Announcements – 4 Dec 2014

1. Prayer

2. Exam 3 – closes today at 3 pm

3. Upcoming dates:
    a. Fri Dec 5 - Photo contest submissions due at midnight
    b. Mon Dec 8 - HW 27 due
    c. Tue Dec 9 - Photo contest results announced in class
    d. Wed Dec 10 - HW 28 due (final homework!)
    e. Thu Dec 11 - last day of class
    f. Thu Dec 11, 5:30 – 7 pm - Jerika final exam review, C295 ESC
    g. Fri Dec 12, 6 – 7:30 pm - Jerika final exam review, C295 ESC
    h. Fri Dec 12 - All extra credit & late HW must be turned in by midnight; this includes all TA-graded stuff as well as all computer-graded stuff
    i. Sun Dec 14 - BYU Instructor/course ratings due http://studentratings.byu.edu (2 pts extra credit)
    j. Tue Dec 16 - Final exam in class (7-10 am or 8-11 pm)

“Which of the problems from last night's HW assignment would you most like me to discuss in class today?”

Decibels, review

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

β = "decibel number", aka "sound level"
log = base 10
$I_0 = 10^{-12}$ W/m^2

intensity	β
$\times 10$	+10 dB
$\times 100$	+20 dB
$\times 1000$	+20 dB
$\times 2$	+3 dB
etc.	

Clicker quiz

You hear a sound level 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 likely now running?

a. 6
b. 8
c. 9
d. 12
e. 20

12

β: +3 dB +3 dB

I: x2 x2 = x4

What if you need to solve for *I*?

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

$$\frac{\beta}{10} = \log\frac{I}{I_0}$$

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

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

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

Review quizzes (quick, no discussion)

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

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

I

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

+3 dB

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

$I_0 = 10^{-12}$ W/m^2 = 0 dB

10^{-4}

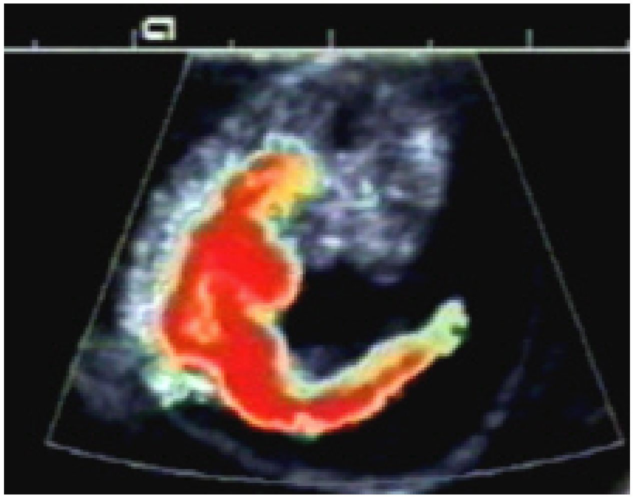
→ $\times 10^8$

80 dB

Doppler Shift—“Race Car Effect”

Some applications:

- Radar guns
- Doppler weather radar
- Doppler ultrasound: blood flow imaging in heart



8 1/2 week embryo blood flow

Doppler: key point

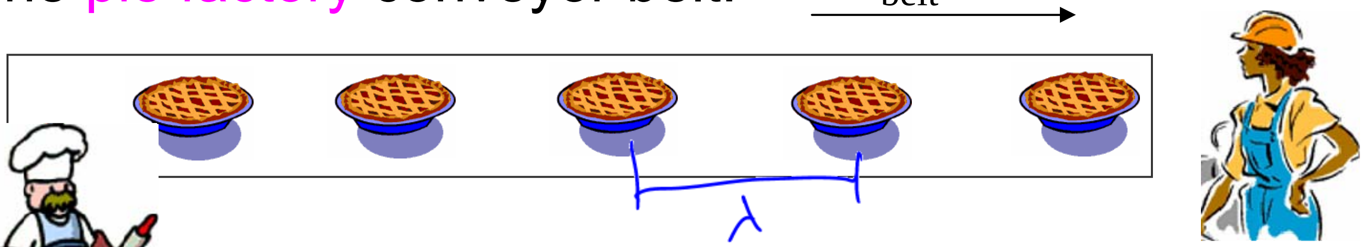
Frequency is ___increased___ when the source and observer approach each other, ___decreased___ when they go away from each other.

Demo: Doppler speaker

Demo: Come, Come, Ye Saints
http://stokes.byu.edu/teaching_resources/bells.wav

$v = \lambda f$

The pie factory conveyor belt: v_{belt}



$f = v/\lambda$ or $\lambda = v/f$ = the spacing between pies

v_s source speed (baker)
v_o observer speed (construction worker)
v speed of sound (speed of pies on the belt)

$f \uparrow$

If **observer moves** toward source, she would measure the same ___λ___ but the pies are coming at her ___more quickly___

If **source moves** toward observer, the ___λ___ shrinks, but the pie ___speed___ doesn't change

Both source and observer can move
http://stokes.byu.edu/doppler_script_flash.html

Doppler Equation

v = speed of sound
v_o = " " observer
v_s = " " source

$$f' = f\,\frac{v \pm v_o}{v \pm v_s}$$

freq heard by observer (f')

freq of source (f)

Choose your signs **carefully**!!

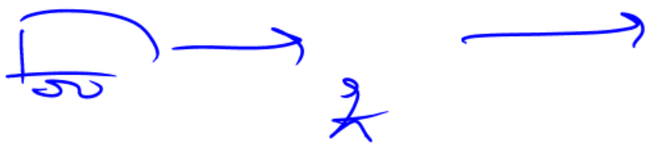
→ + in numerator when observer towards source

→ + in denominator when source away from observer

Otherwise, reversed!

Worked problem

An ambulance siren emits a 500 Hz tone as it approaches you at 25 m/s, and continues to emit the tone as it goes away from you (still at 25 m/s). What two pitches do you hear? (v_{sound} = 343 m/s.)



$$f = f_0 \frac{v \pm \cancel{v_0}}{v \mp v_s}$$

(a) $f = (500\text{ Hz}) \frac{343}{343 - 25} = \boxed{539.3\text{ Hz}}$

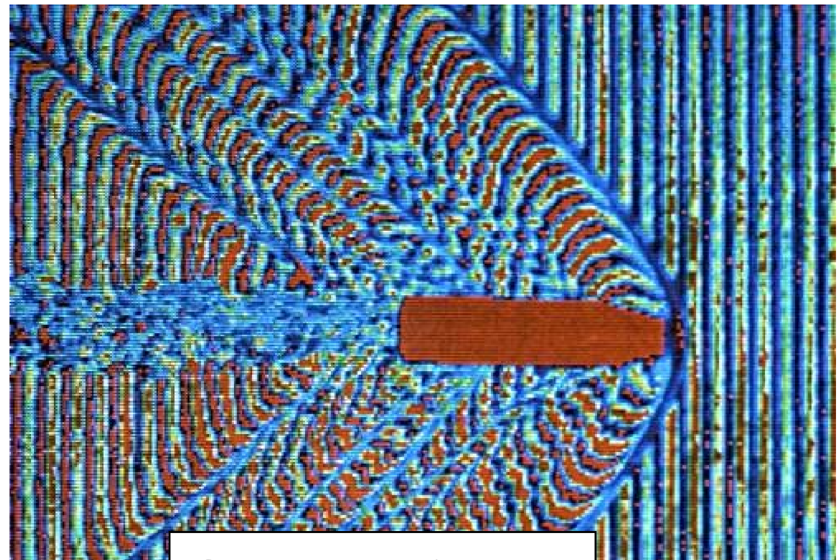
(b) $f = (500\text{ Hz}) \frac{343}{343 + 25} = \boxed{466.0\text{ Hz}}$

Answers: 539.3 Hz, 466.0 Hz

Sonic Boom: if $v_{source} > v_{sound}$

http://stokes.byu.edu/teaching_resources/boom_flash.html

Sonic boom manifested by condensation of water in air



Supersonic bullet imaged by interference effects

Doppler shift of light

From warmup: Ralph wants to know why this bumper sticker is funny.

"Think-pair-share"

- Think about it for a bit
- Talk to your neighbor, find out if he/she thinks the same as you
- Be prepared to share your answer with the class if called on

Clicker: I am now ready to share my answer if randomly selected.

a. Yes

Note: you are allowed to "pass" if you would really not answer.

More Physics Humor

FIGURE 60. *Based on her successful Doppler effect defense, Carla was found not guilty of running a red light and instead was found guilty of speeding and fined eight trillion dollars!*

Galaxies

How far away is a galaxy?

Sombrero Galaxy, 2.6×10^{23} m from Earth
Picture taken with Hubble Space Telescope

Edwin Hubble, 1929: Distance away proportional to speed

→ How did he measure distance?
Supernovae observations (how bright/dim they are)

→ How did he measure speed?
Doppler shift of spectral lines!

That's now a standard technique for today's astronomers when they want to know distances… just measure Doppler "redshift".

$v = \lambda f$

Hubble's Law and the Big Bang

Yes, it's OK for LDS to believe in the Big Bang…

Clicker quiz

Take the speed of sound to be 300 m/s for convenience. A 300 Hz siren is coming towards you on a fast car going 150 m/s. You're driving away from that car at 100 m/s. What frequency do you hear (in Hz)?

a. 225
b. 267
c. 300
d. 367
e. 400

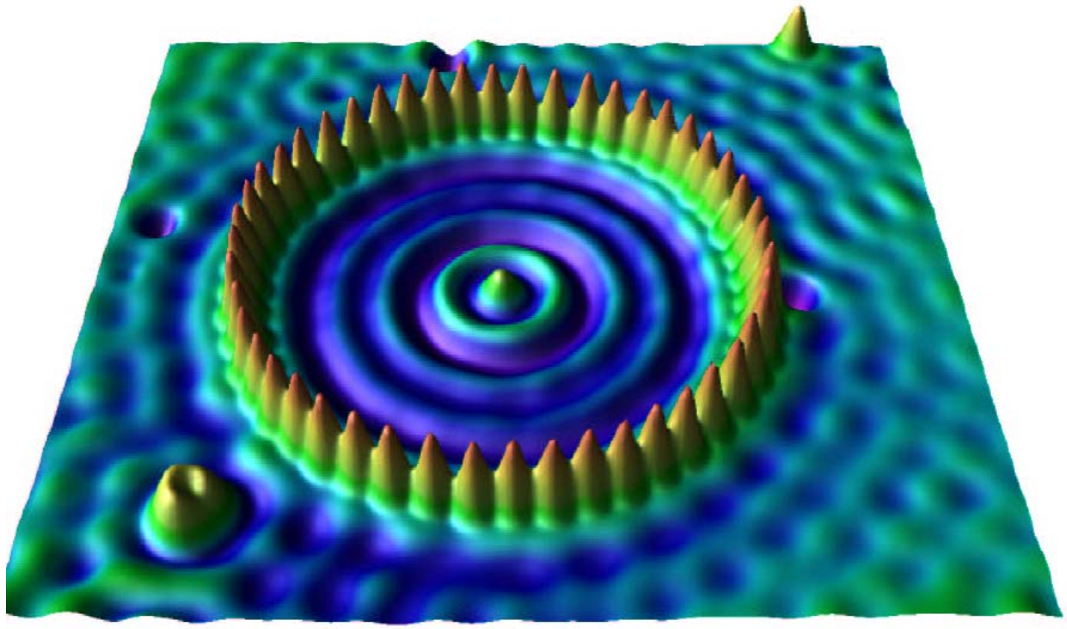
$$f = f_0 \frac{v \pm v_o}{v \pm v_s}$$

$$= (300\text{ Hz}) \frac{300 - 100}{300 - 150}$$

$$= 300\text{ Hz} \left(\frac{200}{150}\right)$$

$$= \boxed{400\text{ Hz}}$$

Interference/superposition: waves adding together

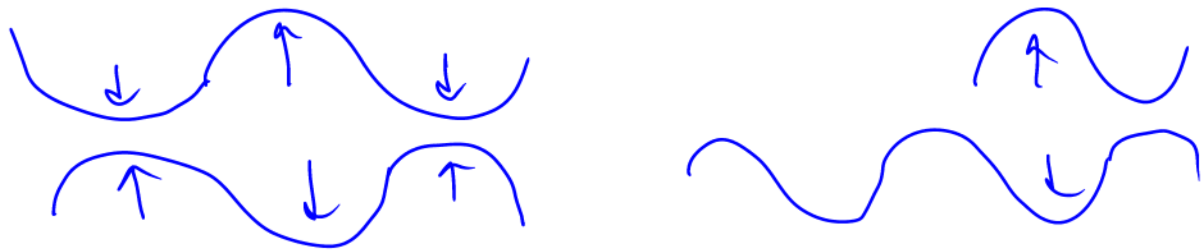


Electron waves on a copper surface with iron impurities, viewed by scanning tunneling microscope.

Path Length Effects

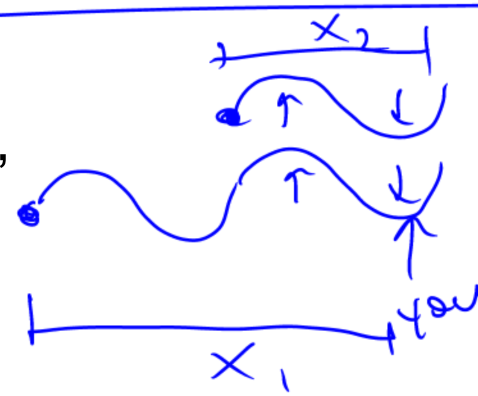
From warmup: If two waves are shifted by _________, completely destructive interference will occur.

a. $\lambda/2$
b. $2\lambda/3$
c. λ
d. 2λ



PL

Path-length dependence: the "interference equations"



Constructive interference: $\Delta PL = n\lambda$

$\Delta PL = x_1 - x_2$

Destructive interference: $\Delta PL = (n + \frac{1}{2})\lambda$

n = integer

From warmup

In a standing wave, the points that have the maximum vibration are called:

a. nodes
b. anti-nodes

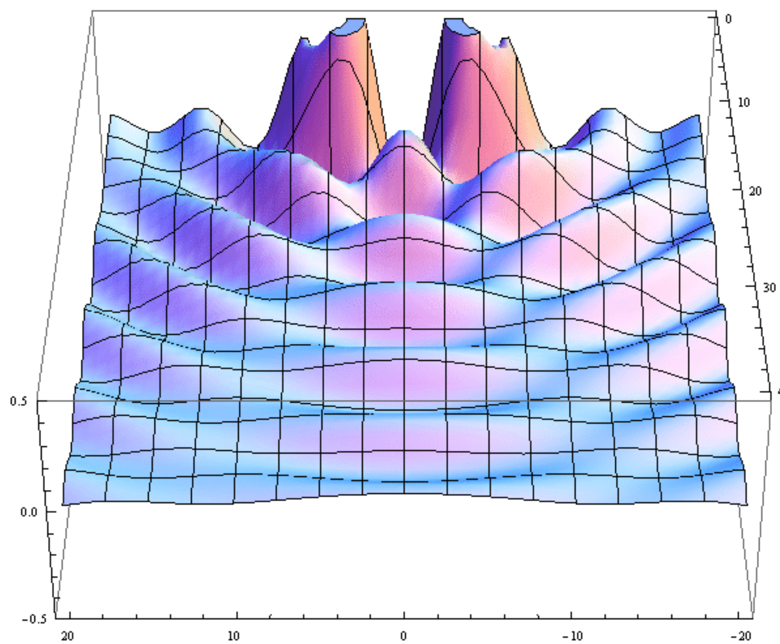
Demo

Two speaker interference

Colton Simulations

Links on class website:

- Left
- Right
- Combined
- "Combined2" (out of phase)
- All four



Ripple Tank

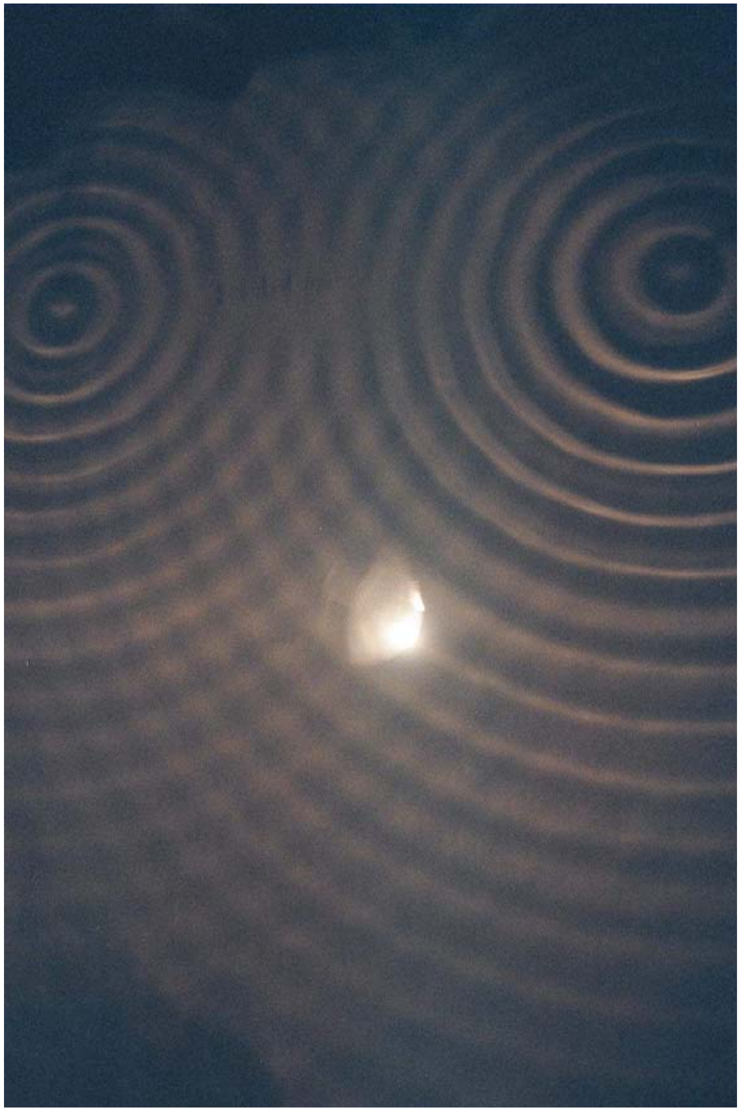


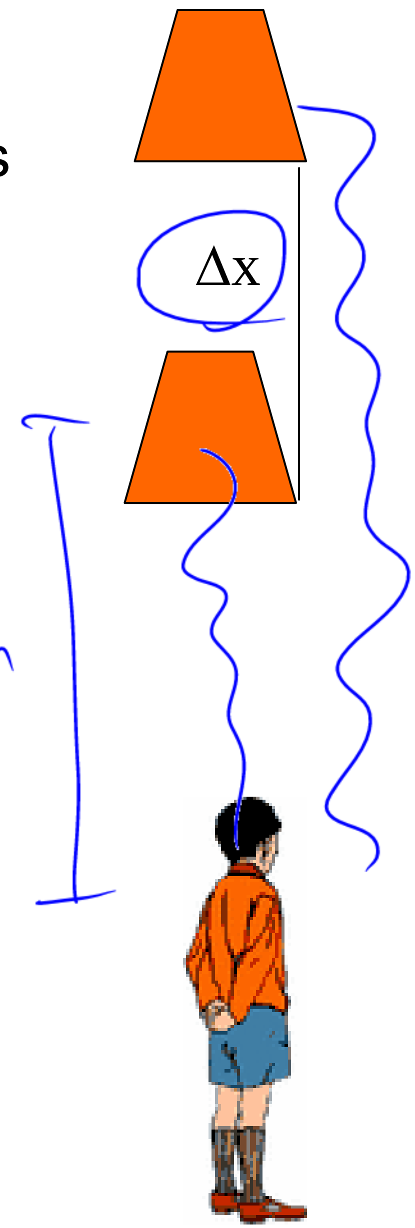
Image from Wikipedia

Demo: "Moire pattern" transparencies

Worked Problem

$\lambda = \frac{v}{f} = \frac{343 \text{ m/s}}{500 \text{ 1/s}} = .686 \text{ m}$

Two speakers are in-line as shown. Both emit sinusoidal sound waves at 500 Hz, oscillating exactly in phase. A boy is standing 5 m away from the nearest speaker.



What should the separation (Δx) be to get a *minimum* where the boy is standing? Hint: first find the wavelength.

$\Delta PL = (n + \frac{1}{2})\lambda$

$\Delta x = \frac{1}{2}(.686 \text{ m})$ or $\frac{3}{2}(.686)$ ... or $\frac{5}{2}(.686)$ ...

$= .343 \text{ m}$

To get a *maximum* where the boy is standing?

$\Delta PL = n\lambda$

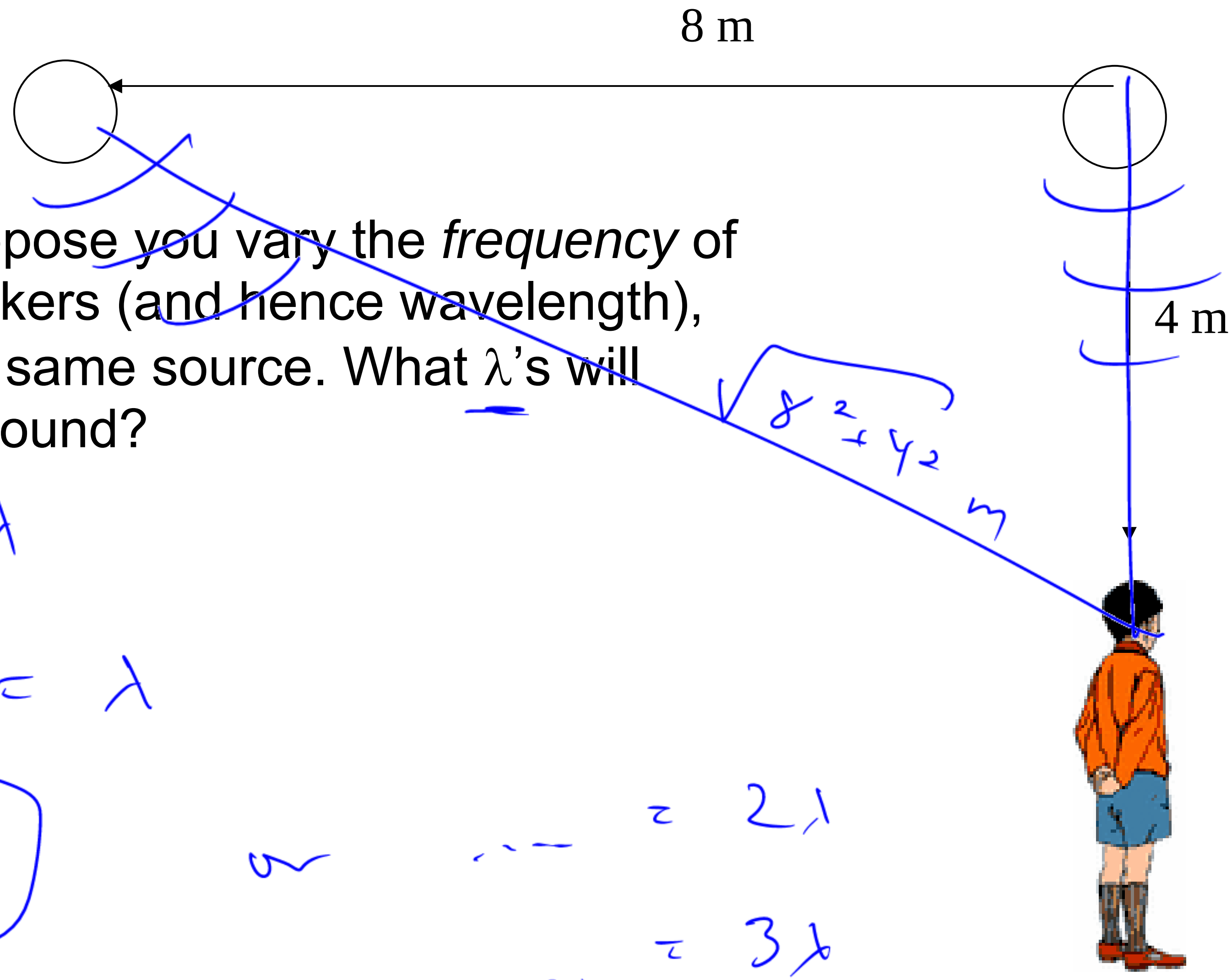
$\Delta x = .686 \text{ m}$ or $2 \cdot .686 \text{ m}$, $3 \cdot .686 \text{ m}$ ...

Answers: λ = 0.686 m; 0.343 m (or 1.029 m, 1.715 m, …); 0.686 m (or 1.372 m, 2.058 m, …)

Demo Video

Two speakers

Worked Problem



In this configuration, suppose you vary the *frequency* of the sound from the speakers (and hence wavelength), both speakers driven by same source. What λ's will give a maximum in the sound?

$\Delta PL = n\lambda$

$\sqrt{8^2+4^2} - 4 = \lambda$

$\lambda = 4.944\text{ m}$

or ... $= 2\lambda$

... $= 3\lambda$

Answers: 4.944 m, 2.472 m, 1.648 m, …

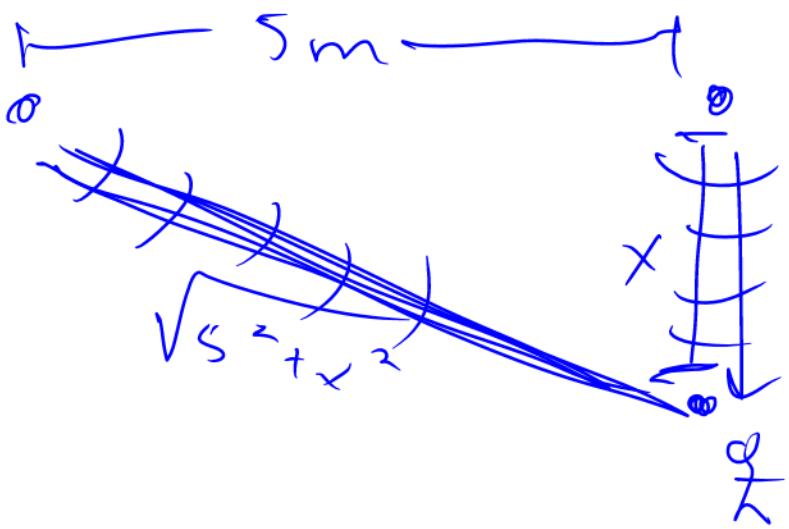
HW 28-1

28-1 A pair of speakers separated by [01] ______ m are driven by the same oscillator at a frequency of 690 Hz. An observer, originally positioned at one of the speakers, begins to walk along a line perpendicular to the line joining the two speakers. (Use 343 m/s as the speed of sound.)

(a) How far must the observer walk before reaching a relative maximum in intensity? [Answer Units: m]

$\Delta PL = n\lambda$

(b) How far will the observer be from the speaker when the first relative minimum is detected in the intensity? [Answer Units: m]

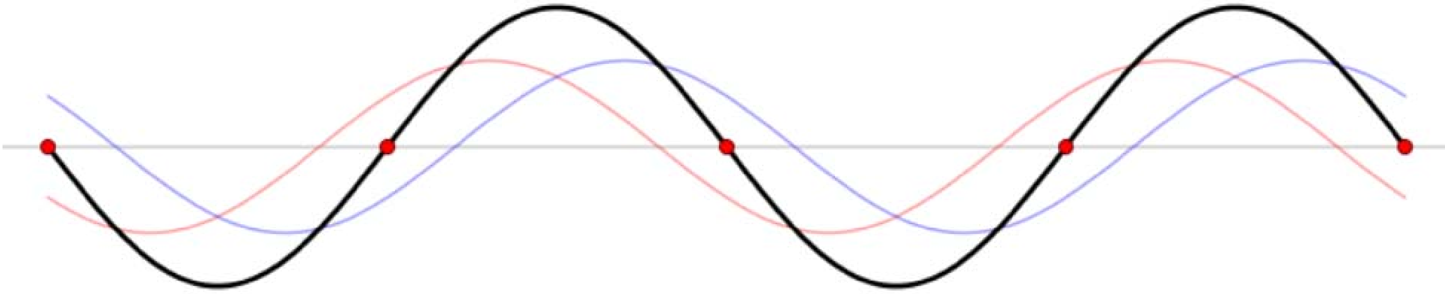


$\sqrt{5^2+x^2} - x = \lambda$

Standing waves

Combination of forward- and backwards-moving waves

Wikipedia: http://en.wikipedia.org/wiki/File:Standing_wave_2.gif



Can be caused by reflection

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

When caused by reflection

Only certain vibration frequencies give you a stable pattern.

Demos

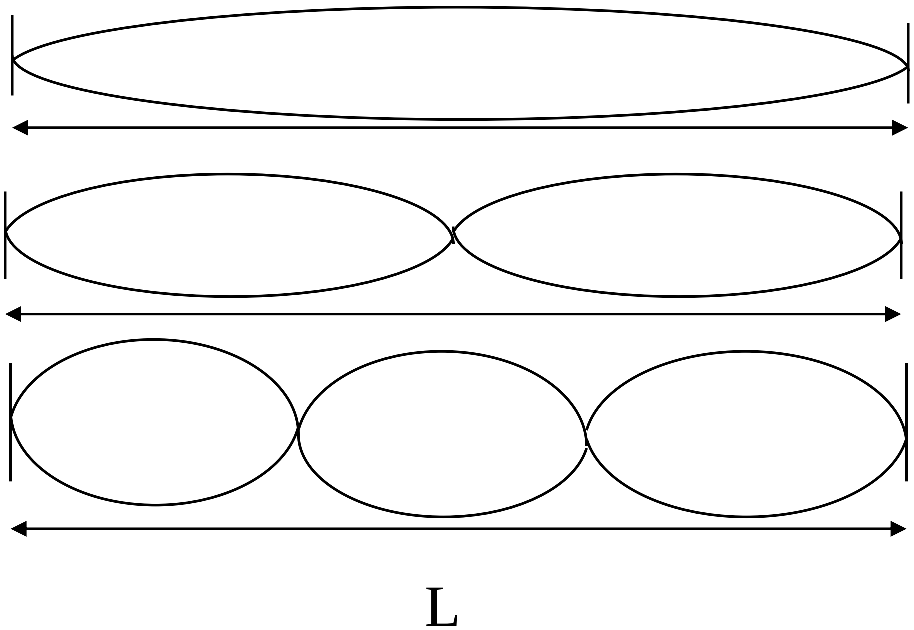
¼ inch tubing
"ladies belt" jig saw

Patterns

What kinds of patterns can you get?

Different stable frequencies called: H_______________

Harmonics of string, both ends fixed ("closed-closed")



L=______

L =______

L =______

What are the frequencies of these harmonics?

1.
2.
3.

The pattern: $f_n = n \times f_1$; n = 1, 2, 3, …