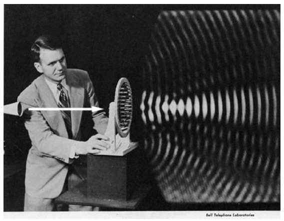
What was that that you said?



Class 25:
Sound

Reminders/Updates:
The PEOPLE have voted…new materials
MT3 optional Long Answer Due Thurs
Reading posted; RQ Thurs
Total Scores w/Drops to be posted online

Improving class experiences:

1)ASSETT Survey on Videos/Tech in Class:.

Complete the survey by FRIDAY, DEC. 7th to enter your name in a drawing for a $100 gift certificate to the CU Bookstore! Link: https://cuboulder.qualtrics.com/SE/?SID=SV_430xyA0dikPPSBv

2) focus groups about usage of digital media.

- 45-minute focus groups : Tuesday – Friday (Nov 27-30) at 1:00 PM, 3:00 PM, and 6:00 PM or
- $10 Dominos / Starbucks gift cards. Brice Nixon, the Research Assistant, at cudigitalmediastudy@gmail.com

3) How do you feel about more video on PhET Simulation use in this class.

a) yes, I think these are important
b) yes it's fine
c) neutral
d) I would prefer not
e) really, please do not

CLICKER Registration

You Must Register:

Last Name	First Name
Anderson	Bradley
Harriger	Brittney
Gurel	Charlotte
Flaherty	Daniel
Charneskie	Emma
Tovo	Jacob
Swihart	Johnathan
Ross	Kathleen
Gabriel	Michael
Williams_Jr.	Ozell
Goldner	Samuel
Sweet	Samuel
Marzano	Stefano
Thammavong	William
Behnam	Yashar

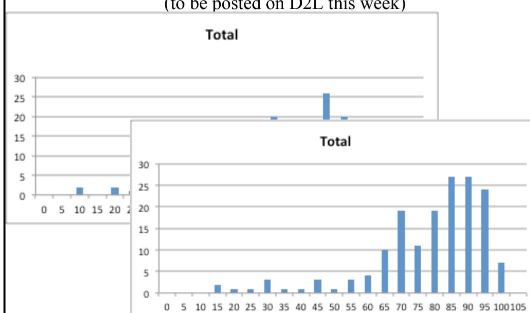
Is this one of yours?

Unregistered i>clicker remotes:

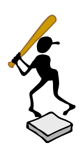
#009269FB	#25C807EA	#36341416
#00DC4995	#2601BB9C	#36535633
#0227183D	#265C750F	#368AD864
#029925BE	#26652F6C	#36D28460
#08FCBB4F	#26B4C153	#36FA05C9
#0D020609	#26BF0E97	#37095C62
#0D3B7442	#32D85BB1	#371B7E52
#0F7B2753	#32DE779B	#372D1B01
#18B82A8A	#331F2D01	#372E5049
#19A167DF	#33438FFF	#372FF4EC
#1BFAB455	#33B09A19	#37302C2B
#1DE2A55A	#33E00FDC	#3733282C
#25C2886F	#340984B9	#37361A1B
		#40206F0F

Scores in Class

(to be posted on D2L this week)



Sound waves

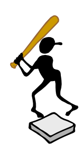


Everyday Life Experience at the Ballpark

You are at Coors Field sitting in the bleachers in the outfield (~325 ft from the batter). You **see** the bat hit the ball. About how long will it take before you **hear** the bat hit the ball?

a. About 10 seconds
b. About 2 seconds
c. About 0.3 seconds
d. About 0.03 seconds
e. There will be no delay between seeing ball hit and hearing ball hit.

Sound waves



Everyday Life Experience at the Ballpark:
You are at the ball park sitting in the bleachers in the outfield (~325 ft from the batter). You see the bat hit the ball. About how long will it take before you hear the bat hit the ball?

c. About 0.3 seconds

How fast is that sound traveling?
Speed = distance/time = 325 ft/0.3 s = 1083 ft/s or 330 m/s

Speed of Sound in Air = 331 m/s at 0 degree C
343 m/s at 20 degree C
(Speed of Light = 3 X 10^8 m/s… much, much faster)

About 0.3 second means ~ 325 ft away from batter.
In 0.03 seconds, travels ~ 32 ft and in 2 sec, ~2,160 ft

6

What causes the delay between seeing and hearing?

- Light (carrying sight information) and sound (carrying noises) travel in totally different ways and at totally different speeds from the event to your eyes/ears.

- Light is an electromagnetic wave.
  - It travels absurdly fast – 3×10^8m/s or 670 million mph!
  - Virtually no delay between bat hitting ball and you seeing it occur

- A sound wave involves the motion of air molecules
  - It travels or propagates much more slowly – 330m/s or 740 mph
  - Sound takes a noticeable amount of time to get from bat to your ear!

Sound Sim

What is air anyway?

a) There's nothing there – can you see anything?
b) Load of stationary atoms of all types
c) Primarily oxygen molecules fixed in a rigid matrix
d) Primarily nitrogen and oxygen molecules bouncing around and colliding with each other and anything else they bump into
e) There's something out there but its got nothing to do with atoms or molecules

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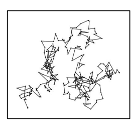
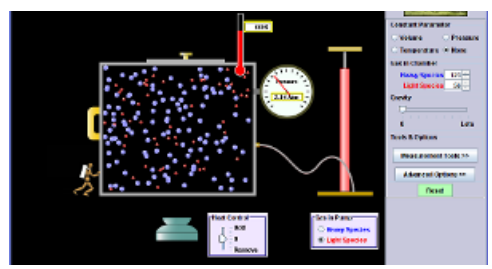
e) There's something out there but its got nothing to do with atoms or molecules

- The molecules are constantly in random 3D motion (~1200 mph)
- In absence of sound wave they maintain uniform density (randomly but evenly spaced)
  ⇒ Uniform air pressure
- Useful visual picture of the stuff air is made of: GO TO IDEAL GAS SIMULATION



Gas Simulation



http://phet.colorado.edu/en/simulation/gas-properties

What is sound?

When you hear the crack of the bat with your ear, what is it that your ear is detecting?

a. Electromagnetic radiation that was produced when the bat hit the ball.
b. A small change in the pressure of the air that is the result of the bat hitting the ball.
c. A wave that travels through the air from the bat to your ear.
d. a. and c.
e. b. and c.

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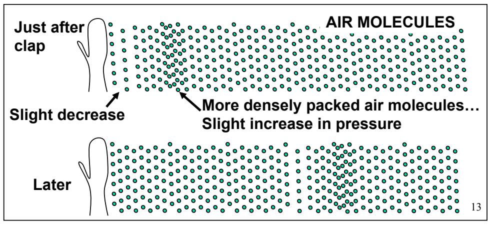
d. a. and c.
e. b. and c.

What produces the sound?

When bat hits ball, they push the surrounding air causing a slight increase in the pressure of the air followed by a slight decrease.

What is it that your ear is detecting?

This pressure fluctuation travels out in all directions as a wave, as air molecules push on the ones next to them and then they push on the ones next to them. As the pressure wave reaches your ear, you hear sound.



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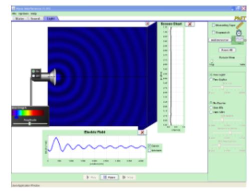
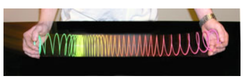
Wave Interference Sim.



http://phet.colorado.edu/en/simulation/wave-interference

Longitudinal wave



Direction of wave propagation

Displacement of medium

Transverse wave

Direction of wave propagation

Displacement of medium

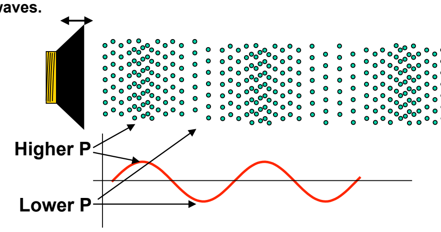
Movement of air molecules:

- Displaced ~10^{-5}m for loudest bearable sound
- Displaced ~10^{-11}m for faintest audible sound
- Back to original position after sound wave passes

Do the wave

Creating Musical Tones

To create a pure sustained tone (like concert A), the speaker pushes on the air at regular intervals creating a series of pressure waves.

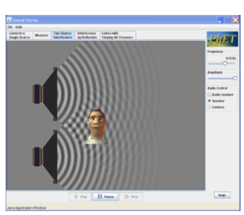


All instruments work with same principle... push on air at regular intervals.

SHOW SPEAKER IN ACTION

16

Sound Sim

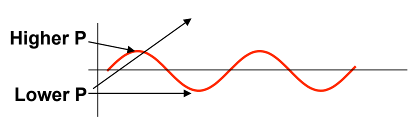


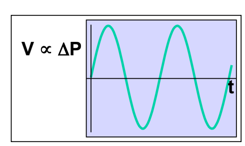
http://phet.colorado.edu/en/simulation/sound

Looking at a soundwave with a scope:

Microphone detects changes in pressure.

Intro to o-scope





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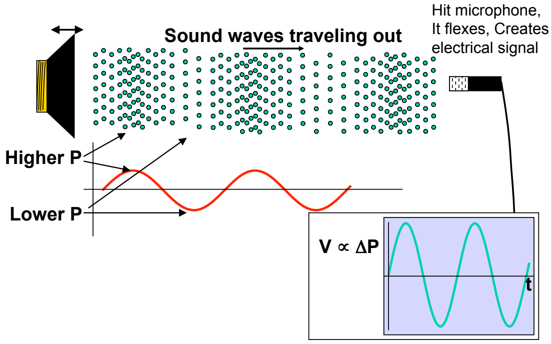
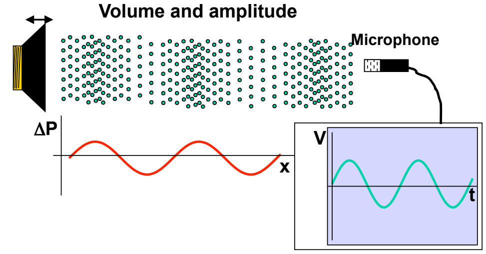


Volume and amplitude

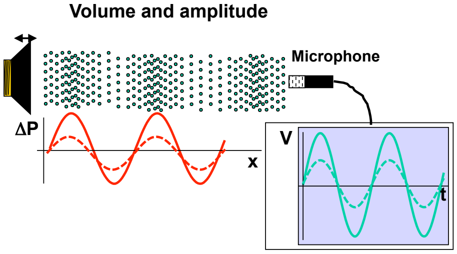


Question: If I increase the volume, what will happen to the signal from the microphone?

a. The peaks will go up and the valleys will go down.
b. The peaks will get closer together.
c. The whole signal will go up.
d. Both a and b.
e. Nothing will happen

DO EXPERIMENT….

Volume and amplitude



Question: If I increase the volume, what will happen to the signal from the microphone?

Answer is a. The peaks will go up and the valleys will go down.

When I turn up the volume, the speaker cone moves further and piles up more air molecules. High pressure is higher. Low pressure is lower. But on average pressure is the same. So, a louder volume means a larger pressure difference between peak and valley.

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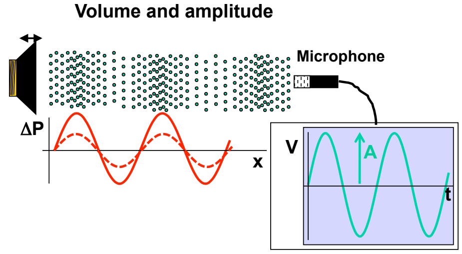
Volume and amplitude



- **The amplitude (A)** of a wave is the measurement between zero and a peak (or trough)
- As you turn up the volume you increase the amplitude of the pressure wave

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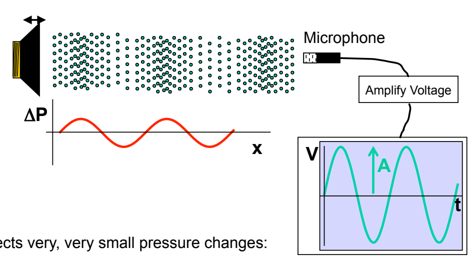
What is the amount of over / under-pressure is that we hear?



Ear is detects very, very small pressure changes:

Normal pressure of air (at sea) = 1 atmosphere

Minimum pressure change detectible by ear = 2 X 10^{-10} atmospheres
minimum change is 1 part in 5 billion,

Maximum pressure change detectible by ear = 3 X 10^{-4} atmospheres
maximum is 1 part in 3600.
More than max === OUCH!!!!!

23

How to change the pitch (note) of the speaker?

To get a higher pitch sound, we need to adjust the speaker to:

a. vibrate back and forth more rapidly, taking a smaller amount of time for each cycle
b. vibrate back and forth at the same rate as before, but the range of it's back and forth motion is larger.
c. receive more power
d. vibrate back and forth more slowly, taking a longer amount of time for each cycle
e. vibrate back and forth at the same rate as before, but the range of it's back and forth motion is smaller.

What if we wanted to change the pitch of the tone produced by the speaker?

To get a higher pitch sound, we need to adjust the speaker so that:

a. It vibrates back and forth more rapidly, taking a smaller amount of time for each cycle
b. It vibrates back and forth at the same rate as before, but the range of it's back and forth motion is larger.
c. It receives more power
d. It vibrates back and forth more slowly, taking a longer amount of time for each cycle
e. It vibrates back and forth at the same rate as before, but the range of it's back and forth motion is smaller.

In physics/wave language this is called adjusting the **frequency (f)**

Frequency (f) of a sound wave

- Controls pitch of sound
- The number of times per second that the speaker goes through one complete pushing motion
- The number of times per second that the pressure in my ear goes through rise-fall cycle.
- Units: Hz (s^{-1}) 1 Hz = 1 cycle per second

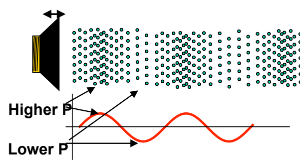
The frequency of Concert A is 440 Hz

FGAB | CDEFGAB | CDEFGAB |

Octave below Concert A (220 Hz) — middle C (256 Hz) — Concert A (440 Hz) — Octave above Concert A (880 Hz)

Range of Human Hearing : 20 Hz to 20,000 Hz
Dogs : 40 Hz to 60,000 Hz
Mice : 1000 Hz to 90,000 Hz

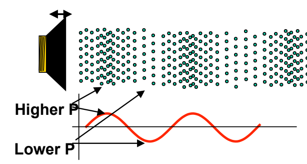
Period of a sound wave



If the speaker vibrates back and forth 200 times each second, (has a frequency of 200 Hz) how much time passes between each time it produces a maximum in pressure?

a. 0.2 seconds
b. 200 seconds
c. 0.005 seconds
d. 0.02 seconds
e. 0.05 seconds

Period of a sound wave



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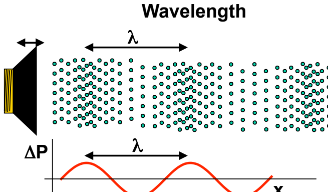
a. 0.2 seconds
b. 200 seconds
c. 0.005 seconds
d. 0.02 seconds
e. 0.05 seconds

Period (T) = Time for one cycle
=1 second/ 200 cycles = 0.005 seconds

Period (T) = 1/frequency

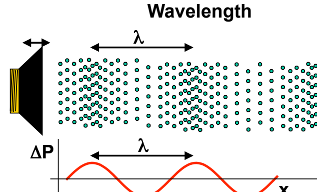
Wavelength



Question: If the speaker oscillates at 200 Hz (remember that is completing one cycle in 0.005 seconds), what is the wavelength (distance between the pressure maximums)
Recall: the speed of sound = 330 m/s

a. 0.6 m
b. 1.65 m
c. 66,000 m
d. 3.3 m

Wavelength



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Recall: the speed of sound = 330 m/s

a. 0.6 m
b. 1.65 m
c. 66,000 m
d. 3.3 m

- Sounds travels at 330m/s,
- Distance = speed × time
- Wavelength = distance travelled in one period = 330m/s × 0.005s = 1.65m

PhET sim

If the speaker vibrates back and forth twice as fast (so 400 times per second), then the *period* of the sound wave (the time between producing each peak in pressure) is

a. twice as long b. half as long c. unchanged

b. Half as long.
Period (T) = 1/f = 1/400Hz = 0.0025 s

What happens to the wavelength of the sound wave when we double f ? The distance between each peak in pressure is

a. twice as far b. half as far c. unchanged

b. Half as far.
Wavelength (λ) = velocity of sound x time between peaks (T)
= 330 m/s x 0.0025 s = 0.825 m

More on speed of sound through air:
- all frequencies travel at same speed … What would happen to orchestra music if frequencies traveled at different speeds?
- speed of sound in air is a fundamental property of the air pressure and density

Thinking about waves:

Frequency (f)	**# of oscillations/sec**	**(Hz = 1/s)**
Wavelength (λ)	**Distance of one complete cycle** (e.g. distance between pressure maximums)	**(m)**
Period (T)	**Time for one complete oscillation**	**(s)**
Speed (v)	**Distance traveled per second**	**(m/s)**

Relationships among these variables:

$v = \lambda \times f$

Distance per second = distance per oscillation × # of oscillations per second

$f = 1/T$

oscillations per second = 1/time for one oscillation

$v = \lambda / T$