"Light, Waves and Interference" - A Teacher's Workshop

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Water Waves

Background

Water waves are the most familiar form of waves. There is probably no kid who does not enjoy playing with water. Water waves are so much fun to play with because they travel slowly enough to observe them in detail. Surfers go even a step further, throwing themselves into the waves and letting them be carried along. Waves on a much smaller scale can be used to illustrate how waves travel, how they pass objects and how they can interfere. By analogy, many aspects of how light as an electromagnetic wave travels and interacts can be illustrated using water waves.

We are showing some very basic examples of classroom and table-top experiments with water waves.

Materials

- 13x9x2 inch glass baking dish (other sizes work, but this size allows for good wave propagation)
- Water

Procedure

All the following demonstrations can either be done using an overhead projector, so the entire class can see the projected image, or with a smaller group on a desktop. To do this demo with an **overhead projector** switch off the projector and unplug it. Place the empty clear glass (!!) baking dish on the glass surface of the projector. Poor water carefully into the dish until it is about half-inch deep. Take care not to spill any water onto the overhead projector (Potential electric shock! Make sure the dish is out of reach of small children!). Make sure that the overhead projector itself is dry. Only now, plug in the projector and turn it on. You might find that the waves are easier to see when you use and overhead projector than when you do the same experiment on a desktop. Please be careful when handling water next to electrical equipment. For a **desktop setup** put the empty dish on a stable leveled support. If you are working on a dark colored desk, you might want to put a white sheet of paper under the glass dish to enhance the contrast of the waves. Fill the dish to about half and inch of water and you are ready to go.

Generating Traveling Waves

There are many ways of generating waves in this set-up. The most reliable instruments are probably your fingertips. You can start by generating single waves by tipping you index finger lightly onto the surface of the water near the short side of the dish. Observe how this wave travels across the dish to the far end of the wall. In most cases you should be able to see how this wave is reflected at the opposite wall of the baking dish and how it runs back toward the point where you tipped down your finger.

If you place small barriers into the water, you can observe how waves interact with edges. Any hard object that is heavy enough not to float on the water and large enough to reach beyond the surface of the water will do. Watch. Do waves cut off exactly at an edge or are they actually bending a little around the corner? Remind you class that light is a wave too (an electromagnetic wave that is). You might ask: If waves bend around corners and if light is a wave, why do sharp objects cast such clear cast shadows in sunlight?

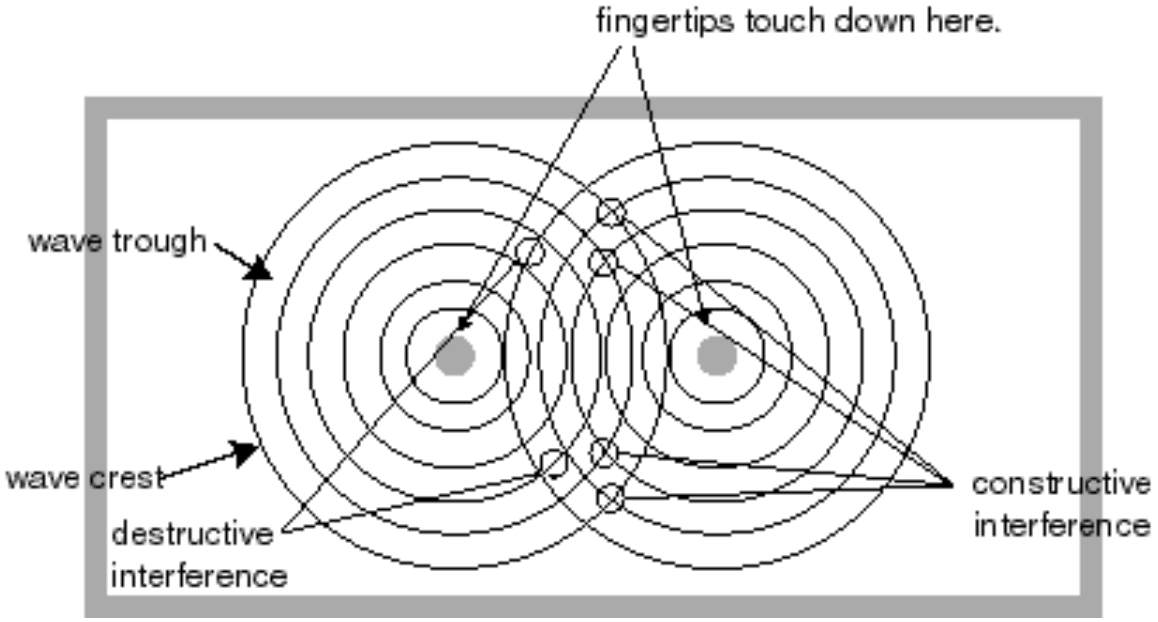
Observing Interacting Waves

To see waves interacting, or interfering, you will need to generate regular waves that have about the same height (amplitude) and are synchronous. In optics, this is referred to as "coherent waves". Some physics labs have wave tanks with wave generators. Those are essentially small tips that are moved up and down by a motor. If you do not have access to such a device, two fingers will do just fine. With a little practice! Spread your index finger and you little finger as far apart as you comfortably can. Curl your middle finger and your ring finger toward your palm where you might want to fold your thumb over them (this is not as hard as it may sound). {As a variation you might also want to the try the "hang loose" signal that you might be familiar with through movies about Hawaii, but I am afraid I am digressing.) Now just bring down the tips of your index finger and your little finger such that they are barely touching the water surface. Now start moving your entire hand up and down in a small but rapid motion. You should see waves traveling across the water from where your fingertips are touching the water.

The trick is to keep the motion as regular as you can make it. It might also help to tighten up your hand so you have a stiff connection between your two fingertips. Please be careful not to overdo it. When your hand gets tired, give it a break and let your kids try it.

In the region where waves generated from your fingertips merge and overlap you will soon see a pattern forming (see figure). Where the crests of two waves meet, the waves will overlap and result in a much higher wave. Where two troughs coincide, they will form a very deep trough. Both cases are called constructive interference. However, if the crest of one wave coincides with the trough of another wave, the two waves will cancel out. This is called destructive interference. If you keep up a stable patter of waves, you will

notice that the areas where waves amplify each other and areas where they cancel out remain in about the same location.



Standards

A visit to the URL http://www.mcrel.org yielded the following standards and included benchmarks that may be applicable to this activity.

Science Standards:

Primary (K-3) Science Standard 12 - *Understands motion and the principles that explain it.*
a) Knows that light travels in a straight line until it strikes an object.
b) Knows that things move in many different ways (e.g., straight line, zigzag, vibration, circular motion).

Middle School (6-8) Science Standard 12 - *Understands motion and the principles that explain it*.
Knows ways in which light interacts with matter (e.g., transmission, including refraction; absorption; scattering, including reflection).