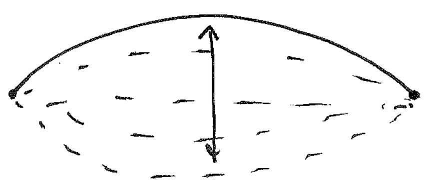
Standing Waves on String

We're going to start w/ some waves that you all are familiar with... waves on a string.

- How many of you play guitar?
- What happens when you pluck the string?
  → vibrates (this vibration creates sound that we hear)
- What does this vibration look like? Take a minute to draw what the string looks like:



string is moving up and down at any given time, see snapshot

Now for those of you who play guitar, can anyone play higher harmonics? If so, what do you do to the string ~~thre~~ to get higher pitch?

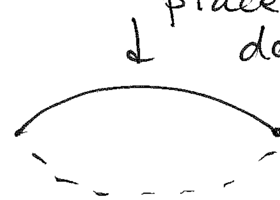
→ pluck string
→ place finger down in specific ~~to~~ location

Take a minute to draw the string if you pluck it then place finger in middle:

pluck

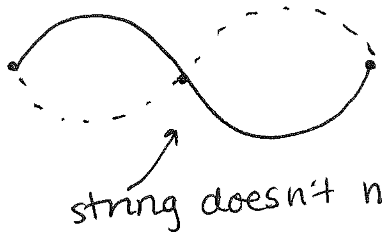
. . . then

place finger down



Finger creates a node - a place where string doesn't move:

2 bumps
2nd mode



higher sound
(higher freq. = more energy)

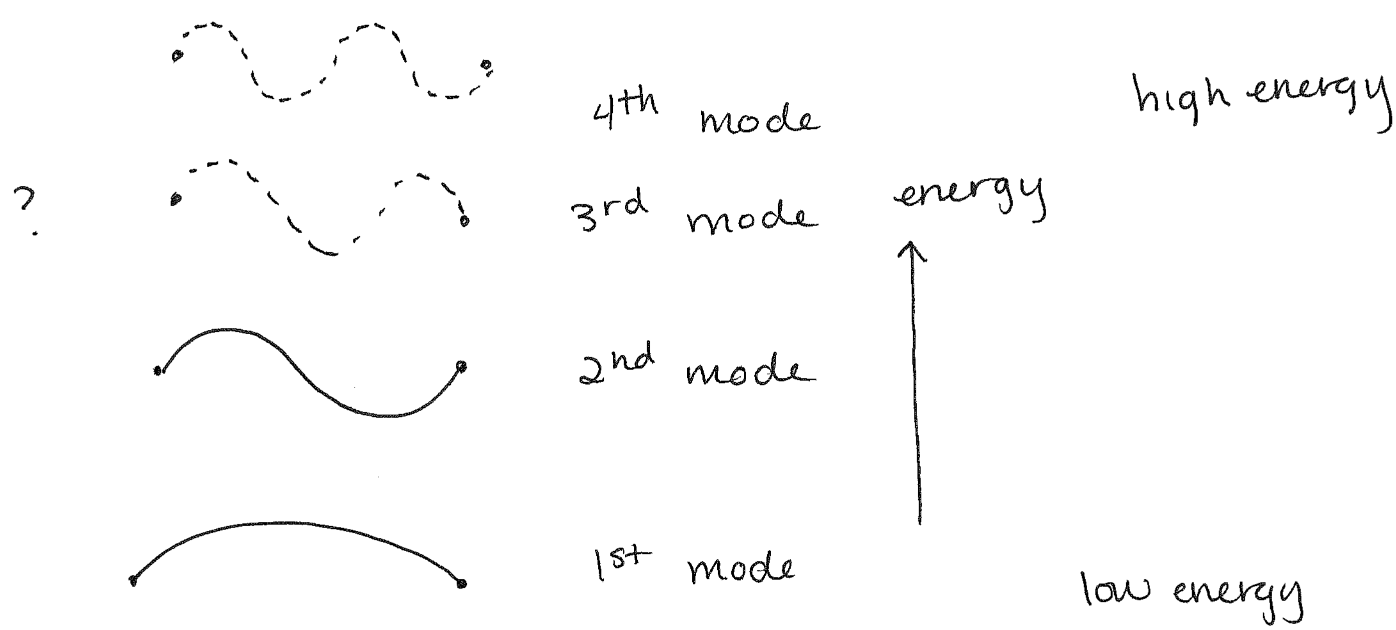
1 bump
1st mode

lower sound
(lower frequency = less energy)

more bumps → higher frequency (pitch) → more energy

(String doesn't like to have bumps - it would rather be flat. To add bumps requires energy - the string is in a higher energy state)

You can imagine that we can create more bumps by placing our fingers in different places. What might the next highest pitch waves look like?

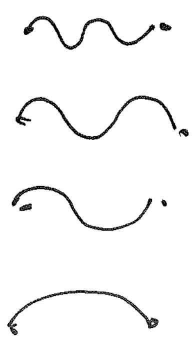


We see that there are only certain allowed modes, or states, of the system. We can only have 1, 2, 3 ... bumps

We say that the states/modes are <u>quantized</u>

quantum = increment

states are separated by increments (call this discrete)



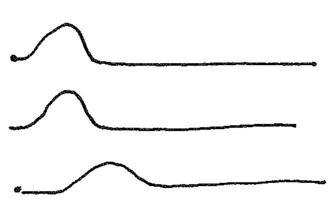
separated by 1 full bump

} separated by an increment of energy.

Think of this like a staircase or ladder.
To climb up the staircase, we have to take one full step. (we cannot take half a step). Each step corresponds to the addition of a bump, + is accompanied by a ~~st~~ jump in energy.
Why do we get quantization? Why don't we find 1.7 bumps, 4.2 bumps~~e~~, etc.?

→ because the ends of string are fixed - we can never have half a bump

→ if the end of the string was not fixed, we could have:



infinitely many states which are not separated by jumps/increments this is called a boundary condition - it tells us what is happening at the boundaries of our system.

some examples of boundaries:

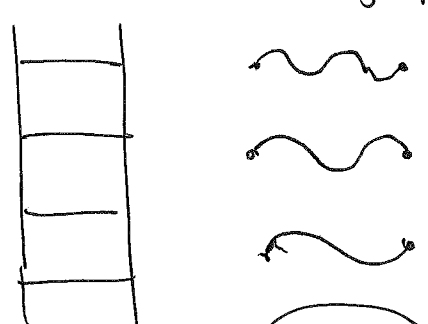
system	boundary
string	2 ends
paper	4 edges
balloon	surface of balloon.

The B.C.'s play a crucial role in determining the type of behavior that we see. (In this case, the B.C.'s give rise to quantization)

To understand a system, we must understand the boundaries

<u>quantization</u>: individual states separated by an increment / gap

energy ladder



<u>boundary cond</u>: what is happening @ boundaries.
Determine behavior of system.