Sand on Vibrating Plate - Standing Waves in 2D

A string is a 1D object. If we wanted to study standing waves in 2D, what might we use?

1D - string
2D - surface

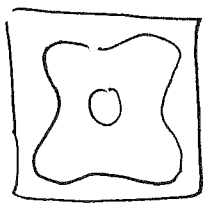
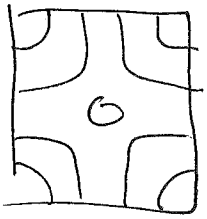
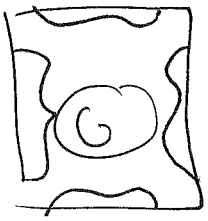
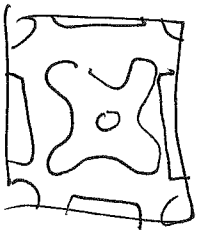
I have a metal plate attached to a vibrator. When plate vibrates, what do you expect to happen?

- parts of the plate move / plate moves up + down?
- parts of plate don't move?

Its a little more difficult to see the waves/ vibrations on the plate, so I'm going to use sand to help me visualize it. How might that help?

sand settles in places where plate isn't moving

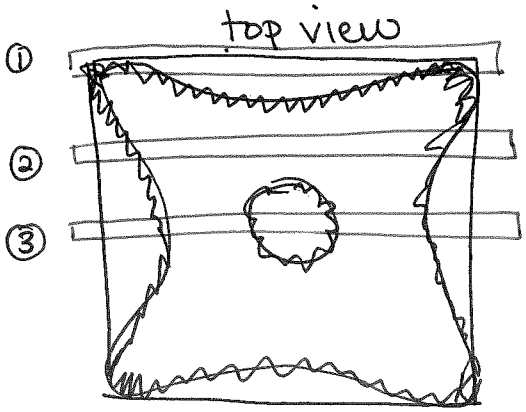
Now take a minute to draw what you expect to see on the plate. Where do you expect the sand will go?

Turn on drum, watch patterns change as turn up frequency. Why?

As you increase freq, you change (increase) the mode, just as we saw w/ guitar string (higher pitch → higher mode)

lowest mode:



the sand falls in the nodes- wherever there is not sand, the drum is vibrating up and down

① zoom in on one one of the edges (top edge) what's happening?

top view

sand just on edges - what does this look like? (guitar string)

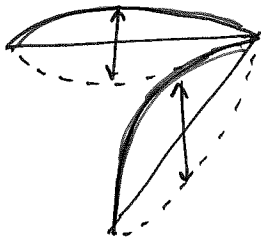
side view:

we see that the corners are fixed, but not the full edges

* see the same pattern on each of the four edges

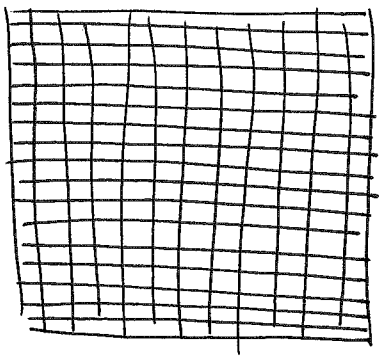
(2) Take another cross section:

If both the top edge + side edge look like a vibrating string:



then what is happening in the middle must depend on what's happening at both the horizontal + vertical edges

Can imagine that the vibrating drum as an infinite number of strings stacked together:

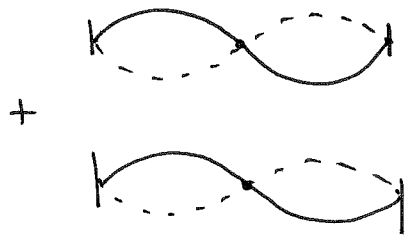
top view 

each string is vibrating, and its mode of vibration depends on its <u>own</u> boundary condition

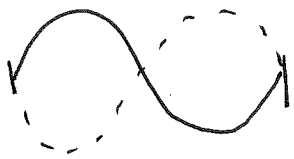
The behavior of the whole drum is a <u>sum</u> of all the individual strings

This is the principle of <u>superposition</u>

Consider one dimension:
imagine two strings are sitting on top of each other:



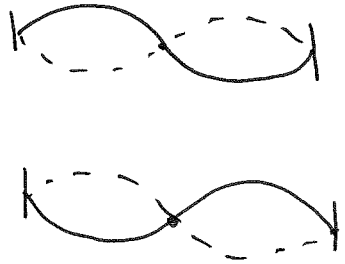
waves are <u>in phase</u>



net effect is superposition of individual effects

constructive <u>interference</u>

have someone draw this →



waves are <u>out of phase</u>

<u>destructive interference</u>

cancel each other out

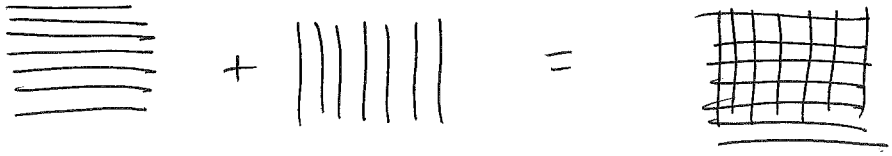
interference – superposition of multiple waves

Note that the pattern is symmetric. Why might that be?

→ b/c all the boundaries look the same

→ if we can figure out whats going on in one direction we know automatically whats going on in the other direction

→ The total behavior is the sum of the two directions



→ We always want to take advantage of symmetries - it makes our life much easier

Again, we find quantized modes that result from the specific boundary conditions - there are only a certain number of ways to fit the strings onto the plate.

superposition : if two waves traverse the same space, the total wave is the sum (superposition) of two waves

interference : superposition of waves can lead to waves adding/canceling each other (interfering w/ each other)
- constructive - add together
- destructive - cancel out

symmetry : one dimension of our system looks same as another dimension, or a behavior is uniform in one dimension / direction