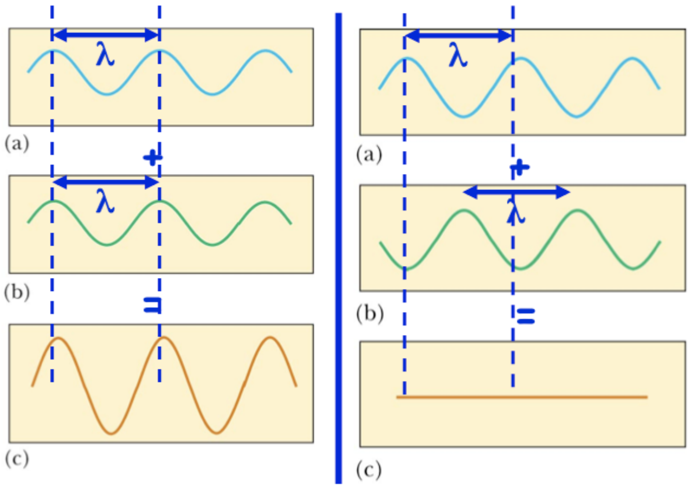
PreLab 5 – Wave Interference

Consider two waves that are in phase, sharing the same frequency and with amplitudes A_1 and A_2. Their troughs and peaks line up and the resultant wave will have amplitude $A = A_1 + A_2$. This is known as **constructive interference** (figure on the left).

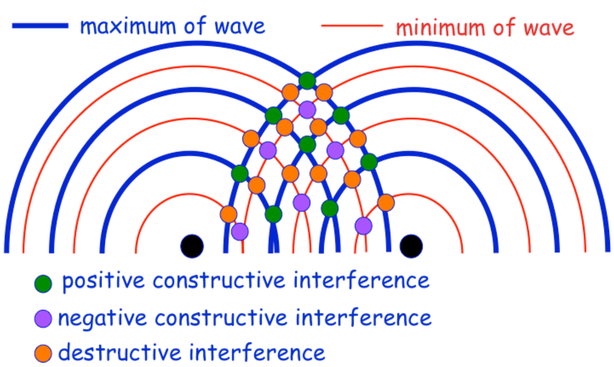
If the two waves are π radians, or 180°, out of phase, then one wave's crests will coincide with another waves' troughs and so will tend to cancel itself out. The resultant amplitude is $A = |A_1 - A_2|$. If $A_1 = A_2$, the resultant amplitude will be zero. This is known as **destructive interference** (figure on the right).

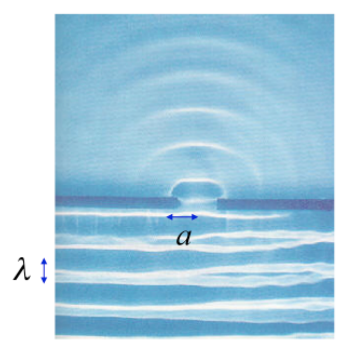


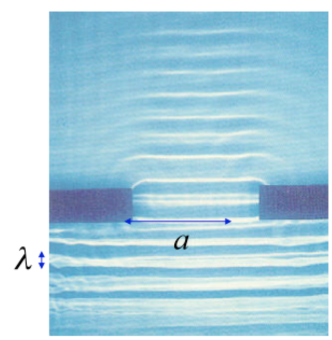
When two sinusoidal waves superimpose, the resulting waveform depends on the frequency (or wavelength) amplitude and relative phase of the two waves. If the two waves have the same amplitude A and wavelength the resultant waveform will have an amplitude between 0 and 2A depending on whether the two waves are in phase or out of phase.

The principle of superposition of waves states that the resultant displacement at a point is equal to the vector sum of the displacements of different waves at that point. If a crest of a wave meets a crest of another wave at the same point then the crests interfere constructively and the resultant crest wave amplitude is increased; similarly two troughs make a trough of increased amplitude. If a crest of a wave meets a trough of another wave then they interfere destructively, and the overall amplitude is decreased.

This form of interference can occur whenever a wave can propagate from a source to a destination by two or more paths of different lengths. Two or more sources can only be used to produce interference when there is a fixed phase relation between them, but in this case the interference generated is the same as with a single source; this is known as **Huygens' principle**.







Interference effects between circular, or spherical, waves lead to beautiful patterns, as we will study in this experiment (see figure above on the left). They are based on the same principles discussed above.

Diffraction is another wave phenomena, related to interference. When a wave meets an obstacle, either an opening in a wall or a "black" object, it bends around. The "bending" is more intense when the wavelength is comparable or smaller than the size of the obstacle, as shown in figure above, right.

Waves **reflect** on walls like a bouncing ball. A wave also **refracts** (changes direction of propagation) when it passes from one medium to another if it has different velocities in each of them.

LAB 5 & Lab Report

Name: ____________________________ **Section**: _______________

Properties of Waves

Equipment: Ripple tank, mechanical vibrators

Although you cannot directly see sound waves there are a number of ways to help you visualize how sound waves (and other types of waves) behave and what some of their more important properties are. The purpose of this experiment is to familiarize you with one of the techniques for investigating the properties of waves and to point out what some of these properties are.

The ripple tank is a large glass-bottomed tray that can be filled with a small depth of water. A lamp is placed above the tank to project light through the water onto a surface below, thus making any ripples generated in the water clearly visible. Ripples can be generated on the surface of the water by means of an electromechanical vibrator driven by a digital function generator driving either a single or double point wave-source or a long straight wave-source. Increasing the frequency of the digital function generator increases the frequency of the generated wave. Pieces of plastic and metal of various shapes and sizes are provided to facilitate the demonstration of reflection, diffraction, and interference of waves.

Experiments Using the Ripple Tank

1. Observe and sketch the wave generated by a single point source.
   What happens to the wavelength when the frequency of the wave is increased?

2. Observe and sketch the waves generated by a double point source. Notice the result of the different sets of waves interfering with each other
   How does the "interference pattern" change when the frequency of the source is increased?

How is the interference pattern affected by a change in the phase (from 0 to 180°) of one point source relative to the other? To change the phase of one source relative to the other, interchange the red and black leads of one driver at the frequency generator terminals.

3. Observe and sketch the waves generated by a straight ripple generator.

4. Observe and sketch the reflection of plane waves from a plane surface. Use a straight ripple generator and use a long straight piece of aluminum standing on its longest edge as the reflector. Position the reflector so that it is at some angle other than parallel to the incoming plane waves. Note: For this part and for parts 5 and 6, try launching just a couple of waves by turning on the vibrator for about one second and then turning it off. It is sometimes easier to watch the results of reflection and focusing without the interference of the incident waves.

5. Observe and sketch the focusing of incident plane waves by a concave reflector. You may have to experiment somewhat to see this effect in the clearest way.

6. Try manually launching a single circular wave from the focus observed in part 5 above by poking your finger in the water at that focus, and see if you observe a plane wave after your circular wave reflects off the concave surface used in part 5.

7. See if you can observe and sketch diffraction effects of plane waves around the edge (or edges) of an obstacle.

8. Using the straight ripple generator, observe the pattern obtained when plane waves pass through a single slit. Investigate how this pattern depends on the slit width for a particular wavelength. Repeat this for a double slit.

A Visual Demonstration of Beats

9. Set up two separate ripple generators and insert just one point source in each generator. Now you can vary the frequency of one point source relative to the other and you can change the distance between the two point sources.

Adjust the frequencies of the two generators to be as close to the same as you can (i.e., try to achieve a "zero-beat" situation) with the point sources about 5 to 8 centimeters apart. This should result in a non-rotating interference pattern similar to that which you obtained using the double point source in part 2 above. Sketch what you observe below.

Change the frequency of one point source relative to the other by a very small amount. First make it a slightly higher frequency than the other. Then make it a slightly lower frequency than the other. Sketch (and describe) what you observe in the space below. Imagine yourself as a miniature person standing in the ripple tank 25 or 30 cm away from the point sources and experiencing the "beat frequency".

What happens to the interference pattern when the difference between the frequencies of the point sources is made larger?

What happens to the beat frequency in this case**?**