TechLab Springboard: Ripple Tank Simulation

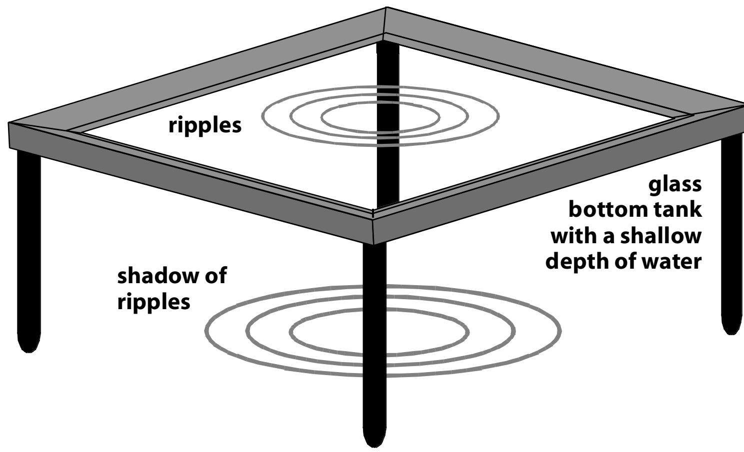
AMPLITUDE, FREQUENCY, AND WAVE SPEED

APPARATUS

__computer (iBook or equivalent) __CPU simulator software: "Waves & Sound"

SIMULATING A RIPPLE TANK

The ripple tank is a popular piece of laboratory equipment used for demonstrating wave phenomena. It resembles a small glass table with raised edges. A shallow depth of water lies atop the glass. Typically, a strong point light source is placed above the tank and shadows of ripples can be seen below the tank. A variety of two-dimensional wave demonstrations can be made by making ripples in the water.



SET UP

a. Start the computer (PhyzMac iBook).

b. When the computer has completed its start-up cycle, open "Ripple Tank Simulator". The document should be visible in the computer's hard drive window. Your instructor will help you as needed. All CPU simulations run from within a web browser such as Internet Explorer.

c. Maximize the window using the zoom button or by stretching the window. Since we won't be browsing the web, clear the tool bar if possible. Internet Explorer has a button (located above the Favorites tab on the left edge of the window) that will collapse/expand the toolbar.

d. Hold the Apple key and click down in the simulator window. A pop-up menu will appear. Let go on "Load" and open "1.xxRipple1.htm.setup0". (The "xx" may be "09," "10," or "11.")

1. INITIAL OBSERVATION

You should see two rectangular ripple tanks as they would appear from above. Each one has a point source (red dot) at about the same place in the center top of the tank. A point source represents a small solid ball that can bob up and down to generate waves in the water. The ball is usually attached to a motor whose rate and other characteristics can be adjusted.

a. Click the arrow below the tanks to start the simulation. (The waves should run continuously once they're rendered. If the waves appear to stop, click and hold down the on-screen play button.) The two tanks were initially configured to be identical to each other. How does this new image of wave propagation differ from previous ones? (How does this representation differ from the one used in the "Amplitude and Wavelength" computer activity?)

[Something, such as "This view is from above instead of from the side," or "These waves appear to move out from the source." Answers will vary.]

b. Ripple tank waves are water waves: they have crests and troughs. In previous graphical representations of waves, crests and troughs were shown as peaks and valleys. How are crests and troughs represented in ripple tank waves?

[Crests are white zones; troughs are black zones. Or vice versa.]

c. How can the wavelength be found in ripple tank waves? That is, what distance needs to be measured? (Don't describe a process for making the actual measurement.)

[Measure from crest to crest or trough to trough; center of one white zone to center of next white zone.]

2. AMPLITUDE

a. Stop the simulation—click the on-screen Stop icon (square). Make sure the Selection Tool is active—it's the arrow icon at the top of the column of tools on the right side of the screen.

b. Double-click the wave source (red) in the ripple tank on the right. Don't click the water (gray) in the tank. If you successfully triple-clicked the wave source, you will have access to "Properties of Point Source 2": amplitude, frequency, and phase. (If you triple-click the water, you will have access to other controls. Click "Cancel" and try again.) These controls would be available on a sophisticated real ripple tank point source. Change the amplitude from 500 to 10. Click "OK" to close the control panel.

c. Run the simulator and observe.

i. How are the low-amplitude waves different from the high-amplitude waves?

They have less contrast--the crests are not as bright and the troughs are not as dark.

ii. How are the low-amplitude waves identical to the high-amplitude waves?

They have the same wavelength.

d. What does the amplitude of a wave indicate?

__wavelength __period __frequency __speed __energy

e. What—if anything—happens to amplitude as the wave gets farther from the source?

The amplitude gets smaller/weaker

f. Wait for the post-activity discussion to describe the implications of your answer to the previous question.

g. At some distance from the source, the amplitude of the waves goes to zero.

i. What is the name of the control used on stereo amplifiers, televisions, and so on to increase or decrease the amplitude of the sound waves it emits?

Volume

ii. Why is this term used—how is it appropriate? Consider a radio playing in the middle of a football field with the sound amplitude turned down to a low level. If you move far enough away from the radio, you can no longer hear it. The sound from the radio occupies a certain amount of three-dimensional space. If you turn the radio up, this space increases. What is the name given to three-dimensional space?

It is an indication of the amount of space the waves will fill. As the volume is turned up, the waves can fill more space before their amplitude fades out.

iii. What term might be more appropriate for this two-dimensional simulation?

Area

3. FREQUENCY

a. Stop the simulation. Open the control panel for the wave source on the right. Restore the amplitude to 500 and increase the frequency from 1.0 to 2.0. Click "OK" to close the control panel.

b. Run the simulation and observe.

i. How are the high-frequency waves different from the low-frequency waves?

Their wavelength is is shorter

ii. How are the high-frequency waves identical to the low-frequency waves?

Amplitude and speed are the same

c. How is the wavelength of the waves related to the frequency of the source?

__Direct proportionality: $\lambda \propto f$ __ Inverse proportionality: $\lambda \propto 1/f$

d. What—if anything—happens to wavelength as the wave gets farther from the source?

Remains the same; no change

4. WAVE SPEED

a. Stop the simulation. Open the control panel for the wave source on the right. Restore the frequency to 1.0. Click "OK" to close the control panel.

b. Now double-click the water in the ripple tank on the right to open its control panel ("Properties of Ripple Tank 1"). Even the most sophisticated ripple tanks don't allow direct control over the water! (Doing so would require real-time manipulation of the viscosity of the water.) This is where the computer takes us places we couldn't otherwise go. Increase the wave velocity from 10 to 20 cm/s. Don't change anything else. Click "OK" to close the control panel. (Is it more correct to say you changed the *velocity* or the *speed* of the waves?)

c. Run the simulation and observe.

i. How are the high-speed waves different from the low-speed waves?

They move faster and their wavelength is longer

ii. How are the high-speed waves identical to the low-speed waves?

They are emitted at the same rate and have the same amplitude

d. How is the wavelength of the waves related to the speed of the waves?
__Direct proportionality: $\lambda \propto v$ __ Inverse proportionality: $\lambda \propto 1/v$

e. What adjustment can you make to the wave source of the ripple tank on the right so that the wavelength of its waves is equal to the wavelength of the waves in the ripple tank on the left? Do it and describe it.

Double the frequency

5. SYNTHESIS. Combine your findings from parts 3.c. and 4.d. to write an equation for the wavelength of the wave in terms of the frequency of the source and the speed of the waves.

$\lambda = v/f$

6. PHASE (OPTIONAL). If time allows, create and observe a simulation with two tanks of identical water and sources having the same amplitude and frequency but completely out of phase ("3.1"). What is the effect of changing the phase of a wave?