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___________ and part of wave t___________
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?**
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: \( v = 343 \text{ m/s at 20}^\circ \text{ C} \)

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

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

Solids
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

To impress your date: ~1 km in 3 seconds
Speed of sound, cont.

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 \[ \frac{I_1}{I_2} = \frac{r_2^2}{r_1^2} \]

\[ i_______ s________ l____! \]

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$^2$
Worked Problem
Same situation (spherically emitting speaker, 10 W/m² at 1.5 meters). What is the total sound power (watts) being produced by the speaker?

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
Decibels

- We hear over a huge 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 = \( \times 10 \) to the intensity
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\times\text{ stereo intensity}  
c. Concert intensity = 2\times\text{ stereo intensity}  
d. Concert intensity = 10\times\text{ stereo intensity}  
e. Concert intensity = 20\times\text{ stereo intensity}  
f. Concert intensity = 100\times\text{ stereo intensity}
Decibels, cont.

From table in book:

<table>
<thead>
<tr>
<th>Source of Noise</th>
<th>Effect</th>
<th>$W/m^2$</th>
<th>dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jet on a runway</td>
<td>Instant pain, damage</td>
<td>1000</td>
<td>150</td>
</tr>
<tr>
<td>Machine gun</td>
<td>damage</td>
<td>10</td>
<td>130</td>
</tr>
<tr>
<td>Rock concert (best seats)</td>
<td>pain, damage</td>
<td>1</td>
<td>120</td>
</tr>
<tr>
<td>Power mower</td>
<td>damage (if all day)</td>
<td>$10^{-2}$</td>
<td>100</td>
</tr>
<tr>
<td>Vacuum cleaner</td>
<td>safe all day</td>
<td>$10^{-5}$</td>
<td>70</td>
</tr>
<tr>
<td>Conversation</td>
<td></td>
<td>$10^{-7}$</td>
<td>50</td>
</tr>
<tr>
<td>Whisper</td>
<td></td>
<td>$10^{-9}$</td>
<td>30</td>
</tr>
<tr>
<td>Rub fingers by ear</td>
<td>Threshold</td>
<td>$10^{-12}$</td>
<td>0</td>
</tr>
</tbody>
</table>
### TABLE D-2 - PERMISSIBLE NOISE EXPOSURES

<table>
<thead>
<tr>
<th>Duration per day, hours</th>
<th>Sound level dBA slow response</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>92</td>
</tr>
<tr>
<td>4</td>
<td>95</td>
</tr>
<tr>
<td>3</td>
<td>97</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>1 1/2</td>
<td>102</td>
</tr>
<tr>
<td>1</td>
<td>105</td>
</tr>
<tr>
<td>1/2</td>
<td>110</td>
</tr>
<tr>
<td>1/4 or less</td>
<td>115</td>
</tr>
</tbody>
</table>

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)

\( \log_{10}(x) \) is the inverse of \( 10^y \) \( \rightarrow \) 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

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

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

**Worked problem:** If \( \log(3) = 0.477 \), what is \( \log(300) \)?
Decibels, cont.

\[ \beta = 10 \log \frac{I}{I_0} \]

\( \beta \) = “decibel number”
\( I_0 = 10^{-12} \text{ W/m}^2 \)

Compare two intensities:
- If you increase \( I \) by a factor of 10, add \( \_\_\_\_\_\_\_\_\_\_\_\_\_\_ \) to \( \beta \)
- If you increase \( I \) by a factor of 100, add \( \_\_\_\_\_\_\_\_\_\_\_\_\_\_ \) to \( \beta \)
- If you increase \( I \) by a factor of 1000, add \( \_\_\_\_\_\_\_\_\_\_\_\_\_\_ \) to \( \beta \)

\( \rightarrow \) each factor of ten added to dB number = \( \times 10 \) to the intensity

**Worked problem**: If you increase \( I \) by \( \times 2 \), what do you add to \( \beta \)?
(Given that \( \log(2) = 0.301 \).)
You may need to know this for final
→ each factor of ten added to dB number = \( \times 10 \) to the intensity
→ each \( \times 10 \) to the intensity means you add 10 dBs

→ each factor of 3 added to dB number = \( \times 2 \) to the intensity
→ each \( \times 2 \) 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 $I$?

(this equation is not given on final)

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 $\times$ 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: $\beta = 10\log\left(\frac{I}{I_0}\right)$  $I_0 = 10^{-12}$ W/m$^2$.)
   a. 4
   b. 8
   c. 60
   d. 80
   e. 90