Lecture 26 Announcements

1. Results of the class votes
   a. Final replace a midterm score? **Yes**
      i. 26% for option A (regular final, safety net at 77%)
      ii. 74% for option B (final score will replace one midterm if it helps you, chosen to maximize your points; safety net moved to 73%)

      → Note: computer grading system does not (yet?) reflect this change in the "Your score on the final exam must be at least xx% to guarantee a final grade of X" statements.

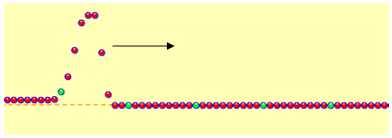
2. Colton "class improvement survey" link sent out, 3 bonus points if you complete it by Thurs, Dec 10.

3. Online course evaluations due Dec 13
   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. (No extra credit)

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

5. Rate the TA-lab tutors! You should receive an email. The top tutor (tutors?) gets a cash prize.

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

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

Boundaries

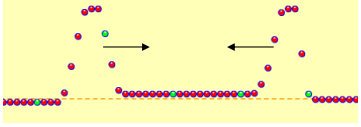
Rope: Light rope meets heavy rope
Light: Air meets glass

In both cases: _____

Sound: Thin air meets dense air
   → Also can cause reflections

Superposition/Interference

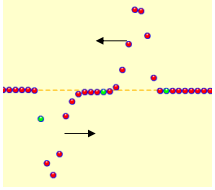
http://www.colorado.edu/physics/phet/simulations/stringwave/stringWave.swf



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:

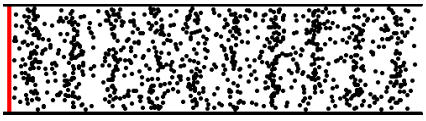
What gets transported by the wave?
What does the transporting?

What was wrong with the Star Wars video?

What is sound?

Clicker quiz: What type of oscillation is a sound wave?
   a. Longitudinal
   b. Transverse
   c. Neither

Kind of like this:



…but not entirely. **What** is oscillating like that? The molecules?

Demo: Vacuum jar

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

Demo: **Hearing test!** Frequency source & speaker

How is sound produced?
   → Speaker cutaway
   → Tuning fork demo
   → Air jet and spinning disk demo
   → Vocal folds ("cords") demo
   → "singing rod" demo

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 don't need to know this)

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

Solids

"Sound waves" in solids are like the P (longitudinal) and S (transverse) waves in earthquakes

Table in book:

Aluminum	5100 m/s
Copper	3560 m/s

} Almost certainly these speeds are for *longitudinal* waves

Liquids

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

Table in book:

Water	1490 m/s
Methanol	1140 m/s

→ Why would solids be the fastest?

Intensity

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

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

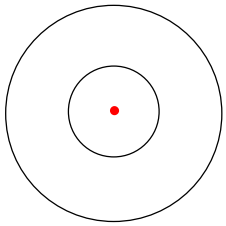
→ Not just for sound

Intensity vs distance?

For a *spherically* emitting source:

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

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



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?

_____W/m^2

a. 2.5 b. 5 c. 10 d. 20 e. 40

Problem: What is the total sound power (watts) being produced by the speaker?

Decibel intensity scale

- We hear over a huge range of intensities
- So use a ***logarithmic scale***

(multiplied by 10, for no apparent reason)

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

"log" = "logarithm, base 10"

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

Answer: 282.7 W

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

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	safe all day	10^{-5}	70
Conversation		10^{-7}	50
Whisper		10^{-9}	30
Rub fingers by ear	Threshold	10^{-12}	0

"Jet on a runway?" → calling Mythbusters! ☺

http://www.youtube.com/watch?v=eTQh7D-nDNM start at 2:48

OSHA regulations: ≤ 90 dB averaged over 8 hour day.

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?

Answer from the class:

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))

Review of "Laws of Logs":

1. **log(ab) = log(a) + log(b)**
2. **log(a^n) = n log(a)**

$\log_{10}(100) = ?$ 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 $\log_{10}$

Worked Problem: $\log_{10}(1{,}000{,}000) =$

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

Decibels again

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

β = "decibel number"
$I_0 = 10^{-12}$ W/m^2

Compare two intensities:

If you increase I by a *factor* of 10, *add* _____ to β
If you increase I by a *factor* of 100, *add* _____ to β
If you increase I by a *factor* of 1000, *add* _____ 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.)

You need to know this for final

→ 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

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

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?

What if you need to solve for *I*?

$$\boxed{I = I_o\left(10^{\beta/10}\right)}$$ (this is not given on final)

Review quizzes

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

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

Clicker quiz 2: True/false: 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.

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