Announcements – 10 Dec 2013

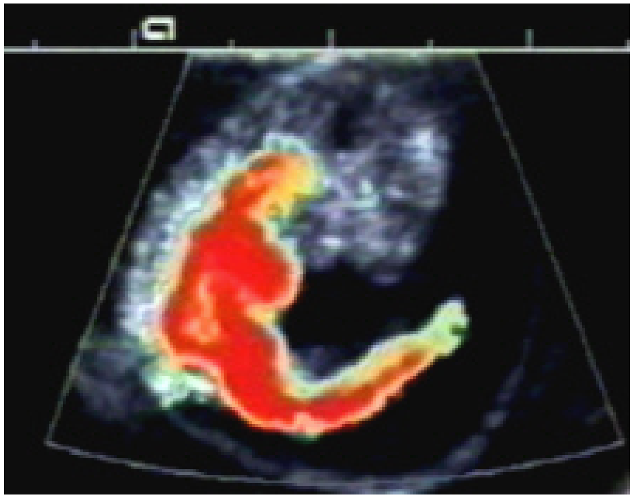
Today!

1. Thursday lecture: Half new stuff, half final exam review. Photo contest ~~winners will be announced~~! And a demo with flames!!
2. TA-led final exam reviews, voting results: Fri + Sat 12-1:30
3. Upcoming dates:
   a. HW 27 – "due" Thursday Dec 12… but no penalty if turned in before Friday Dec 13 (midnight).
      i. **WARNING: the link doesn't show up on the Max home page, you have to click on "Calendar" on the left.**
   b. All TA-graded extra credit, late FBDs, and satellite game extra credit must be turned in by midnight Fri, Dec 13
   c. BYU Instructor/course ratings must be done by Dec 15 http://studentratings.byu.edu
   d. Final exam in Testing Center anytime during finals week, Mon – Fri
   e. All computer-graded late homework must be turned in by midnight Fri, Dec 20

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

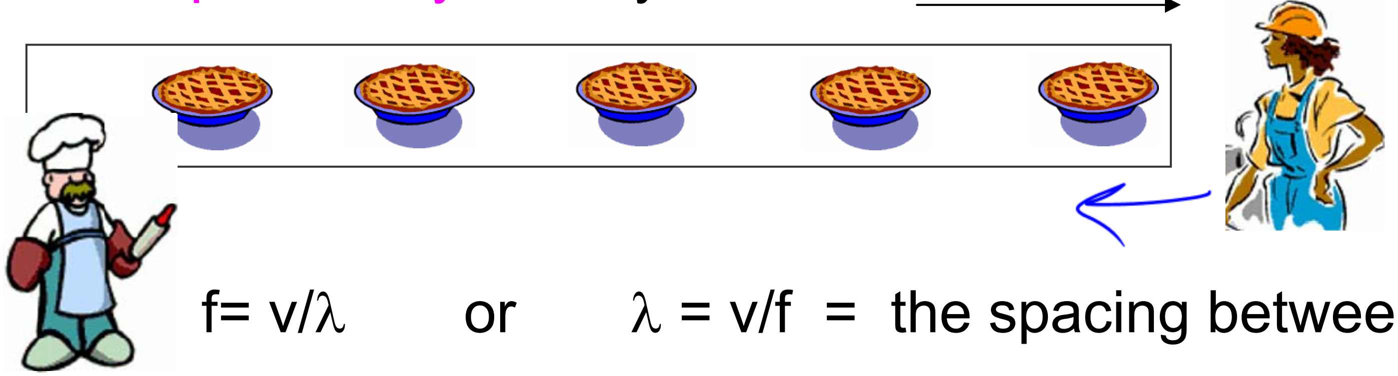
Doppler: key point

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

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 (pies on the belt)

If **observer moves** toward source, she would measure the same ___λ___ but the pies are coming at her at ___a faster speed / greater freq.___

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

$v = \lambda \cdot f$ ($\lambda \downarrow$, $f \uparrow$)

Both source and observer can move

http://stokes.byu.edu/doppler_script_flash.html

Doppler Equation

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

speed of sound (v) · your speed (v_o) · speed of source (v_s) · you hear (f') · emitted (f)

$$\frac{v + v_s}{v} \qquad \frac{v}{v - v_s}$$

Choose your signs **carefully**!!

→ + in numerator when <u>you are moving towards source</u>

→ + in denominator when <u>source is moving away from you</u>

Otherwise, reversed!

Worked problem

$V_o = 0$

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.)

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

Case 1

$$f' = (500\text{ Hz}) \frac{343}{343 - 25}$$

$$= 539\text{ Hz}$$

Case 2

$$f' = (500\text{ Hz}) \frac{343}{343 + 25}$$

$$= 466\text{ Hz}$$

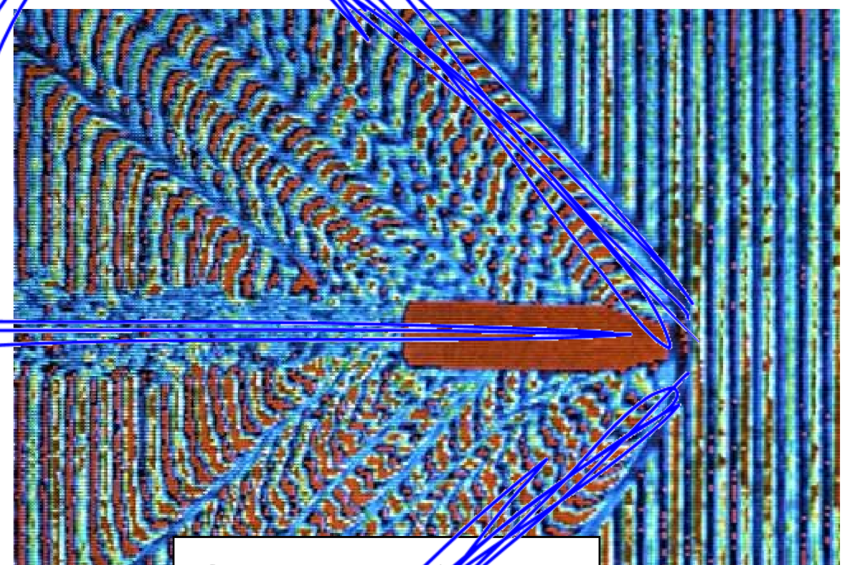
Answers: 539.3 Hz, 466.0 Hz

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

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

$\tan\theta = \frac{v_{sound}}{v_{bullet}}$

Sonic boom manifested by condensation of water in air



Supersonic bullet imaged by interference effects

θ

θ

$\tan\theta = \frac{v_{sound}}{v_{bullet}}$

Doppler shift of light

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

"Pair share"–I am now ready to share my neighbor's answer if called on.

a. Yes

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?

Edwin Hubble, 1929: Distance away proportional to speed

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

→ 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 shift.

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

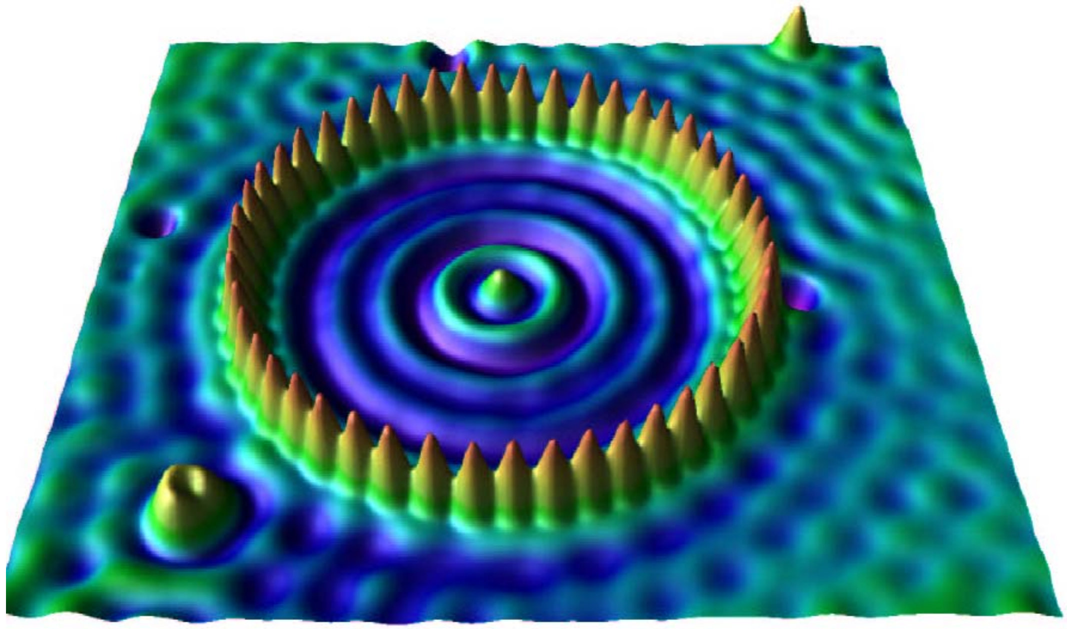
$$f' = f \frac{v \pm v_o}{v \pm v_s}$$

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

$$= 300 \cdot \frac{200}{150}$$

$$= 400\text{ Hz}$$

Interference/superposition: waves adding together

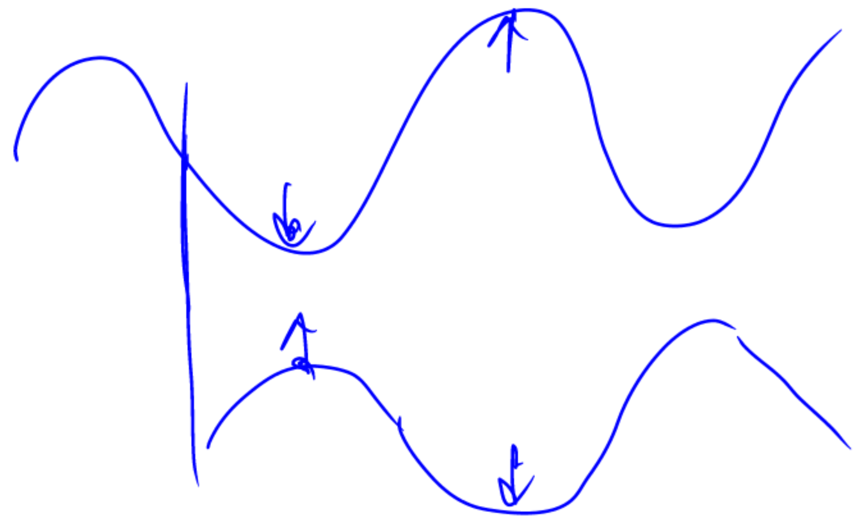


Electron waves on a copper surface with iron impurities,
viewed by scanning tunneling microscope.

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



Path-length dependence

$\Delta PL = n\lambda$

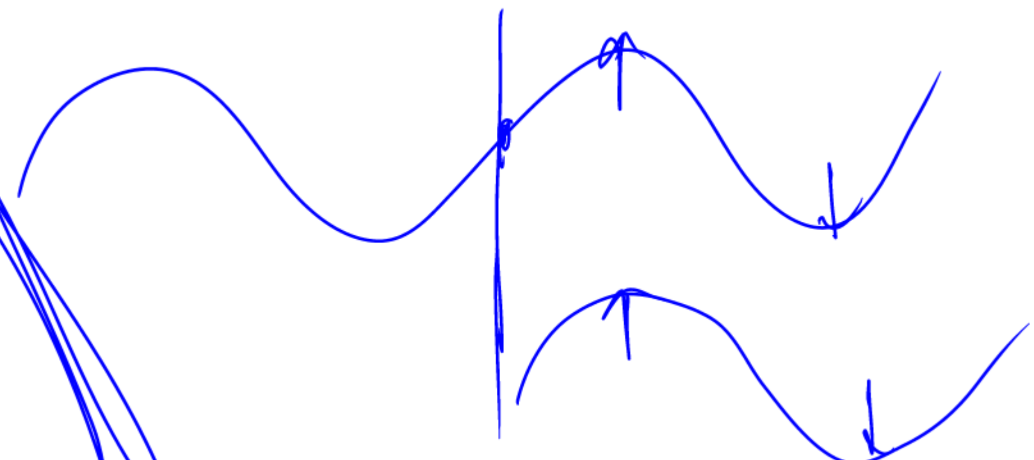
Constructive interference:

shift by $n\lambda$

Destructive interference:

shift by $\frac{\lambda}{2}, \frac{3}{2}\lambda, \frac{5}{2}\lambda, \ldots$

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



From warmup

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

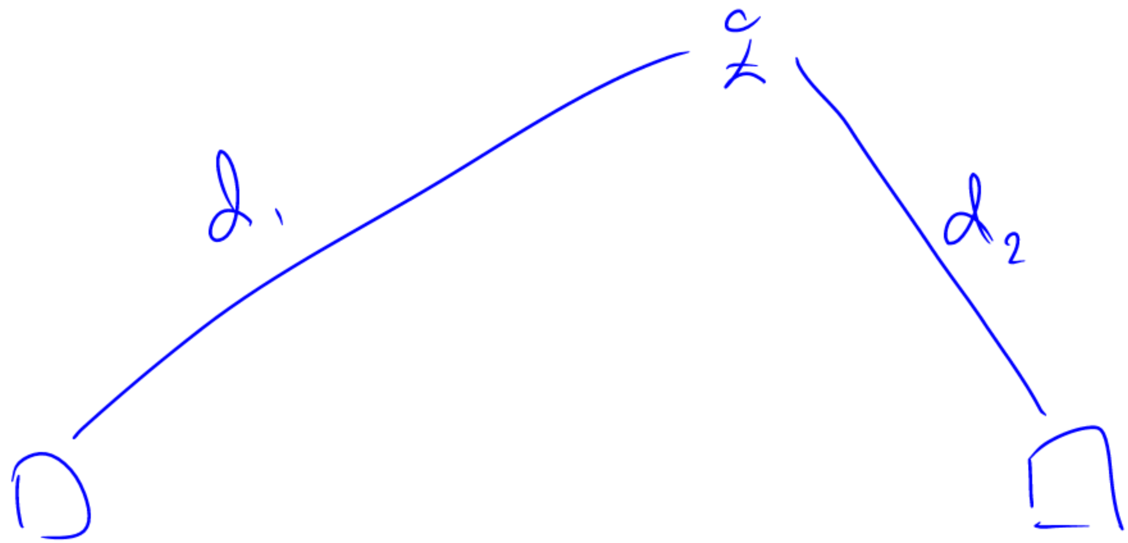
a. nodes
b. anti-nodes

cnstr: $d_1 - d_2 = n\lambda$

destr: $d_1 - d_2 = (n+\frac{1}{2})\lambda$

Demo

Two speaker interference



Colton Simulations

Links on class website: http://www.physics.byu.edu/faculty/colton/courses/phy105-fall13/

Left
Right
Combined
“Combined2” (out of phase)
All four

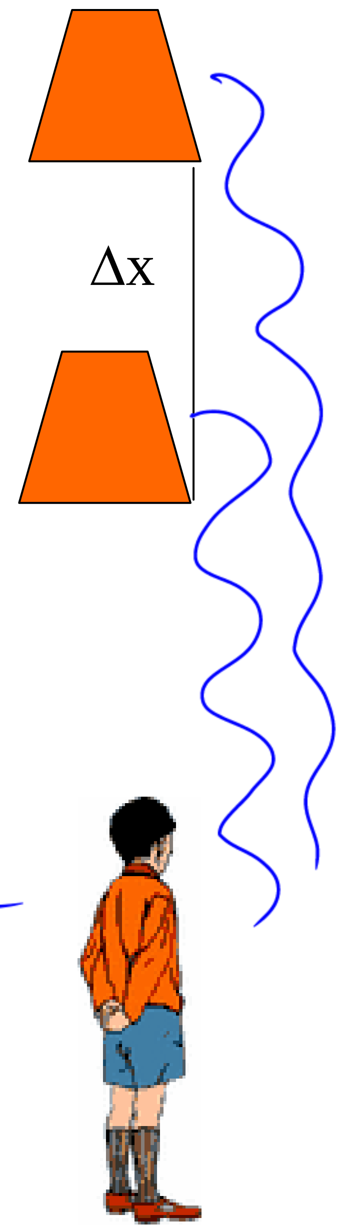
Ripple Tank

Image from Wikipedia

Demo: "Moire pattern" transparencies

Worked Problem

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.

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

$\frac{1}{2}\lambda$: $.343\text{m}$

$1\frac{1}{2}\lambda$, $2\frac{1}{2}\lambda$, $3\frac{1}{2}\lambda$

5m

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

$.686\text{m}$

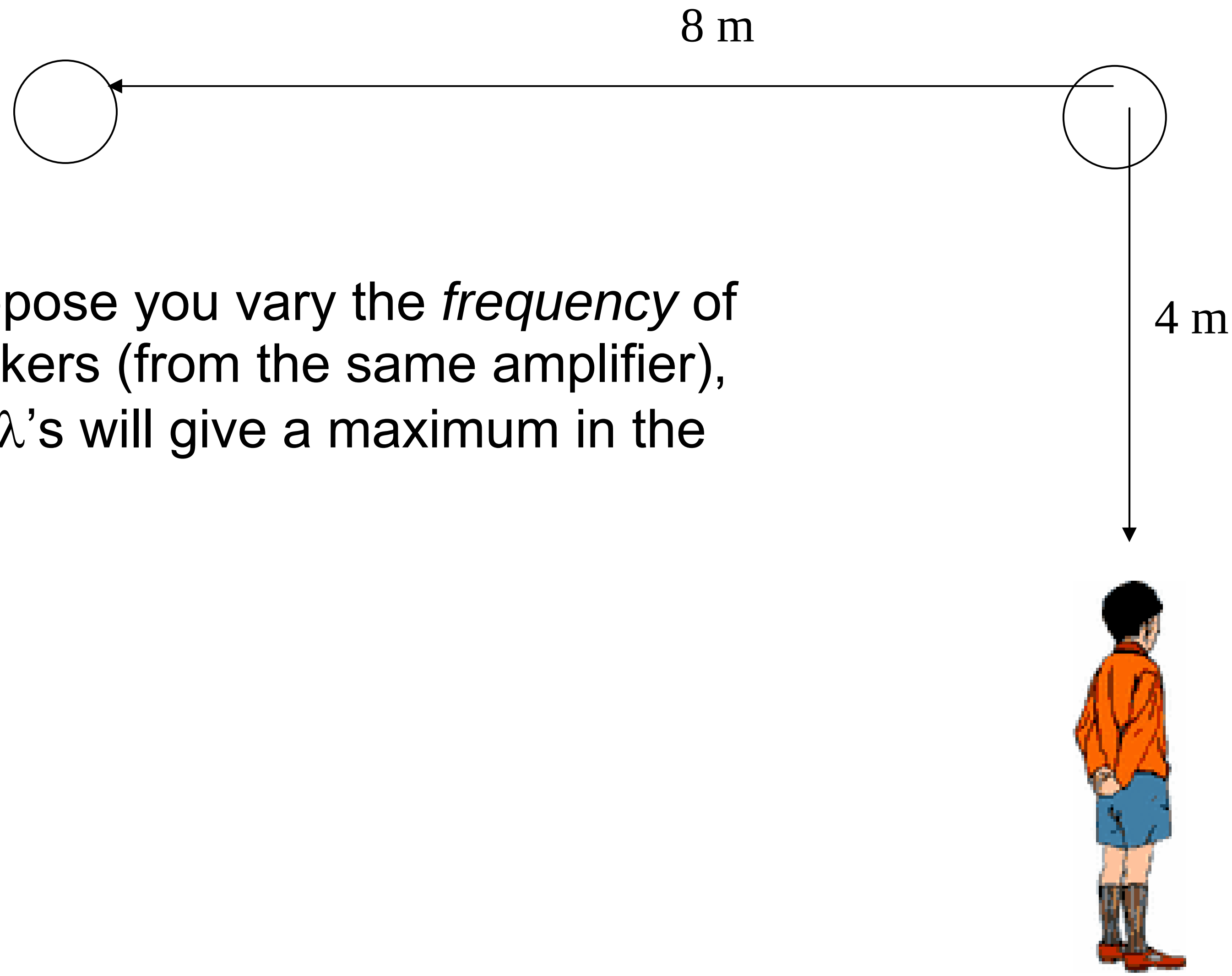
or 2λ or 3λ or . . .

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
(see HW 27-3)



In this configuration, suppose you vary the *frequency* of the sound from the speakers (from the same amplifier), not the distances. What λ's will give a maximum in the sound?

Answers: 4.944 m, 2.472 m, 1.648 m, …

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

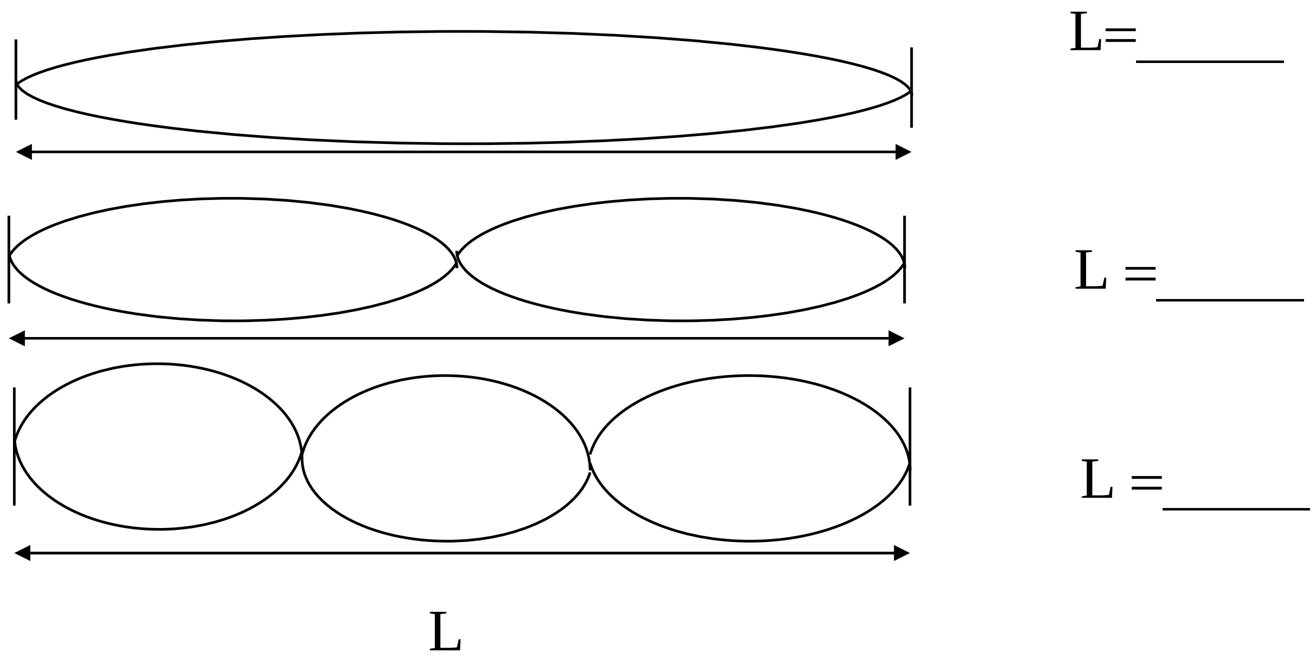
¼ inch tubing
"ladies belt"

Patterns

What kinds of patterns can you get?

Different stable frequencies called: H_______________

Harmonics of string, both ends fixed (“closed-closed”)



What are the frequencies of these harmonics?

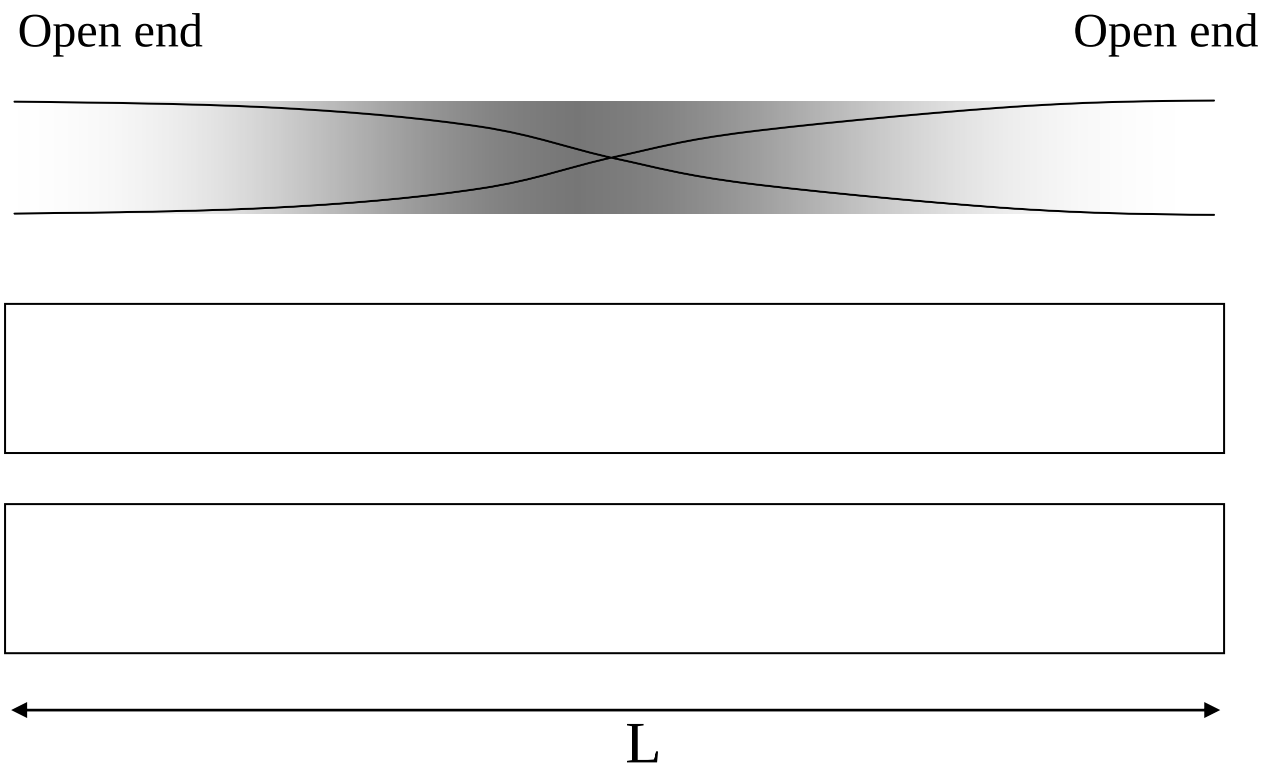
1.
2.
3.

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

Standing waves in air

Demos: trumpet, organ pipe

Harmonics of pipes, “open-open”



<u>frequencies</u>

L=_____

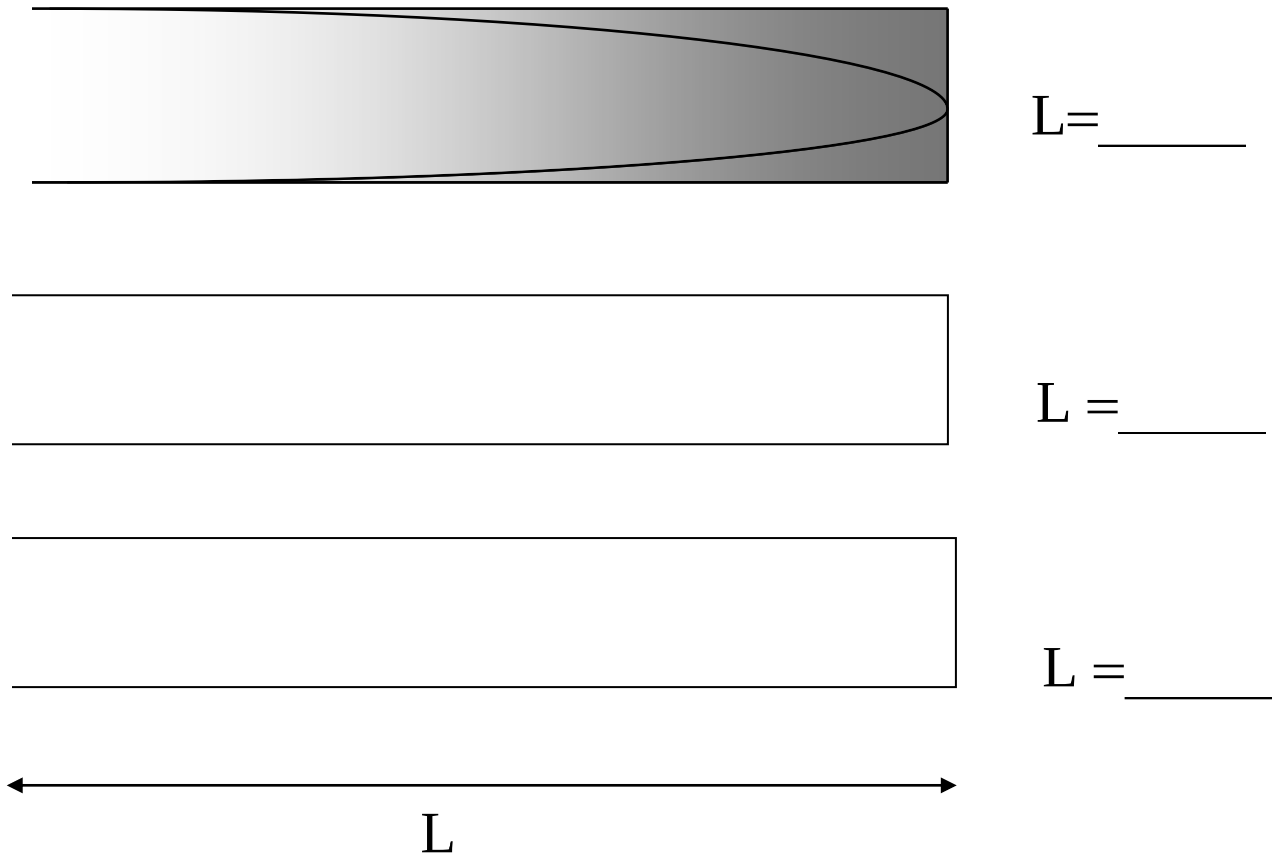
L =_____

L =_____

Same pattern as before: $f_n = n \times f_1$; n = 1, 2, 3, …

"Open-closed" pipes

frequencies



The pattern: $f_n = n \times f_1$; n = 1, 3, 5, …

From warmup

You have two pipes which produce sound: one is open at both ends (like an organ pipe) and the other is open at only one end (like a panpipe). If the two pipes have the same length, the fundamental resonant frequency will be ____________ for the two.

a. the same
b. different

Demo: pipe with removable cap