"Pongileoni's bowing and the scraping of the anonymous fiddlers had shaken the air in the great hall, had set the glass of the windows looking on to it vibrating: and this in turn had shaken the air in Lord Edwards' apartment on the further side. The shaking air rattled Lord Edwards' *membrana typani*; the interlocked *malleus*, *incus*, and stirrup bones were set in motion so as to agitate the membrane of the oval window and raise an infinitesimal storm in the fluid of the labyrinth. The hairy endings of the auditory nerve shuddered like weeds in a rough sea; a vast number of obscure miracles were performed in the brain, and Lord Edwards ecstatically whispered 'Bach!'"

-- Aldous Huxley, Point Counter Point

1

Announcement

- Practicals begin today with P0601 (1 – 3 PM) & P0701 (3 – 5 PM)
- For your 1st Practical:
  - Go to the Practicals section of the course web site
  - Print and bring **Week 1 Student Guide**
  - Come to MP125
    - Your name should appear on a list, telling you which room to go to

2

Last Time

- Finished the Doppler Effect
  - Moving source, stationary observer: $f_{wave} \neq f_{source}$
  - Stationary source, moving observer: $f_{observer} \neq f_{wave}$
- Reflection
  - Fixed end: inverted
  - Open end: not inverted
- Standing Waves: $D_{tot} = [2a\sin(kx)]\cos(\omega t)$
- Sound Waves:

  1. Displacement Wave 2. Pressure Wave

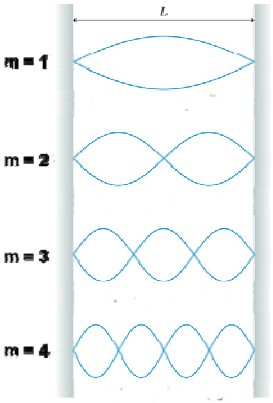
3

Today

- Finish Chapter 21
  - §21.4 – Standing Sound Waves and Musical Acoustics
  - §21.5 – Interference in One Dimension
  - §21.6 – The Mathematics of Interference
  - §21.7 – Interference in Two and Three Dimensions
  - §21.8 - Beats

4

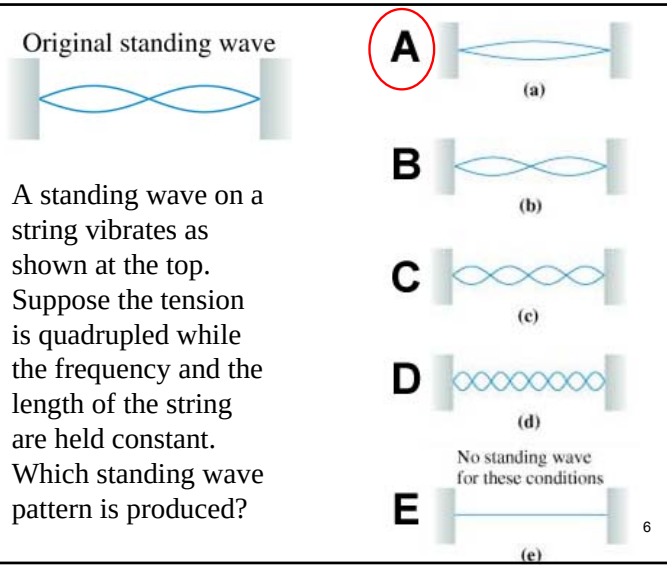
Possible Standing Waves on a String



$$\lambda_m = \frac{2L}{m}, \quad m = 1, 2, 3, 4, \ldots$$

$$f_m = \frac{v}{\lambda} = \frac{v}{2L} m, \quad m = 1, 2, 3, 4, \ldots$$

$$v = \sqrt{\frac{T_S}{\mu}}$$



A standing wave on a string vibrates as shown at the top. Suppose the tension is quadrupled while the frequency and the length of the string are held constant. Which standing wave pattern is produced?

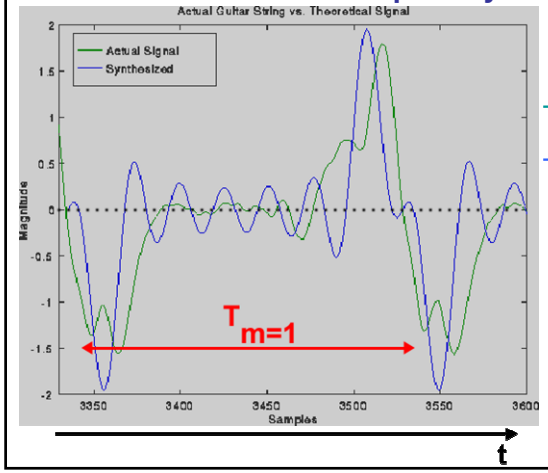
Possible Standing Waves on a String

m = 1	f = 440 Hz	"concert A" = A4
m = 2	f = 880 Hz	A one octave above A4 = A5
m = 3	f = 1320 Hz	E6
m = 4	f = 1760 Hz	A6
m = 5	f = 2200 Hz	C#7
m = 6	f = 2640 Hz	E7

All these are notes of the A chord

(In a Pythagorean temperament)

History Graph of the Sound Produced by a Guitar and an Attempt to Synthesize It



Real

Synth

(http://www.ee.washington.edu/research/sahr/pages/physics.html)

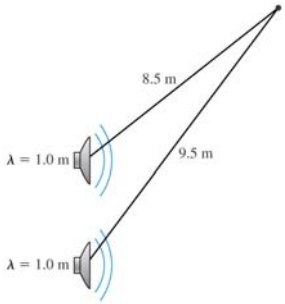
$$D_1(r_1,t) = a_1 \sin(kr_1 - \omega t + \phi_{10}) = a_1 \sin(\phi_1)$$
$$D_2(r_2,t) = a_2 \sin(kr_2 - \omega t + \phi_{20})$$

$$D_2'(r_2,t) = a_1 \sin(kr_2 - \omega t + \phi_{20}) = a_1 \sin(\phi_2)$$

$$\phi_2 - \phi_1 = k(r_2 - r_1) + (\phi_{20} - \phi_{10})$$

$$\Delta\phi = 2\pi \frac{(r_2 - r_1)}{\lambda} + \Delta\phi_0$$

9

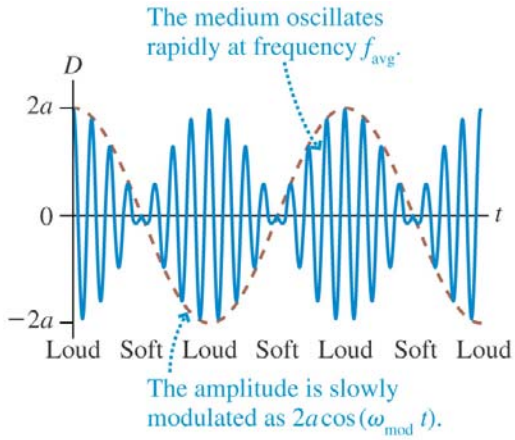


These two loudspeakers are in phase. They emit equal-amplitude sound waves with a wavelength of 1.0 m. At the point indicated, is the superposition constructive, destructive or something in between?

A. constructive
B. destructive
C. something in between

10

Fig 21.32



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