Experiment 11: The Ripple Tank

CAUTION: Anyone with photosensitive epilepsy should ask to be excused from this experiment.

You will study the relationship among speed, frequency, and wavelength of waves. The apparatus is a ripple tank: A glass-bottomed tank of water is between a light above and a screen below. A horizontal bar in the tank, hung from springs, bounces as a motor on it shakes, creating waves. Each wave acts as a lens, focusing light into a bright line on the screen, where it is observed. Frequency is measured using a strobe light: When flashing at the wave’s frequency, it appears to freeze motor, and the frequency is read from the strobe. Wavelength is measured by forming a standing wave, which can be traced on the screen. The effect of the water’s depth is observed by placing a glass plate on one side of the tank; the shallower water above it is compared to the deeper water next to it.

PREPARATION: The tank should be standing on a screen. The light on the tank uses a 12 volt bulb; use it only with the 12 V power source provided. Connect the motor to the DC terminals of the power supply. If there are two balls hanging from the wave generator bar, they should be turned up out of the way or removed. Fill the tank about 1/2 cm deep. Check the depth in each corner, and level the tank with the screw-in feet or by shimming with slotted weights or coins. Adjust the height of the bar so that one edge just touches the water. Set the motor’s power supply knob at the second mark, as shown. Switch on the power supply, and if necessary push the motor to start it. You can regulate its speed with the knob.

PROCEDURE:

1) **Effect of f on λ**: Observe the waves with the bar vibrating at different frequencies, and answer the question.

2) **Effect of f on v**: This is can’t be just judged by eye, so we will take some measurements.

   (Under 3000 flashes per minute, the strobe’s maximum operating time is 30 minutes, with a 10 minute cool-down in between. Over 3000 fpm, it’s 5 minutes on, 10 minutes off.)

   A) To measure f, turn off the overhead light and flash a strobe light on the motor.

      - Start with the strobe very high, around 7000 fpm.
- Turn it down fairly slowly. Eventually it should look like there are two stationary screws on the motor. This is because the light flashes on it exactly once every half turn, always illuminating the screw on the motor in the same two positions. This is twice the correct frequency.

- Continue turning down the flash rate. Half the rate where you saw two screws should give you one. If it does, record it. Since a wave has the same frequency as its source, this is the wave's frequency too.

The usual mistake is a frequency which is one half or one third of the correct value, because flashing the strobe once every two revolutions or once every three will also make the screw look stationary. This is why you need to come down from a high frequency rather go up from a low one.

B) To measure $\lambda$, you will use a standing wave because its features will be at stationary points on the screen. This makes them easier to measure than with a traveling wave. Standing waves will be covered in PHY 133. For now, just a little information to get you through this lab:

Standing waves form when identical waves with opposite directions pass through each other. At certain points, called nodes, the two waves always give the surface equal and opposite pulls, so the water never moves there. The points of maximum vibration halfway between are called antinodes. The overall effect is as shown. (The solid line is the farthest the water’s surface goes in one direction. The dashed line is half a cycle later, the farthest it goes the other way.) Each antinode goes back and forth between being a crest and being a trough. Following the solid line, notice that at an instant when one antinode is a crest, the antinode next to it is a trough. So, the distance from antinode to antinode is half a wavelength.

You will make a standing wave by reflecting a wave back through itself. Put a metal barrier in the water parallel to the vibrating bar some distance away for waves to bounce off of. With the tank’s light on, notice there are rapidly flickering bright bars on the screen in front of the barrier. These are the antinodes. Trace several of them on a piece of scrap paper. Remember the distance between them is not the wavelength. It's half a wavelength. Measuring across several and dividing will give you $\lambda$ more accurately than just measuring one to the next.

C) Calculate the wave's speed from $v = f\lambda$.

D) Repeat steps A-C until you have done a total of five frequencies. Show your results to the instructor before going on, in case something needs to be rechecked. Notice what effect, if any, $f$ has on $v$. (Consider each $v$ to be $\pm 10\%$.)
(Footnote: What you just calculated is actually the speed of the images on the screen, not the speed of the waves in the tank. Projecting the image enlarges it, so the actual waves are slower.)

3. Effect of medium on $\lambda$, $v$, and $f$: Put a glass plate into the ripple tank so that the water just covers it. (Shim it up with pennies if necessary.) Have the edge of the plate parallel to the wave generator. You can now compare waves in shallow and deeper water.

A) Unplug the overhead light and once again hold the strobe by it. Adjust it so the motor looks like it is standing still. Notice now that the waves in deep water and the waves in shallow water also look like they are standing still. So, the frequency does not depend on properties of the medium; it just equals the frequency of the source.

For the rest of this, a low frequency is best because there are fewer waves cluttering up the picture. Have the tank’s light on, and draw what you see on the screen.

B) Both ends of a given crest leave the bar at the same time, so if one end gets to the back of the tank first, it's going faster. If the picture is too cluttered to tell when running the motor, try turning it off and tapping the bar with your finger to make just one wave. How does depth affect the speed?

C) Notice how the wavelength in deeper water compares with that in shallow water. (You don’t need to measure. Just decide which looks bigger.) Think about whether this is what you would expect from $\lambda = v/f$ and your answers to A and B.

As your conclusion, answer the following based on your results:

1) If you increase a wave's frequency without changing its speed, what happens to the wavelength?

2) Does a wave's speed depend on its frequency?

3) Does a wave's speed depend on the condition of the medium?

4) If you increase a wave's speed without changing anything about its source, (as in part 3 when you shift your attention from one side to the other) what happens to the frequency?

5) If you increase a wave's speed without changing its frequency, what happens to its wavelength?

After the instructor approves your results, please drain the tank. Carrying it to the sink or pouring it back into the large beaker can be tricky. Your best bet is soaking up the water with a large sponge.
1) When f increases, what happens to the distance between waves?

2) Complete the following table:

<table>
<thead>
<tr>
<th>f (f. p. m.)</th>
<th>f (Hz)</th>
<th>λ (cm)</th>
<th>v (cm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Wavelength = _________ times the distance between antinodes.)

As f increases, v _________________________________.
(increases, decreases, stays same)

3) Finish picture, showing waves above glass and in deep water:

In deep water, f is the same as in shallow.

In deep water, v is ___________________________.
(faster, slower, or same)

In deep water, λ is _____________________________.
(longer, shorter, or same)