.
- The frequency created by an object depends on that objects composition, density, tension, and length.
- The pitch of a sound can be manipulated using the things listed above. Music is made this way.
- Notes on instruments are created by standing waves in the object producing the sound.

Resonance and Harmonics

- Everything has a natural vibrating frequency. Something vibrating at this frequency has resonance.
- Objects can also have forced vibrations. (tuning fork making a table top vibrate with the same frequency)
- The amplitude of an object's vibrations can be increased if the vibrations of another object matches the natural frequency of the first object. Examples: Tuning forks of the same note, Tacoma Narrows Bridge, a boy bouncing a ball, a child being pushed on a swing, a singer shattering a glass.
- Standing waves with increasing numbers of nodes create harmonics in a vibrating object.

Practice Problems:

1. Draw a transverse wave and label: Wavelength, amplitude, crest, trough.

2. Draw a spring pulse moving toward a fixed end **then** draw the reflected pulse as it travels back. (include direction arrows).

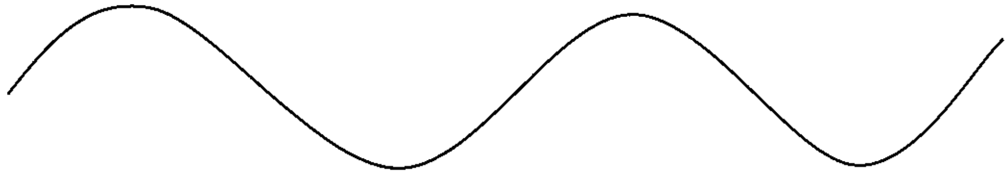
Pulse Toward Fixed end | **Reflected pulse**

3. Describe what constructive and destructive interference is and include a picture in your explanation.

Constructive Interference:

Destructive Interference:

4. The wave below represents a sound wave traveling in the air. Use it to answer the following questions:



   a. Draw a wave that has greater energy:

   b. Draw a wave that has a lower frequency:

   c. Draw a wave that had the same pitch but was softer:

   d. Draw a wave that would have a higher pitch:

   e. Which of the waves that you drew has the longest wavelength (a, b, c, d)? ________

   f. Which of the waves you drew would travel the slowest? _______

   g. Which of the waves you drew has the highest frequency? _______

5. What is resonance? Describe two situations where it can be observed.

6. Explain why an ambulance siren sounds higher pitched when approaching you and lower pitched when moving away from you (use a picture in your explanation).

7. Explain what creates a sonic boom and why people at different locations hear it at different times.

8. Draw the fundamental and second and third harmonics of a standing wave moving between the endpoints shown below. Which note will have the lowest pitch? Which 2 notes will be octaves? Label the nodes, anti-nodes, amplitude and wavelength for the third harmonic.

Fundamental: Second Harmonic:

Third Harmonic:

9. Describe three different ways that pitch can be manipulated in a guitar to make music.

10. Why do longer objects make lower-pitched notes than short objects (i.e. rulers, straws...)?

11. The speed of sound in fresh water at 20°C is 1482 m/sec, while it is 1522 m/sec in seawater at 20°C. Why do you think it is faster in seawater?

12. Draw and label the electromagnetic spectrum. Label which end is high frequency, short wavelength, and which end is low frequency, long wavelength.

13. Draw the visible light range and label which color has the longest wavelength and shortest wavelength.

14. How can astronomers tell what elements are in stars they look at?

15. Which 2 elements are the most common in stars? ________________________

16. Explain how the Doppler Effect is related to the Big Bang theory.

Emission Spectra for Common Elements in Stars

Use the emission spectra of common elements in stars below to identify the elements in the stars in your activity.