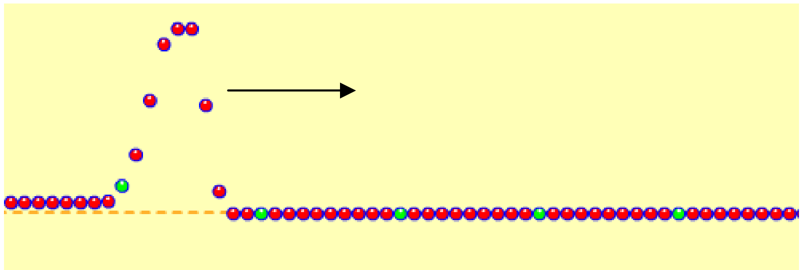
Announcements – 5 Dec 2013

1. Photo contest submissions due tomorrow night!

2. Online course evaluations due Sun, Dec. 15
   http://studentratings.byu.edu
   → Please take both the ratings and the comments seriously. I read every single comment, as does the Physics Department promotion/tenure committee.

3. TA-led final exam review—doodle.com survey again

Reflections



Clicker quiz: What happens when an upward pulse hits the end and turns around?

a. the wave reflects back, upward
b. the wave reflects back, downward
c. it depends

Demo: rubber tubing

Web demo:
http://www.colorado.edu/physics/phet/simulations/stringwave/stringWave.swf

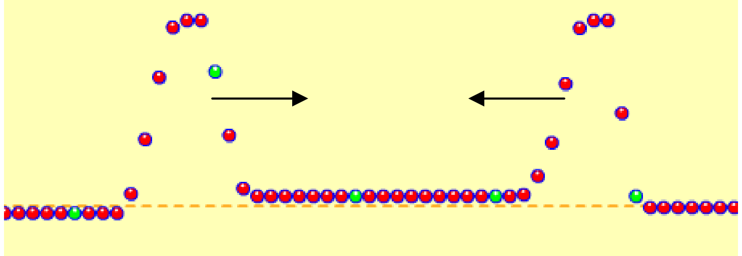
Boundaries

Rope: Light rope meets heavy rope
Light: Air meets glass

In both cases:
Part of wave r__eflect__ and part of wave t__ransmit__

Superposition/Interference

http://www.colorado.edu/physics/phet/simulations/stringwave/stringWave.swf

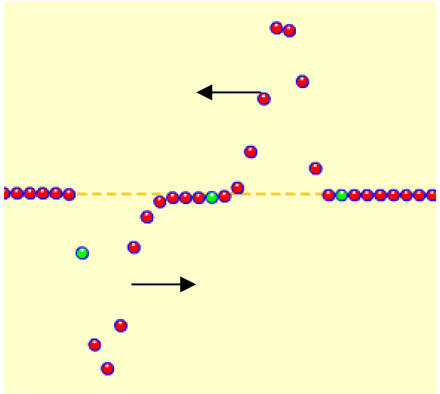


From warmup: What happens when two pulses on a string (one coming from each end) meet in the middle?

a. The pulses pass through each other
b. The pulses reflect off of each other

Demo: Shive wave machine

What about this case?



Review:

What gets transported by the wave? energy

What does the transporting? medium

What was wrong with the Star Wars video?

Demo

No sound in a vacuum

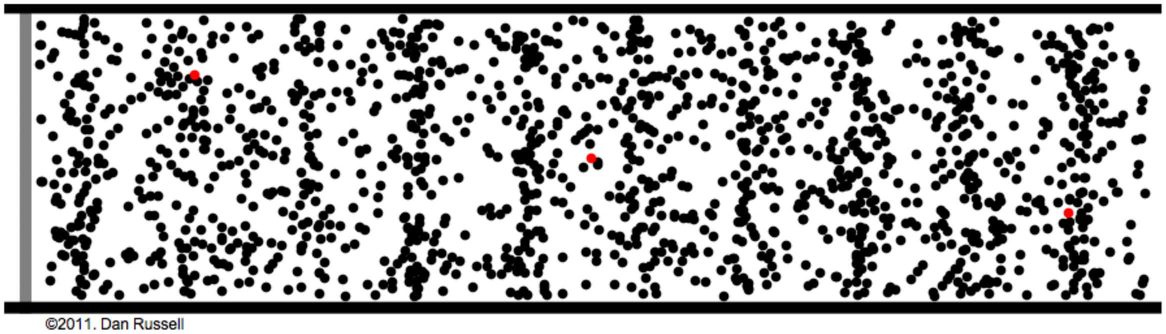
Sound

Clicker quiz: What type of oscillation is a sound wave?

a. Longitudinal
b. Transverse
c. Neither

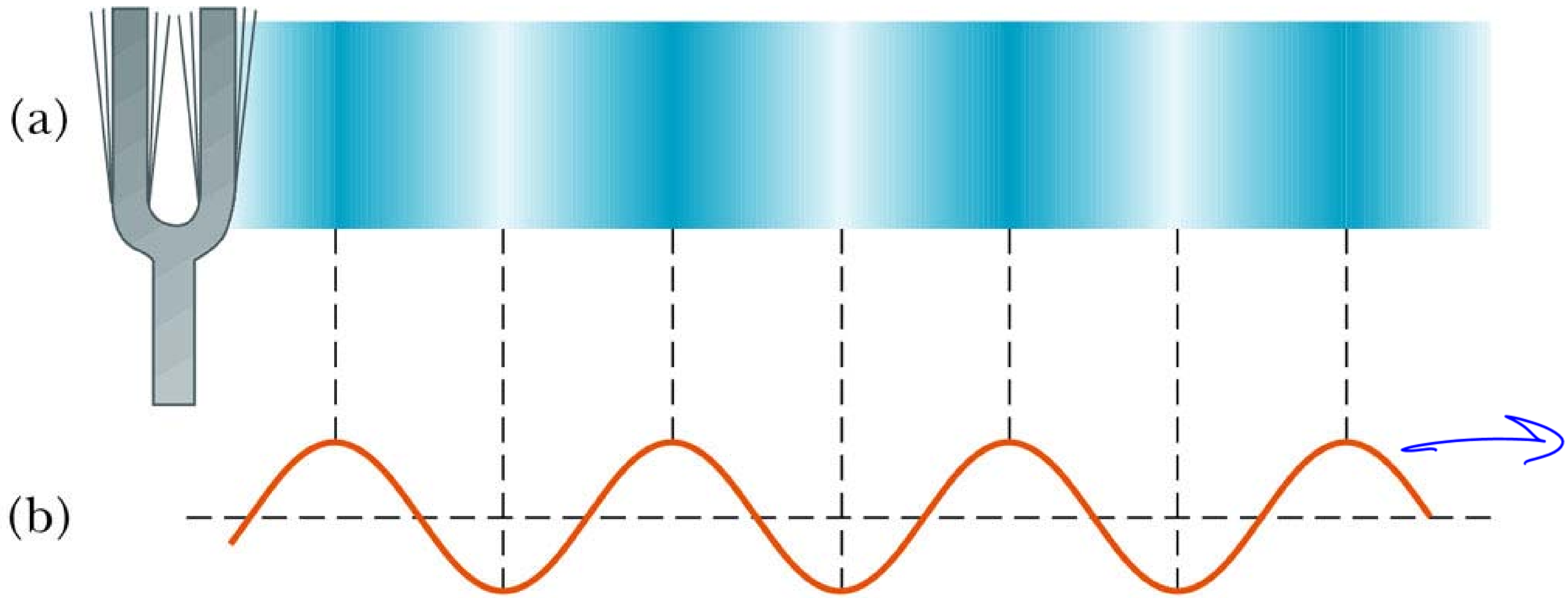
What is Sound?

Kind of like this:
http://www.acs.psu.edu/drussell/demos/waves/wavemotion.html



…but not entirely.   (What's different?)

Compressions & Rarefactions



Demo

Hearing test! Frequency source & speaker

Audible sound waves: ~20 Hz to ~20 kHz (different for everyone)

How is sound produced?

→ Speaker cutaway
→ Demo: Tuning fork
→ Demo: “singing rod”
→ Demo: Air jet and spinning disk

Speed of sound

Gases

Air: v = 343 m/s at 20° C

To impress your date:
~1 km in 3 seconds

Other temps: $v = 331\text{ m/s}\sqrt{\frac{T}{273K}}$ (You need that for HW 26-1)

Helium: 972 m/s (at 0° C) Why so much faster?

Solids

Like the P (longitudinal) and S (transverse) waves in earthquakes

<u>Table in book:</u>

Aluminum	5100 m/s
Copper	3560 m/s

Almost certainly these speeds are for *longitudinal* waves

Speed of sound, cont.

Liquids

Only longitudinal. (Why are transverse waves not possible?)

$v = \lambda f$

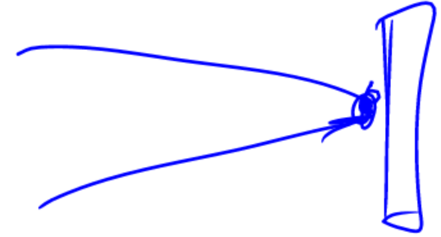
same

<u>Table in book:</u>

Water	1490 m/s
Methanol	1140 m/s

→ **Why would solids be the fastest?**

Intensity



→ How concentrated (or "focused") the wave is

Definition $$I = \frac{P\text{ower}}{A\text{rea}}$$

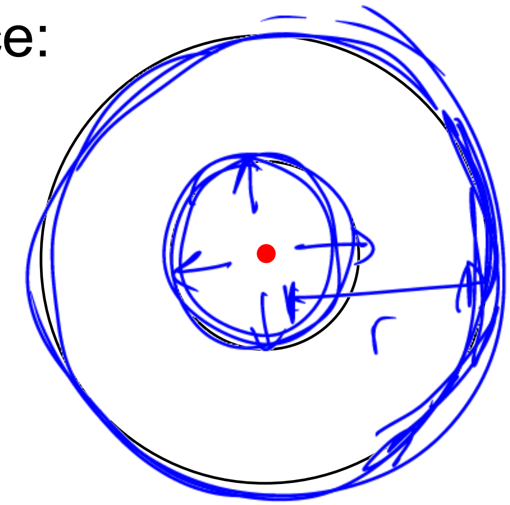
(not just for sound)

Intensity vs distance

For a *spherically* emitting source:

$$I = \frac{P}{A} = \frac{P}{4\pi r^2}$$

$$\text{so} \quad \frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$$



inverse square law!

True also for most sound waves, even if not spherical, since $A \sim r^2$ for other shapes as well.

From warmup

If a loudspeaker emits spherical sound waves in all directions, what decreases as you go farther away from the loudspeaker?

a. frequency
b. intensity
c. wavelength

Clicker quiz

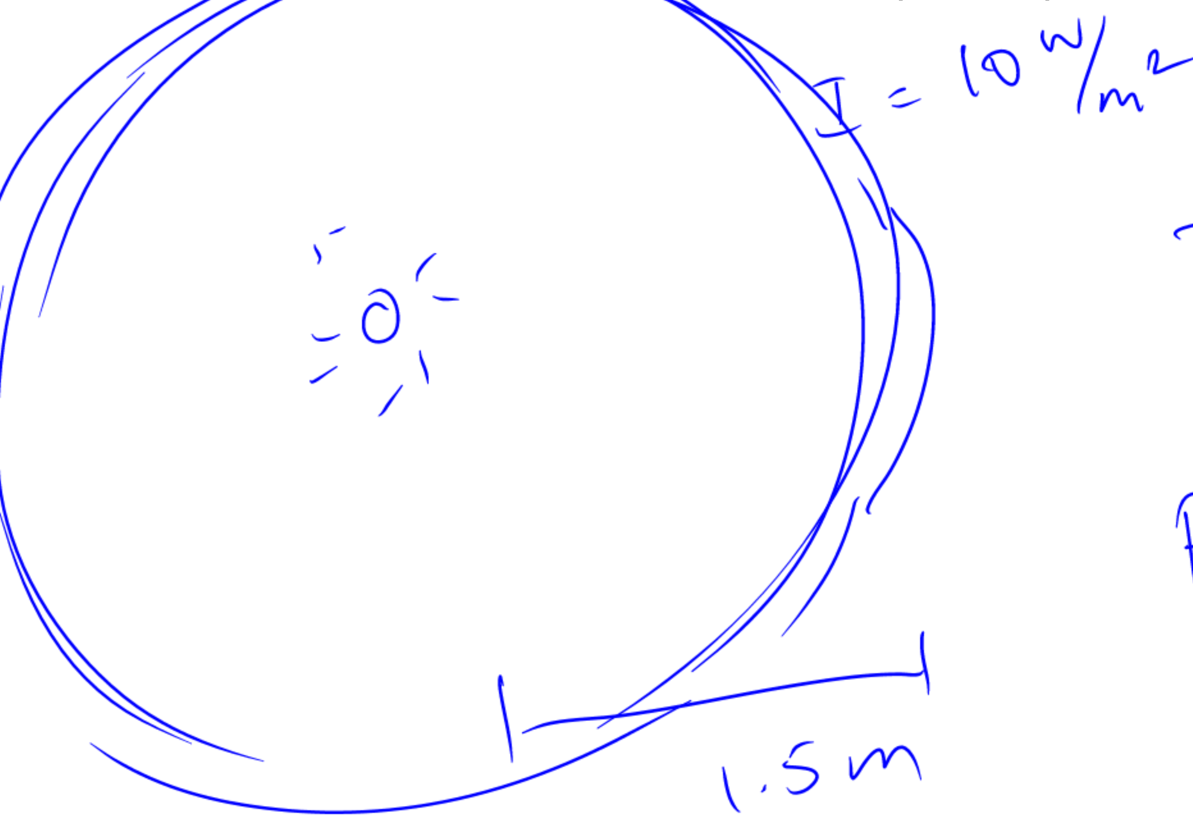
You measure the sound intensity produced by a spherically-emitting speaker to be 10 W/m^2 at a distance of 1.5 meters. What will be the intensity at 3 meters away?

a. 2.5 W/m^2
b. 5
c. 10
d. 20
e. 40 W/m^2

$\frac{10}{4}$

Worked Problem

Same situation (spherically emitting speaker, 10 W/m^2 at 1.5 meters). What is the total sound power (watts) being produced by the speaker?



$$I = \frac{P}{A}$$

$$P = I \cdot A$$

$$= \left(10\,\frac{W}{m^2}\right)\left(4\pi(1.5\,m)^2\right)$$

$$= \boxed{282.7\,W}$$

Answer: 282.7 W

Clicker quiz

An earthquake that has a Richter scale magnitude of 8 is how much more "powerful" (in some sense) than one that has a magnitude of 7?

Earthquake1 = _______ × Earthquake 2.

a. 1.1
b. 1.1429
c. 2
d. 8
e. 10

+1 ×10

+2 ×100

Decibels

- We hear over a <u>huge</u> range of intensities
- So use a ***logarithmic scale*** (like earthquakes)

multiplied by 10, for no apparent reason

"Decibel number" $\beta = 10\log\frac{I}{I_o}$ where $I_o = 10^{-12}\ \text{W/m}^2$

"log" = "logarithm, base 10"

→ **adding ten to dB number = ×10 to the intensity**

+10 ×10

+20 ×100

+30 ×1000

From warmup

You go to a rock concert where the sound level where you are standing is 110 dB. How does the intensity (power/area) of sound waves compare to when you listen to the same music on your home stereo system, 90 dB at the spot you sit?

a. Concert intensity = Stereo intensity
b. Concert intensity = 1.20× stereo intensity
c. Concert intensity = 2× stereo intensity
d. Concert intensity = 10× stereo intensity
e. Concert intensity = 20× stereo intensity
f. Concert intensity = 100× stereo intensity

+20 dB

= ×100

Decibels, cont.

From table in book:

		W/m^2	dB
Jet on a runway	Instant pain, damage	1000	150
Machine gun	damage	10	130
Rock concert (best seats)	pain, damage	1	120
Power mower	damage (if all day)	10^{-2}	100 ←
Vacuum cleaner @ 5ft	safe all day	10^{-5}	70
Conversation		10^{-7}	50
Whisper		10^{-9}	30
Rub fingers by ear	Threshold	10^{-12}	0

OSHA

TABLE D-2 - PERMISSIBLE NOISE EXPOSURES

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or less	115

https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10625

From warmup

Ralph is confused about Table 14.2 (8th edition), where the book lists different intensity levels for different sources. For example, the table says a vacuum cleaner has an intensity of 70 dB. What confuses Ralph, is that it seems like a vacuum cleaner should sound louder to someone who is pushing the vacuum cleaner than to someone who is a little farther away. How can the intensity level be 70 dB for both people? How should you answer Ralph's question?

My answer: For once in Ralph's life, he got something right!!

Logarithm Review (base 10)

$\text{Log}_{10}(x)$ is the inverse of 10^y → if $x = 10^y$ then $y = \log_{10}(x)$

I.e. **"10 to the what equals 22?"** answer: 1.3424 (log(22))

$\log_{10}(100) =$? Translation: 10 to what number equals 100? (2)

Test: $10^2 = 100$ ✓

ln(100) = ? ("ln" = $\log_e = \log_{2.71828}$)

Translation: e to what number equals 100? (4.605)

Test with calculator: $2.71828^{4.605} = 99.983$

If the problem just says log(100)…could be either $\log_{10}$ or ln

For us: assume $\log_{10}$

Clicker quiz

What is $\log_{10}(1,000,000)$?

a. 1
b. 6
c. 7.5
d. 10
e. 93

"Laws of Logs" Review

$\log(6)$ $\log(2) + \log(3)$

1. **$\log(ab) = \log(a) + \log(b)$**

2. **$\log(a^n) = n \log(a)$**

$\log(8) = 3\log(2)$

2^3

Worked problem: If log(3) = 0.477, what is log(300)?

$\log(3 \cdot 100)$

$= \log 3 + \log 100$

$= .477 + 2$

$= 2.477$

Decibels, cont.

$$\beta = 10 \log \frac{I}{I_o}$$

β = "decibel number"

$I_0 = 10^{-12}$ W/m^2

Compare two intensities:

If you increase I by a *factor* of 10, *add* ____10____ to β

If you increase I by a *factor* of 100, *add* ____20____ to β

If you increase I by a *factor* of 1000, *add* ____30____ to β

→ **each factor of ten added to dB number = ×10 to the intensity**

Worked problem: If you increase *I* by ×2, what do you add to β?
(Given that log(2) = 0.301.)

+3 dB = ×2

<u>You may need to know this for final</u>

→ **each factor of ten added to dB number = ×10 to the intensity**

→ **each ×10 to the intensity means you add 10 dBs**

→ **each factor of 3 added to dB number = ×2 to the intensity** ☆

→ **each ×2 to the intensity means you add 3 dBs**

$8 = 2 \times 2 \times 2$

Clicker quiz: If you increase I by *a factor* of 8, *add* ____________ to the decibel level (Hint: do it with 2's)

a. 4
b. 6
c. 8
d. 9
e. ~~12~~

$+3 + 3 + 3 = \boxed{+9}$

Worked problem

You hear an average of 82 dB in your workshop as three printing presses run. The next day you come in and find the sound level to be 88 dB. *How many* total printing presses are now running?

$+6\text{ dB} = +3 \quad +3$

$\uparrow \quad \uparrow$

$\times 2 \quad \times 2$

12 presses

What if you need to solve for *I*?

$$\beta = 10 \log\left(\frac{I}{I_0}\right)$$

(this equation is <u>not</u> given on final)

$$\frac{\beta}{10} = \log\left(\frac{I}{I_0}\right)$$

$y = \log x$

$10^y = x$

$$10^{(\beta/10)} = \frac{I}{I_0}$$

$$I = I_0 \, 10^{(\beta/10)}$$

Answer: $I = I_0 \cdot 10^{\beta/10}$

Review quizzes

Clicker quiz 1: The *intensity* of a wave is its

a. power
b. power/area
c. power × area

Clicker quiz 2: T/F: If you double the sound intensity, the decibel number also gets doubled.

a. true
b. false

Clicker quiz 3: 10^{-4} W/m^2 has a dB level of ________ dB. (Eqn given on exam is: $\beta = 10\log\left(I/I_0\right)$ $\quad I_0 = 10^{-12}$ W/m^2.)

a. 4
b. 8
c. 60
d. 80
e. 90