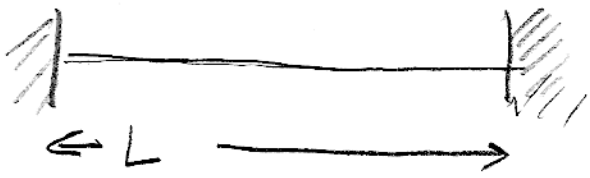
Course Goals: Waves, Sound (3 weeks)
Electricity (7 weeks)
Midterm – Oct. 28
Problem Sets – due Mondays

Free vibrations of a stretched string....



↙ string, length L stretched between "walls"

Music – like guitar string
Musical note → time dependence
pitch → frequency ν
middle C $\simeq$ 262 Hz
= 262 cycles/second
A above C $\simeq$ 440 cycles/second.

Functional Dependence in Time
for a "pure tone"... "sinusoidal" (how? why? later)
$\propto \sin(2\pi ft)$ or $\sin(2\pi ft + \phi)$
$\cos(2\pi ft)$ or $\cos(2\pi ft + \phi)$ ideally

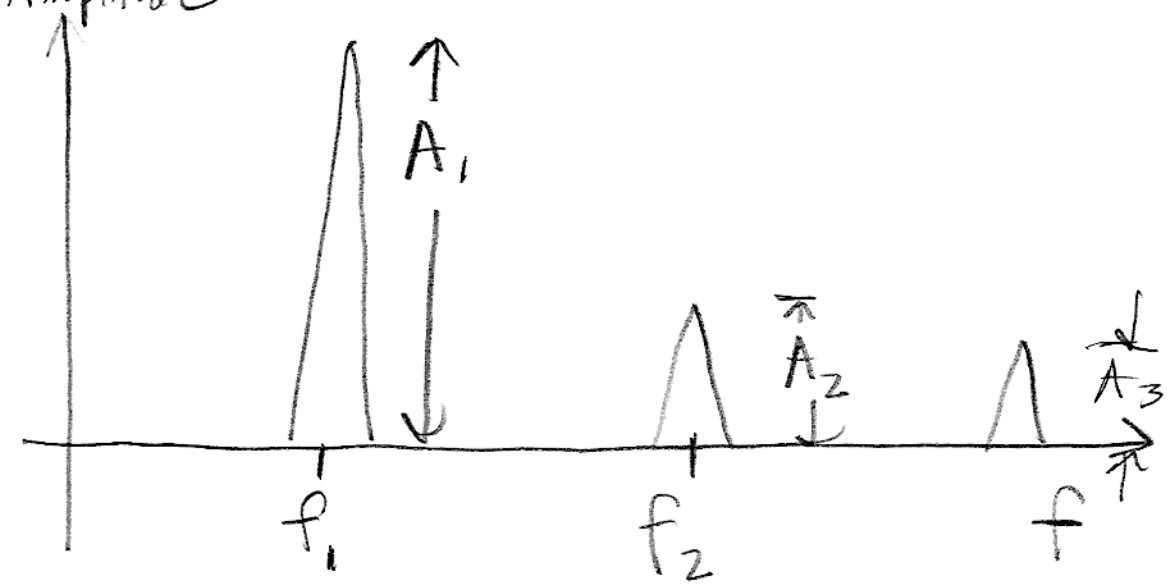
Most sounds (voice, instrument...) are not pure tones --- They sound much more "natural"

recall... $\omega \equiv 2\pi\nu$

Real "Tone" $\simeq A_1 \sin(\omega_1 t + \delta_1)$
$+ A_2 \sin(\omega_2 t + \delta_2)$
$+ A_3 \sin(\omega_3 t + \delta_3) + \cdots$

Analysis of a tone to extract $A_1, A_2, A_3, \ldots$ and $\omega_1, \omega_2, \omega_3, \ldots$ $\delta_1, \delta_2, \delta_3$ is called... "Fourier Analysis"

"Sigview" on web can do Fourier analysis in real time...



The spatial pattern that produces one frequency is called a "normal mode!"

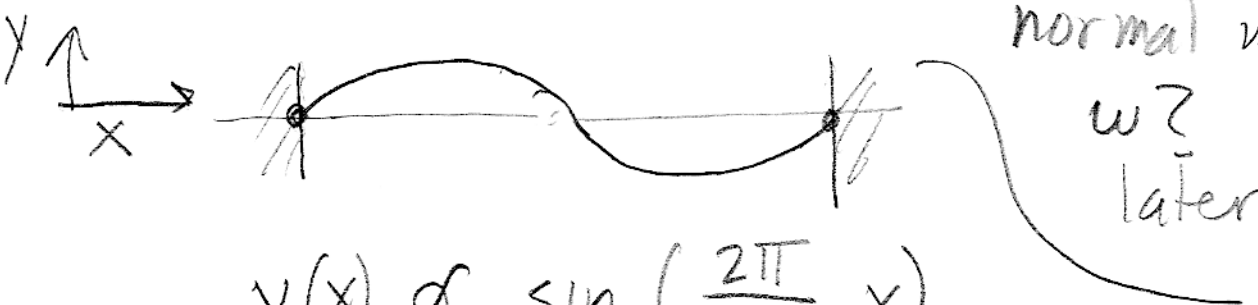
For a string between walls, the normal modes are also (ideally) sinusoidal....

$y(0)=0$ $\quad y(L)=0$

$$y(x) \propto \sin\left(\frac{2\pi}{(\lambda=2L)} \cdot x\right)$$

$$\propto \sin\left(\frac{\pi}{L} x\right)$$

"fundamental normal mode"



ω? later

$$y(x) \propto \sin\left(\frac{2\pi}{(\lambda=L)} x\right)$$

$$\propto \sin\left(\frac{2\pi}{L} x\right)$$

"first overtone"

"Normal Modes"

$$y_n(x) \propto \sin\left(\frac{n\pi}{L} x\right)$$

What frequency ω_n goes with $y_n(x)$? Derive this.

→ describe stretched string.

T = tension in it (Force)

$\mu = \frac{\text{mass}}{\text{length}}$ of string.

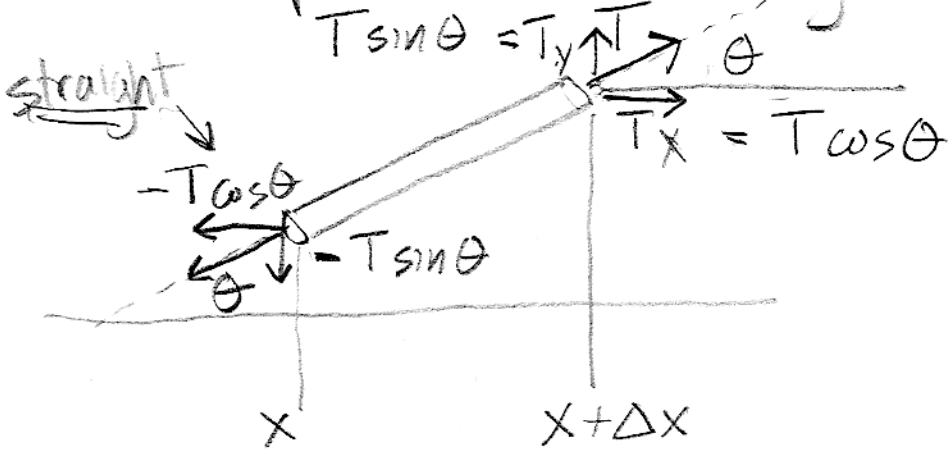
Now it's just Newton's 2ND law... subtleties are:

(1) t, x, y ... 3 variables.

(2) $y(x)$ must have curvature for interesting physics...

$$\frac{\partial^2 y(x)}{\partial x^2} \neq 0$$

Consider piece of string:



Net force on element of string is... ZERO! Because string straight