

## Phys 1240: Sound and Music

**LAST:** harmonics, perception and ears

**TODAY:** spectra

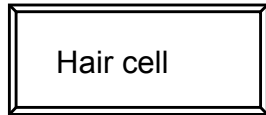
**NEXT: Enjoy your break!**

Next Tues - more on spectra, back to instruments.

Reading: 8.3 (AM/FM)

10.2 (vibrations in string instruments)

12.1 (vibrations in wind instruments)



[ccrma.stanford.edu/courses/220a-fall-2001/dancingHairCell.mpg](http://ccrma.stanford.edu/courses/220a-fall-2001/dancingHairCell.mpg)

CT ex-TG

Shouldn't concept tests be worth double, the class before Thanksgiving break?

- A) Yes indeedy
- B) Of course
- C) Why not?
- D) Seems only fair to me.
- E) No!

From last week's long answer:  
"Why do the frets of a guitar get closer together as you move up the fingerboard?"

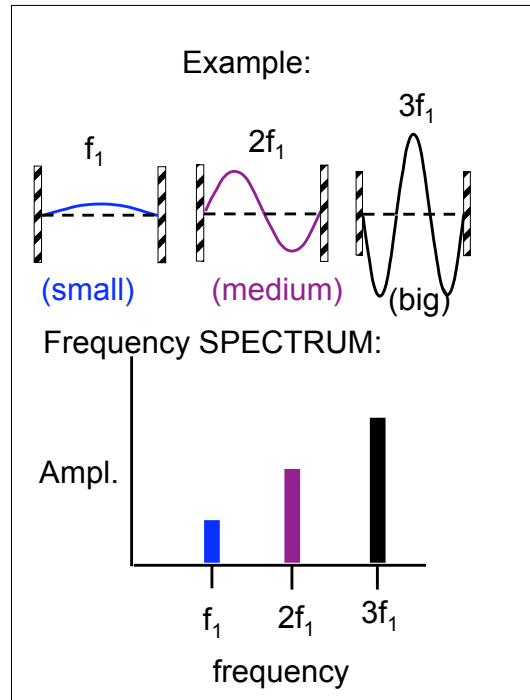
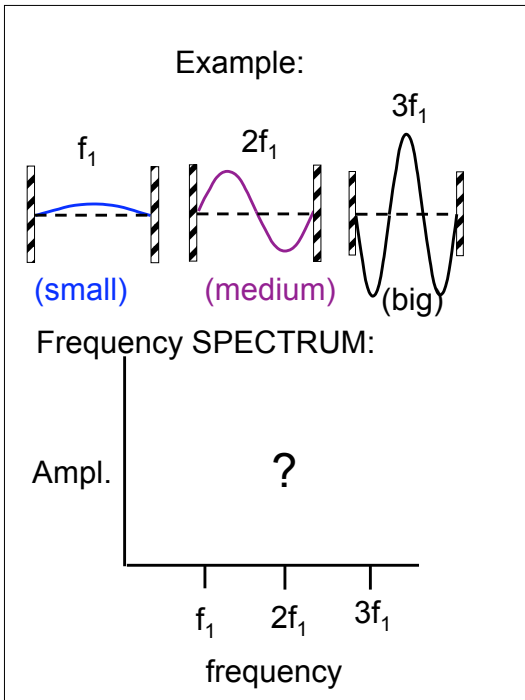
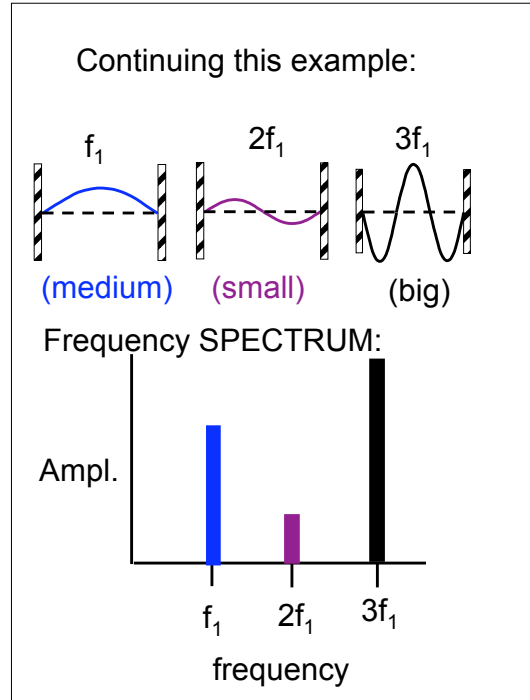
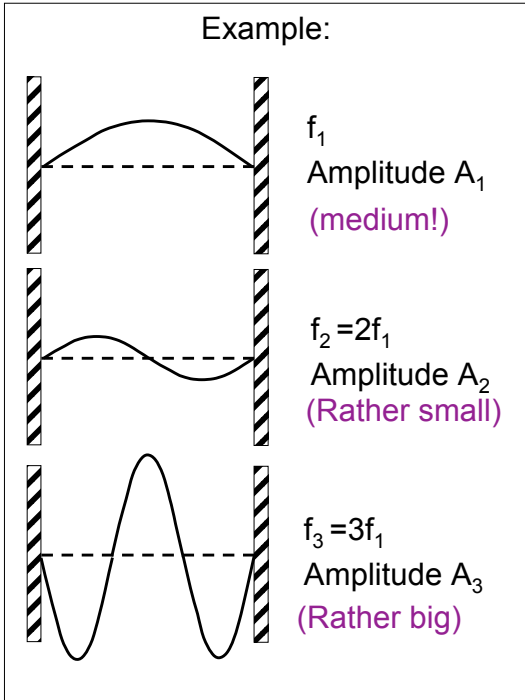
Do you think you need to have ever held/played a guitar to answer this question?

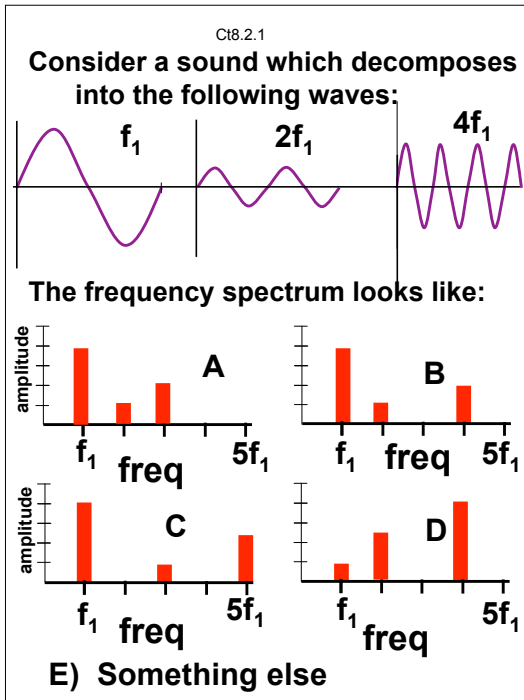
## Harmonics on a string

$$f_n = n \cdot f_1$$

You usually hear several of these Harmonics *simultaneously*.

Which ones are present (and how strong) does NOT (much) impact "pitch" you hear,  
But => BIG impact on the TIMBRE ("character") of sound.





## Spectral analysis

Fourier simulation

phet.colorado.edu/simulation-pages/sound-simulations.htm

CT8.2.3

You're listening to a computer-tone which contains TWO harmonics:  
 the fundamental ( $f_1 = 100$  Hz)  
 + the 6th harmonic ( $f_6 = 600$  Hz).

What frequency do you (likely) perceive?

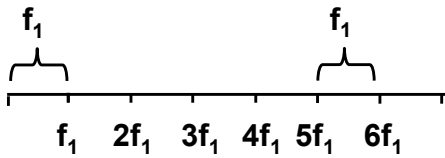
A) 100 Hz  
 B) 500 Hz  
 C) 600 Hz  
 D) 700 Hz  
 E) Something totally different

CT 8.2.3b

A string has fundamental  $f_1$ .  
 What is the *spacing* (the *difference*) between two successive higher harmonics?

A) That would be  $f_1$  also  
 B) It varies, it depends on "n".

Spacing between harmonics:



CT8.2.4

You're listening to a computer-tone which contains 200, 300, 400 and 500 Hz, but is missing 100 Hz.

What is the fundamental frequency? (i.e. what is the frequency at which the combined tone repeats itself?)

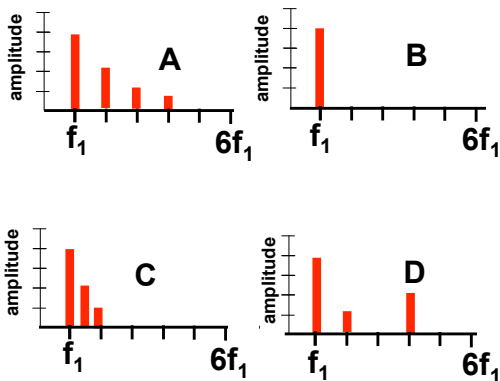
- A) 100 Hz
- B) 200 Hz
- C) Something totally different

What frequency do you (likely) perceive?

CI8.2.2

An ideal string instrument has a fundamental frequency of  $f_1$ .

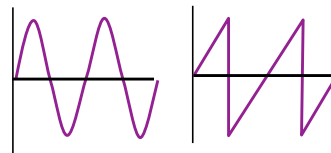
Which of the following frequency spectra is most *unlikely*?



E: (All are fine, or else several are completely unphysical)

CI8.1.1a

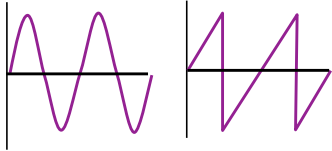
Consider the following waveforms:



True (A) or False (B): Both have the same fundamental frequency

CI8.1.1b

Consider the following waveforms:



True (A) or False (B): Both have the same frequency spectra.

## Real spectra

Ideal instruments produce only sounds at exact (harmonic) frequencies

*Real* sounds contain all frequencies (but with *peaks* at the harmonics!)

**Anharmonic** sounds (e.g. drums) don't have such simple patterns.

*AudioXplorer*

CT ex-TG2

Which is better?

- A) Turkey
- B) Tofu