M14 Lecture Revised version

Thursday, April 07, 2011
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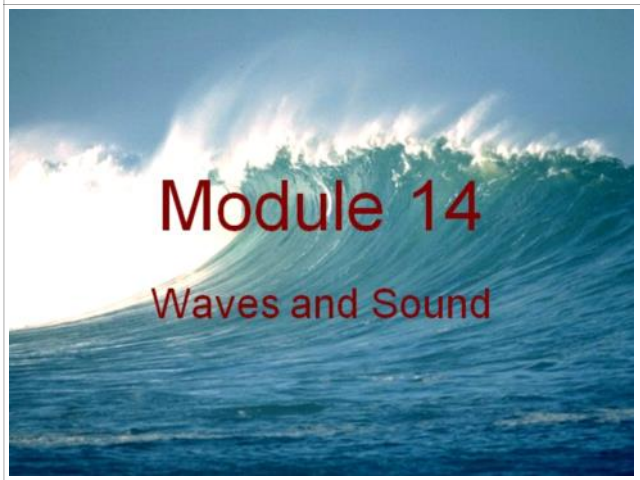
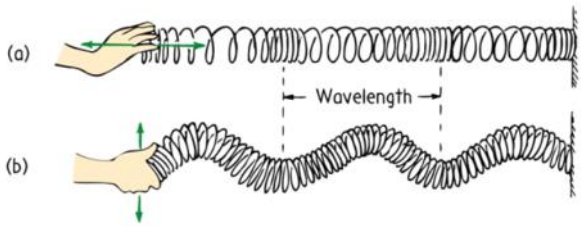
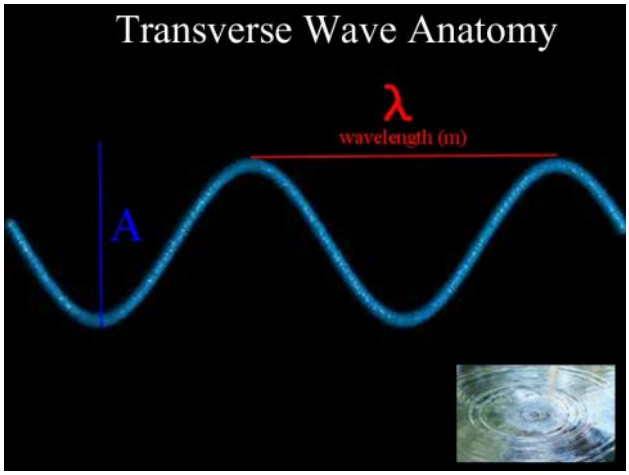
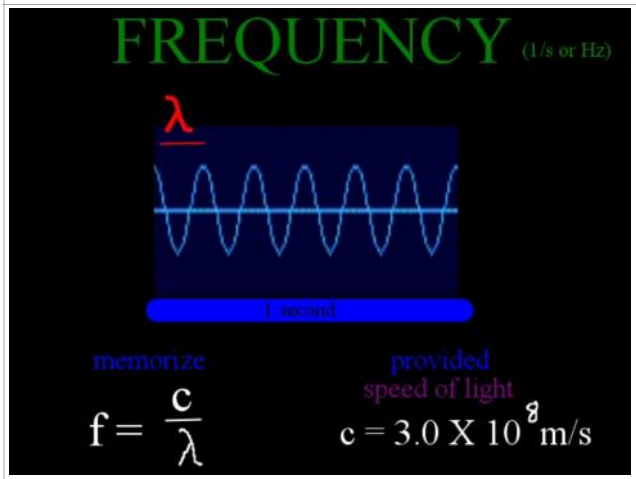
Slides	Notes
	When you think of waves, you most likely thing of the wet kind. Waves, however, can be many other things such as sound waves. Electromagnetic waves which are the type that propagate light.
Waves transfer energy not matter. The water waves below are carrying energy but are not moving. Waves can only exist as they have energy to carry.  Falling pebbles transfer their kinetic energy to the particles of water in a pond, forming waves.	Read this slide. When a pebble disturbs a water surface, is the water molecule right next to where the pebble entered the water moved all the way along the ripple, or is it more like the molecule bumps the next one and then that molecule bumps the next one, and on and on? What about a surfer's dream wave or a tsunami? We saw how much water came in to the land there. What made all that water come up on shore if waves transfer energy but not matter? [The bottom of the ocean rises as it comes up to land forms. The energy is propagated to less and less water and the land under the water provides a lift causing it to swell up over the land.]
Longitudinal or Transverse? 	Here are two types of waves. The top one is a transverse wave. It is .. A wave whose propagation is perpendicular to its oscillation. transverse wave Sound is a transverse wave. The vibrations push the air in little pulses as the object making the sound goes back and forth. The bottom one is a longitudinal wave. It is ... A wave whose propagation is parallel to its oscillation. longitudinal wave An example of a transverse wave is an ocean wave. You can actually see a very ocean wave like look in it the way it goes up and down. --- Do sound waves oscillate parallel or perpendicular to the direction in which the wave travels? Choose one answer. a. perpendicular b. parallel



Water waves are more familiar to us, so let's look at the transverse waves first. We will examine them even closer in the next module when we talk about light.

The height of the wave is called amplitude. It is designated with the letter A. In light, the amplitude will be how dim or how bright the light is. If the amplitude is large, the light will be bright.

The distance from one point of the wave to a corresponding point on the next one is called the wavelength. Wavelength is is designated by a Greek letter called lambda. It looks a little like a person waving, so it may be easy to remember that wavelength and that funny symbol go together.

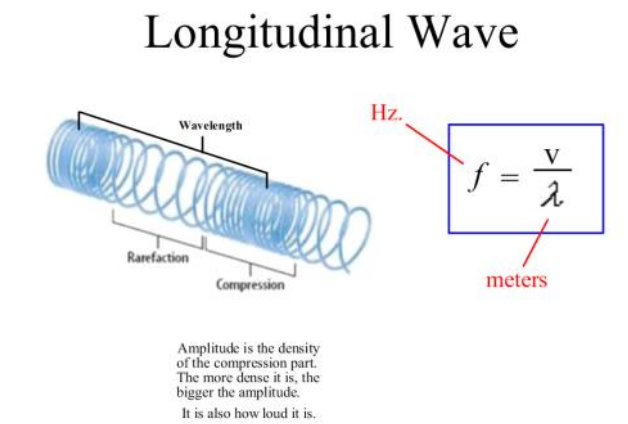


The frequency is how many wavelengths pass by a given point is a second. It is designated by the lowercase letter f and the unit it Hertz. For short, you can write Hz with a period after it to show it is an abbreviation like this …

Hz.

To mathematically relate these things, you can use the formula f = c/lambda. The c is a constant which is the speed of light.

Don't worry about memorizing this one since light will be in the next module, but I wanted you to get a feel for this type of wave so that you can compare it to the type of wave that sound is.



Now we will dig in to what a sound wave is all about. Remember that sound waves are longitudinal waves.

The anatomy of a sound wave has some commonalities with the light wave we looked at. Notice that it has wavelength which is the distance between two corresponding parts of the wave just like the other one did. Wavelength is still measured in meters.

The wave also has amplitude, but this one is more related to the density of compression than the height of a wave. With liht the amplitude was related to how bright or dim the light was. In a sound wave, it is related to how loud or soft the sound it. That makes a lot of sense.

Notice how similar the math equation is too. It is the same except that the numerator has a v instead of a c. The c was the velocity of light. This one is the velocity of sound. With light, the velocity is pretty constant. With sound, the velocity will be quite a bit different depending on the temperature and the medium that the sound goes through.

Let's look at that next.

Impact of temperature on sound velocity.

Celcius!

How does temperature impact sound?

Sound moves by molecules striking each other and then those molecules bump in to the next one and so on. Would sound travel better if the molecules were packed pretty close together or if they were spaced far apart? [close together]

Now, let's relate that to temperature. When a substance is warm it typically has molecules more spread out than when it is cold. So, do you think that sound would travel faster in something cold or something hot? [cold]

Notice that I have a red note that we will be working in Celsius.

What about outer space?

> "In space, no one can hear you scream"
>
> Based on what you have learned about sound waves, *why* would you say that is true.

phET sound virtual lab
https://phet.colorado.edu/en/simulation/sound

phET Wave-on-a-String simulation
https://phet.colorado.edu/en/simulation/wave-on-a-string

phET wave interference simulation
https://phet.colorado.edu/en/simulation/wave-interference

$V = (\text{medium} + 0.60 \times T)$

Scratchpaper

Table 1 Speed of Sound in Different Mediums

Medium	Speed of Sound (in m/s)
Air	347
Cork	500
Water	1,498
Brick	3,650
Aluminum	4,877

Sound will travel in different speeds through different mediums. Let's look at this chart.

> In which medium will sound waves travel faster?
>
> Choose one answer.
> - a. air
> - b. water

Notice that I have a mathematical equation for you. The v is velocity. We can compute velocity if we know the substance and the temperature.

Lets try a few computations:

> Computations:
>
> What is the speed of sound in air that has a temperature of 25 degrees Celsius?
>
> Answer:
>
> 346.5 m/sec

Sometimes you will need to chain our two equations together to solve a problem. Here is the other equation that we have learned in this module:

Hz.

$$f = \frac{v}{\lambda}$$

meters

Now we can try ...

A sound wave traveling through 17 degree air has a wavelength of 2 meters. What is the frequency of the sound wave?

Answer:

170.85 Hz.

The temperature is 10 degrees C. You see a lightening strike and then hear the thunder 2 seconds later. How far away did the lightening strike?

Answer: 675 m

How is *frequency* related to *pitch*?

The ***pitch*** of a sound wave is directly related to ***frequency***. A high-pitched sound has a high frequency (a screaming girl). A low-pitched sound has a low frequency (a fog-horn).

A healthy human ear can hear frequencies in the range of **20 Hz to 20,000 Hz**. Humans cannot hear below 20 Hz. Sounds below this frequency are termed ***infrasonic***.

Sounds above 20,000 Hz are termed ***ultrasonic***. Some animals, such as dogs, can hear frequencies in this range in which humans cannot hear.

[Just read the slide]

Which wave has the longest wavelength:

Choose one answer.
- a. infrasonic waves
- b. ultrasonic waves
- c. sonic waves

Supersonic

(sonic boom)

Any speed that is faster than the speed of sound in a substance of interest. supersonic

The sound produced as a result of something traveling at or above Mach 1. sonic boom

Pitch and the length of a musical instrument.

Pitch:
The highness or the lowness of the sound.

Pitch is the highness or the lowness of a sound.

There is a simple little graphic there that represents an instrument. When the instrument is long or the air has a long way to travel through it, the pitch will be low. It the length is shortened, the pitch will go up.

[The instrument graphic can be manipulated to make it short or long]

A musician has two wind instruments of the same type. One is long and one is short. Which recorder will be able to play the lowest pitch?

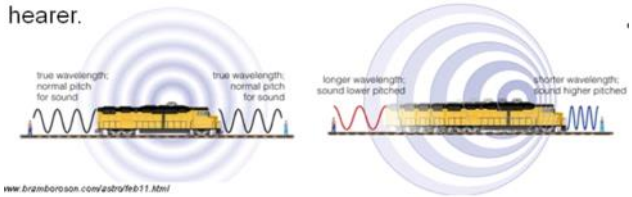
Choose one answer.
- a. long
- b. short

The highness or lowness of a sound pitch

Constructing and using a straw flute
http://www.youtube.com/watch?v=JsmFfgunJ-o

What is the *Doppler Effect*?

The ***Doppler Effect*** is the apparent change in frequency detected when the sound is moving relative to the hearer.



Video-Excellent example of Doppler Effect with car horn (26 seconds)

Video-A Motorcycle does the Doppler Effect (27 seconds)

Have you ever noticed that when a vehicle is coming toward you it sounds like the pitch is higher than when it has passed you? That is the Dopplar effect.

This occurs because the waves get compressed or spread out when something is moving.

Compare the sound waves when the train is still (image to the left) and when it is moving (image on the right).

As you speed up, the pitch of a siren gets higher. Are you driving toward or away from the source of the sound?

Choose one answer.
- a. toward the sound
- b. away from the sound

Doppler effect interactive
http://www.pbs.org/wgbh/nova/physics/doppler-effect.html
(More for light, has sound examples)
Similar to lab 14.5 on Doppler Effect

What is sound intensity?

Sound ***intensity*** is the energy that the sound wave possesses. The greater the intensity of sound the farther the sound will travel and the louder the sound will appear.

Loudness is very closely related to intensity. ***Loudness*** is the human perception of the sound intensity. The unit for loudness is ***decibels***.

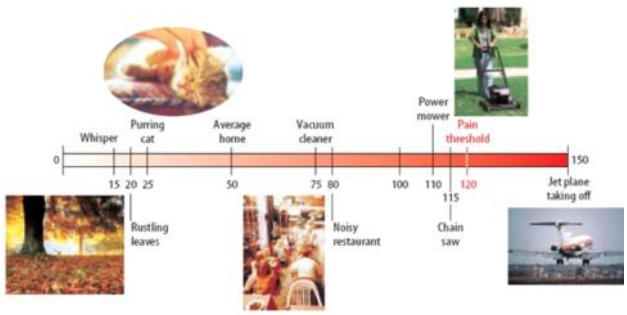
[Just read the slide at first]

When you increase in decibels, you are actually increasing by a factor of ten. If you went from 40 decibels to 90 decibels you would subtract the two to get 50. Since there are 5 tens in 50, you would need to be sure to add that many zeros after a one when asked how many times more intense a sound is. So an increase from 40 to 90 would be 100000 times greater.

An amplifier takes a 30 decibel sound and amplifies it to an 80 decibel sound. How many times more intense is the sound?

Answer: 100000

Loudness in Decibels



Let's compare some decibels.

Using Sound

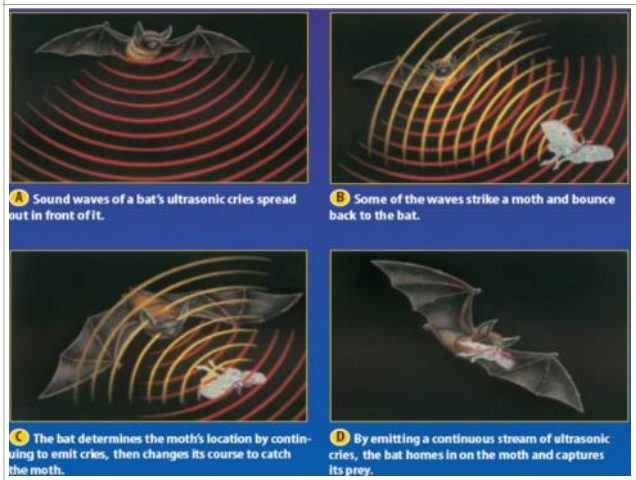
What is *Acoustics*?

Acoustics is the study of sound and ways to optimize the hearing of sound inside various structures.

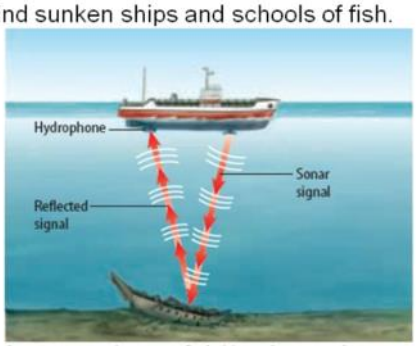
This concert hall uses cloth drapes to help reduce reverberations.

[Just read the slide]

[Just read the slide]



[Just read the slide]

What is sonar? ***Sonar*** is a system that uses the reflection of underwater sound waves to detect objects. This has been used to find sunken ships and schools of fish.  Sonar uses sound waves to find objects that are underwater.	[Just read the slide]
 What is ultrasound?  	Ultrasound has become a very useful tool in medicine. It can be used to image many different types of tissues in the human body so that doctors can tell what is going on inside of the body without needing to cut the body open. Medical advances in 3-D imaging can now give some amazingly detailed information. The black and white image at the top is an ultrasound that would have been common just five years ago. More and more medical facilities are getting the 3-D devices all the time.
	Fun sound videos: Spiral water hose - http://www.youtube.com/watch?feature=player_embedded&v=uENITui5_jU Human genome soung: http://www.youtube.com/watch?v=nhAcHuzfZfk&list=UUMcODIGPzifIRSJasg2VYTg&index=2 Rosslyn Stave Angel http://www.youtube.com/watch?v=cy2Dg-ncWoY

2011-12 Quiz link: http://www.virtualhomeschoolgroup.com/mod/quiz/view.php?id=17727