Traveling Waves in 2D - Ripple Tank

We just looked at standing waves, where the shape of the wave doesn't change in time and the wave doesn't travel (wave is standing still)

Now let's consider traveling waves, where the wave is moving in time. What are some examples?

- water, sound, light

There are two types of traveling waves - can anyone name them?

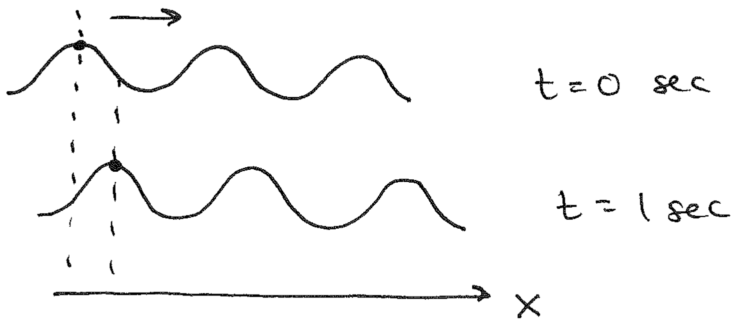
- transverse - motion ⊥ to propagation (string)
- longitudinal - motion ∥ to propagation (slinky)

* show applet

The standing wave on a string that we just saw - which type of wave was that?

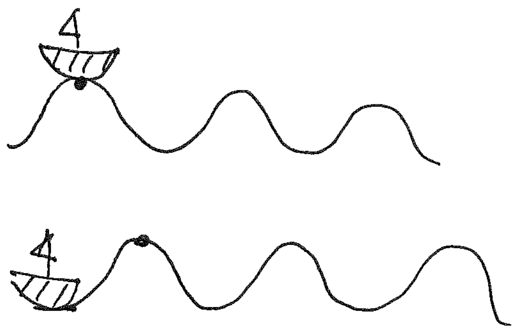
- ~~traveling~~ transverse

We can see that in this case, the wave is moving forward, not standing still. In fact, if we take several snapshots at different points in time, we would see:



Note that the wave (disturbance) is moving forward, but each point is only moving up + down. If I'm on a boat in the ocean, my boat just moves up and down as waves pass by me, but the waves themselves move forward.

side view

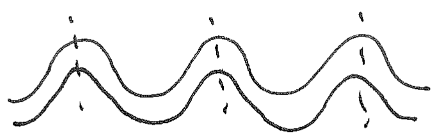


t=0

t=1 sec

Let's study some different properties of these waves. To illustrate, I'm going to use water waves b/c they're easy to see. I'll draw them the following way:

side view:



"stacked" waves

top view

line = peak / crest

space = dip / trough

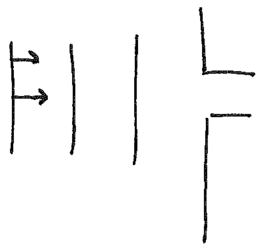
We have a good intuition for how waves behave out in the open. But we often want to know what happens when a wave hits a boundary, like an island, a ~~boat~~, a dam, a channel way, etc.

For example, what happens when a water wave hits a wall?

It bounces back – ~~we~~ or <u>reflects</u>

(to learn more, see wiki)

What happens when ocean waves hit a channel way?

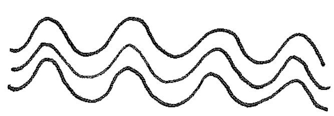


any guesses?

To answer this, we'll use a ripple tank.

* Demo plane waves

I've just created a whole line of waves

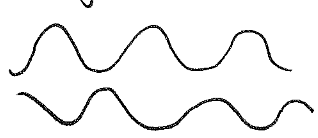


show up as shadows - dark + bright lines

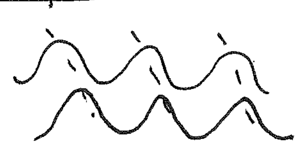
all of the peaks are lined up, and the spacing between peaks (frequency) is same.

When this happens, we say the waves are in phase. We'll talk more about this later (or refer back to standing waves)

What do you think out of phase would look like?



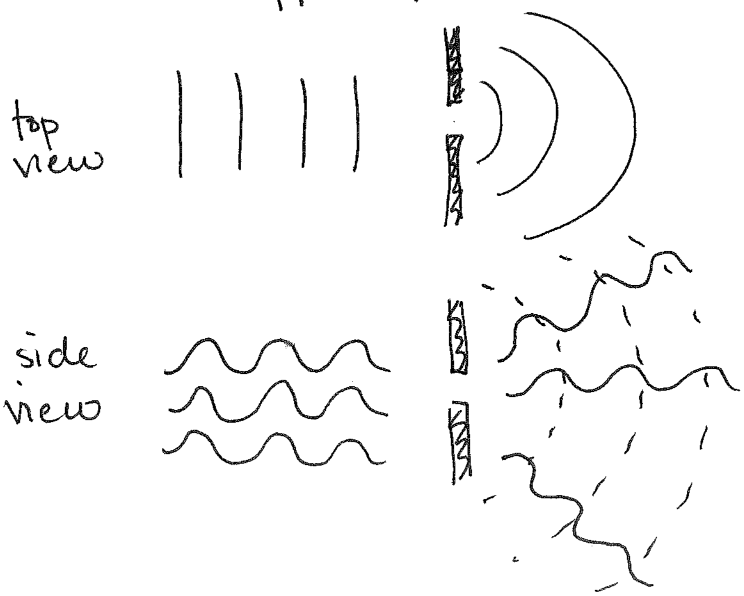
or



Now what happens if I send these plane waves toward a boundary? We'll model our channel as a slit in a wall.

* Demo single slit, small spacing

What happens?



get circular waves

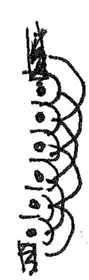
What does this look like? Example?
→ stone in a pond  point source

We see that the slit/opening acts like point source, or a stone in a pond that creates circular waves. This is called diffraction - bending of waves around obstacle

What happens if we make the slit bigger? Think about what you already know about a small slit...

A big slit is just a bunch of small slits placed really close together:

And we know that each slit acts like a point source



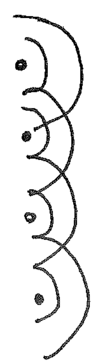
In physics, we use what we know about a small piece of a system to understand bigger pieces.

know → small slit = point source

big slit → series of small slits

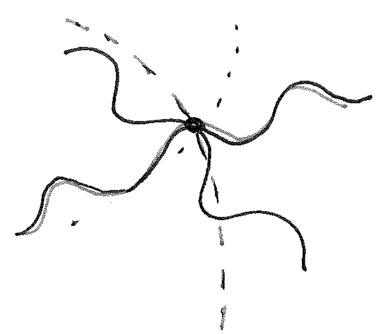
Now, we have a series of stones, each creating their own waves. How do we find the total wave?

→ add up all waves from each of stones
(total wave is <u>superposition</u> of all individual waves)



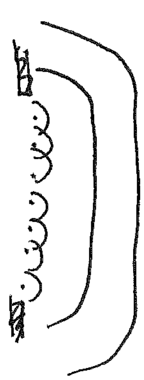
remember that lines represent peaks of wave. Where two lines cross, two peaks overlap. What happens?

→ <u>constructive</u> interference



two peaks add together → bigger peak

What we get is something that looks like:



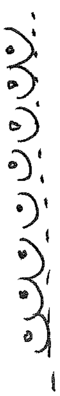
curved portion due to <u>boundaries</u> - edges of slit (again, boundaries play huge role in behavior)

flat portion of wavefront

Now, we should always check that our description (point sources) is consistent w/ what we know.

What happens if we make slit as big as tank?
→ should see no change, just plane waves

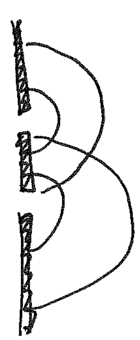
Do we get that w/ our stone in pond description?



Yes - many stones gives rise to flat wave front

Turns out that we can think of any wavefront | as a series of "stones in a pond." If the wave passes around a boundary, that boundary picks out some of the stones and not others. Can use this idea to analyze and boundary/barrier.

Test your understanding:
What happens when you have two small slits?
Draw on white boards what you expect to see



You see that there are certain areas where the circular waves cross. What happens here?

→ constructive interference - big wave

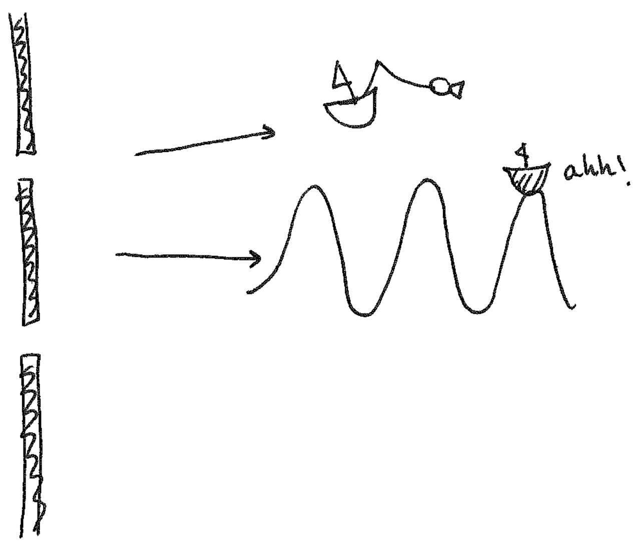
What about the regions where two spaces cross?

→ destructive interference - no wave

If you were sitting in a boat in the ripple tank, what would you expect to feel?

→ depends on where your boat is.

Some places, your boat would be thrashing up and down from the huge waves. But your buddy, in the boat next to you, could feel nothing - no wave at all.



We can calculate where the huge waves will be and where the calm water will be (so we know where to put our boat). We'll talk about this in more detail later...

Motivation for next time:

We just saw how important this idea of "stones in a pond" can be for describing wave behavior. These stones will pop up again + again when we talk about QM.