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Ripple Tank Instructions

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The Ripple Tank comprises the following individual parts:

Ripple Tank………………..… …....1pcs

Detachable legs……………….……..….3pcs

Angular holders…………...………..…2pcs

Plate fitting……………………………...1pcs

Fixing rods for Strobe-unit and vibration Generator………………………… ….....1pcs

Mirror……………………………..…….1pcs

Perspex plate …………………………......1pcs

Strobe-unit…………………………….....1pcs

Vibration-Generator……………………..1pcs

Controlling-Unit……………………….....1pcs

Single dipper…………………………..….1pcs

Double dipper………………………….…...1pcs

Triple dipper……………………………..1pcs

Dipper for parallel waves………………..…1pcs

Acrylic block, ……..…………..……...1pcs

Pipette ……………..……………………..1pcs

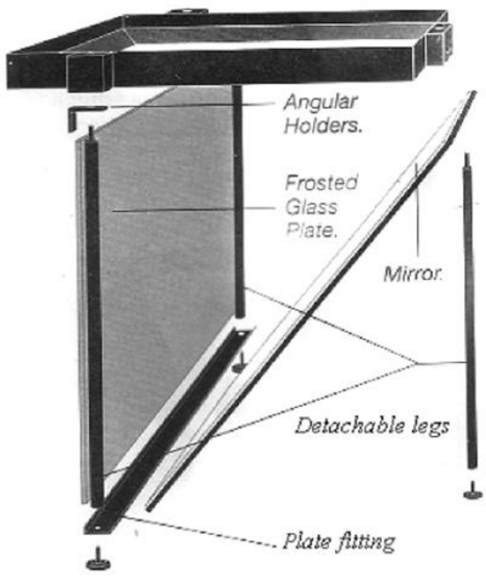
Acrylic block rectangle………………….1pcs

Connection wire for Strobe–Unit………....1pcs

Connection wire for Vibration-Generator..1pcs

Transparent Ruler………………………..1pcs

Assembly of the ripple tank:



RT-1

Users can assemble the ripple rank according to picture RT-1.

Attach the 3 detachable legs to the ripple tank. The 2 angular holders must be inserted in between the fixtures and the 2 front legs. Likewise the plate holder is inserted between the leg and the leveling feet of the 2 front legs. The plate holders' oblique edge must point backwards-in direction towards the third leg. The strobe-unit should be placed with the display facing you when viewed from the front. The frosted glass plate and the mirror slides in place under the tank, the mirror in an oblique position.

Adjust the tank to level by means of the leveling feet. If the table top is level it may be sufficient to adjust the hind leg, as this leg is slightly shorter than the 2 front legs with the angular holders inserted. A spirit level could come in handy for this job.

Mount the fixing rods for Vibration-Generator and Strobe-Unit. Connect Vibration-Generator and Strobe-Unit to the Controlling-Unit. N.B. always connects the connection wire's red

Dippers:

Single point dipper:
Utilized for experimental demonstration of a wave produced by a point source.

Double point dipper:
A tool for demonstrating interference patterns from two point sources.

Triple point dipper:
Will allow for demonstrating the interference pattern for waves produced from 3 point sources.

Straight wave dipper bar:
Used for demonstrating parallel straight waves.

Acrylic blocks:
These three transparent blocks can be used in two manners:

1. If the water level is deep enough that the entire block is submerged, the blocks are used to demonstrate that the velocity of propagation varies with the depth of the water.
2. If the water level is lowered, the blocks are used to demonstrate reflection.

LED-stroboscope:

The operation of the strobe light is designed to be user friendly. The total power consumption is less than 10 watts.

Wave generators:

Two are included. As an optional exercise, they can both be attached to tank to allow for observation of interference of waves approaching at right angles to each other.

Control Unit:

1. The power switch is located on the side of the unit.
   If the switch is set to "asynchronous," one can see the wave travel across the screen.
   If the switch is set to synchronous, the strobe will be synchronized with the generator, producing a "stopped" wave pattern.

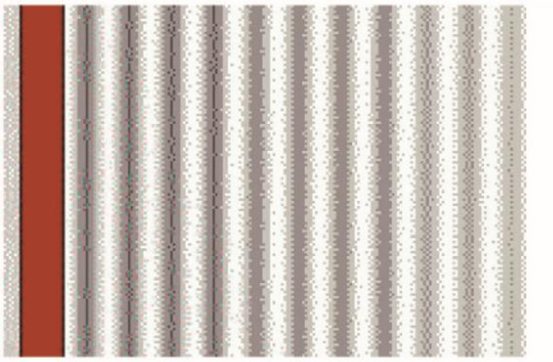
2. With the larger knob on the controller, frequency can be adjusted from 40Hz to 100Hz in 0.01 steps.

3. Amplitude is adjusted with the smaller knob.

Demonstrating wave properties:

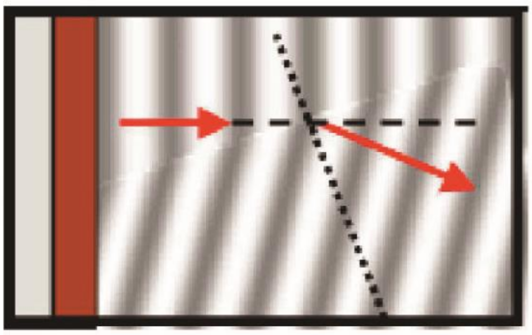
A number of wave properties can be demonstrated with a ripple tank. These include plane waves, reflection, refraction, interference and diffraction

Plane waves:



Use the straight wave dipper to generate plane waves, as shown above.

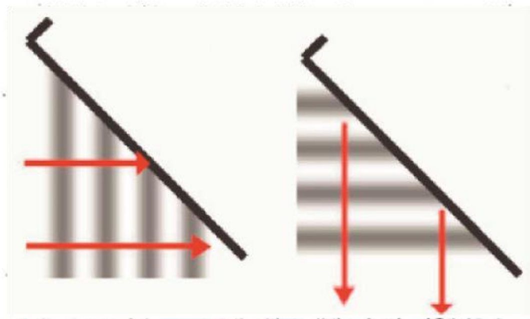
Refraction:



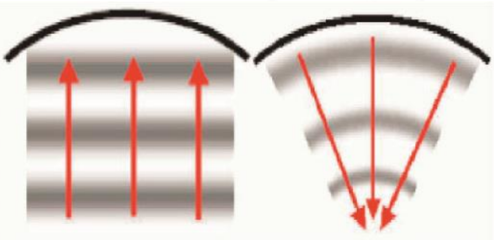
If a block is placed in the tank, the depth of the water in the tank will be shallower over the block than elsewhere. The speed of a wave in water depends on the depth, so the ripples slow down as they pass over the block. This causes the wavelength to decrease. If the junction between the deep and the shallow water is at an angle to the wave front, the waves will refract.

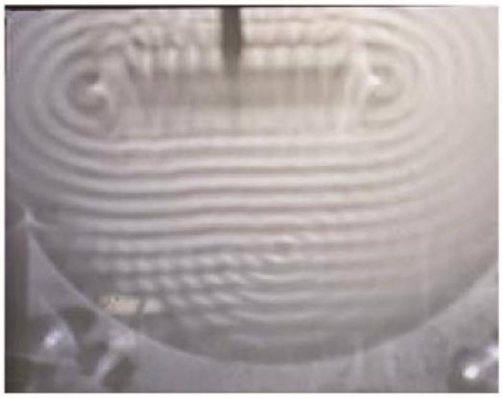
In the above diagram, an clear acrylic plate has been placed in the tank at an angle to the parallel waves. The normal to the edge of the plate is indicated with a dashed line. One can see that the wave is bent towards the normal as the wave moves from the deeper water into the shallow side.

Reflection:



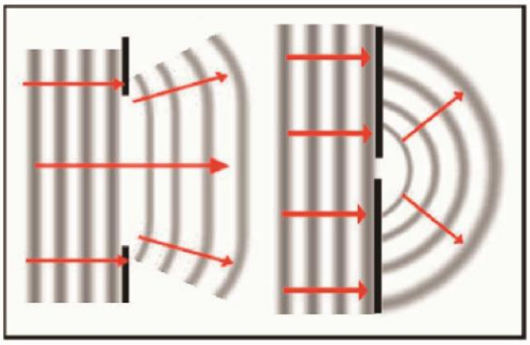
Place a bar in the tank. The ripples will reflect from the bar. If the bar is placed a an angle to the wave front, the reflected waves can be seen to obey the law of reflection.

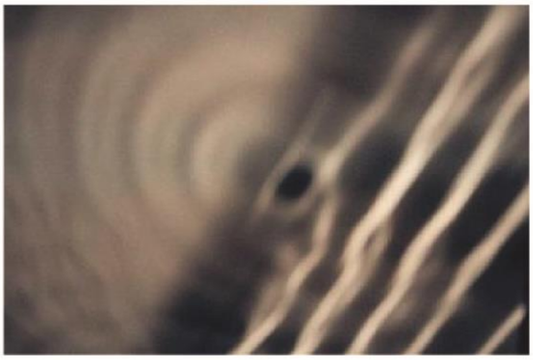




If the concave acrylic block is used, a plane wave will converge on a point after reflection. This point is the focal point of the mirror. Circular waves can be produced by using the single dipper. If the single dipper is placed at the focal point of the "mirror," plane waves will be reflected back.

Diffraction:

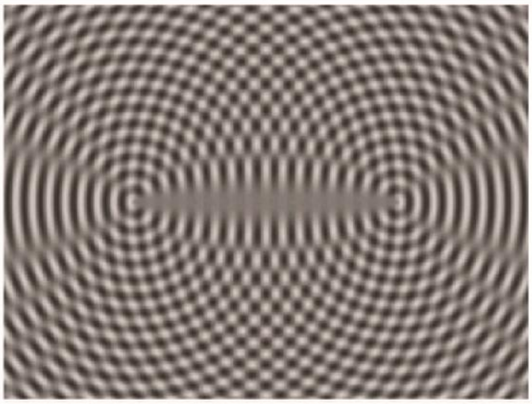


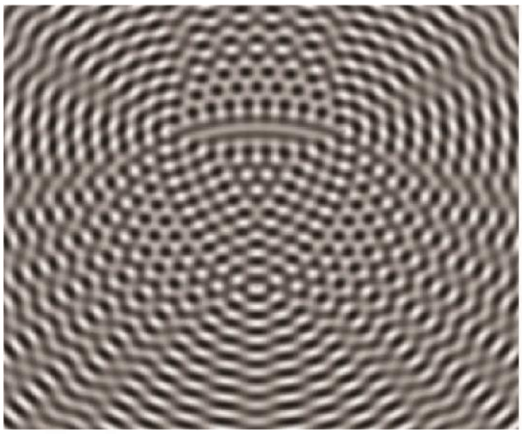


If an obstacle with a small gap is placed in the tank, the ripples emerge in an almost semicircular pattern. If the gap is large, however, the diffraction is much more limited. *Small,* in this context, means that the size of the obstacle is comparable to the wavelength of the waves.

Interference:

Interference can be produced by using the double dipper. In the diagrams in the next column, the light areas represent the crests of the waves; the black areas represent troughs. Notice the grey areas: they are areas of destructive interference where the waves formed from the two sources cancel out one another.





RIPPLE TANK EXPERIMENTS

Experimental series 1: speed of propagation

The purpose of this experiment is to demonstrate the relationship: $v = f \cdot \lambda$ where v is the propagation speed of the wave, f is the frequency, and λ is the wavelength.

The wave generator should be set up with the straight wave generator attached. A row of light and dark stripes will be observed on the projection screen due to wave peaks and troughs respectively. One wavelength, λ, is the distance between two light or between two dark stripes. It may be necessary to regulate the amplitude of the wave generator to obtain reasonably sharp images of the waves on the screen. Also, be sure that there are no bubbles or other impurities in the water container or on the wave generator. Set the on/off switch to "**synchronous.**"

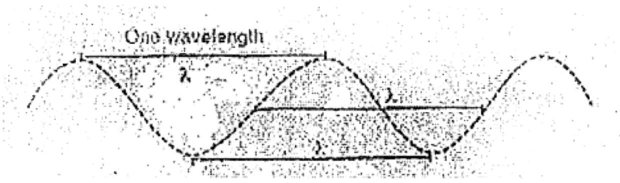


Figure 1: A harmonic wave

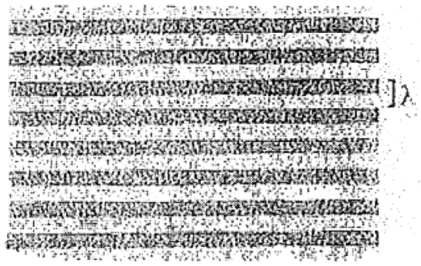


Fig. 1: The projection of the water waves on the table should look like this (λ is exactly one wave length.)

Exercise 1:

Use the ruler to measure the wavelength in meters and record in the data table. Read the frequency from th control unit and record it on the second line of the data table.
Change the frequency and repeat the measurements of wavelength and frequency. Continue changing the frequency and measuring the wavelength until you have five sets of measurements in all.

Data table:

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
f (Hz)					
λ (m)					
v (m/s)					

Calculations:

a. Compute the speed $v = f \bullet \lambda$ and record the values in the last row of the above table.
b. Is the speed reasonably constant?
c. Compute the average value of v.

Exercise 2:

The equation $= f \bullet \lambda$ can be rewritten as $\lambda = v \bullet f^{-1}$. Thus in a coordinate system with λ plotted as a functio of f^{-1}, a straight line should result with the speed v as the slope.

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
f^{-1} (s)					
λ (m)					

Draw a graph plotting f^{-1} on the x-axis and λ on the y-axis.
Find the slope of the line, and compare it with the average value of v you found in Exercise 1.

Exercise 3:

Because it is difficult to measure λ exactly, it is a good idea to repeat the exercise but measure 5 λ instead of λ. Do this for at least five sets of data.

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
f (Hz)					
5 λ (m)					
λ (m)					
v (m/s)					
f^{-1} (s)					

a. Compute λ and v for each set. Is v roughly constant?
b. Compute the average value of v.
c. Draw a graph as in Exercise 2 but with λ plotted as a function of f^{-1}. compute the slope (v).
d. Compare the four values for v which you now have found: the average from Exercise 1, the slope from Exercise 2, and the average and the slope from Exercise 3.

Experimental series 2: varying the depth of the water

Exercise 1:

With the straight wave generator still attached, place a glass or Plexiglas plate in the water table. (Note: It can be difficult to lift the plate up again, as it sticks to the bottom of the tank. This problem can be alleviated by putting a small piece of paper under one corner of the plate.) Adjust the water depth so that there is only a thin layer of water covering the glass plate. Place a piece of paper on the viewing screen and draw what you see.

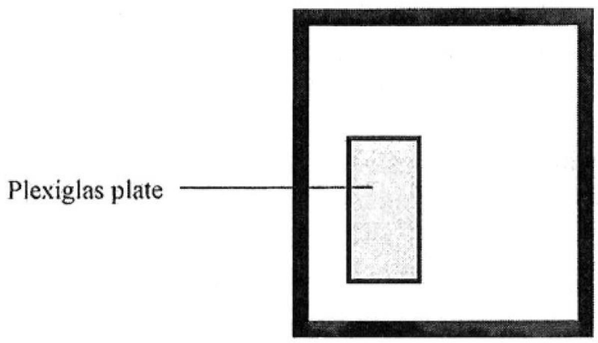


Fig. 2: Wave table with an extra glass plated added.

a. Can you explain your observation? (The wavelength is reduced in shallow water because the speed, v, is reduced.
b. Determine two values for λ – one for deep water and one for shallow water. The best results are achieved when you measure multiple wavelengths (for example: 5 λ) as you did in Exercise 3 of Experimental Series 1.
c. Compute the speed of water wave using $v = f \cdot \lambda$.
d. Try placing a thicker glass plate in the water. Again adjust the water depth so there is just a thin layer of water above the plate. Draw the image you are seeing and explain.

Exercise 2:
Set up an experiment as in Exercise 3 of Experimental Series 1 but vary the water depth.

Experimental series 3: refraction and reflection

Exercise 1:
Prepare the following experimental setup:

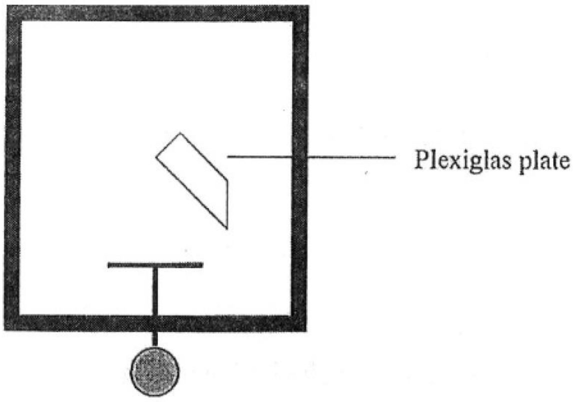


Fig. 3: Setup for demonstrating the refraction of water waves.

Choose a frequency.
Since the speed of propagation is lower in shallow water than in deep water, the wave will be refracted at the border between the shallow and deep water. This means that the direction of propagation of the wave will change. The direction of propagation is always normal (perpendicular) to the wave fronts.

Place a piece of paper against the screen and trace the following: the border between deep and shallow water (i.e. the edge of the Plexiglas plate) and 3 to 5 wave fronts both for deep and shallow water.

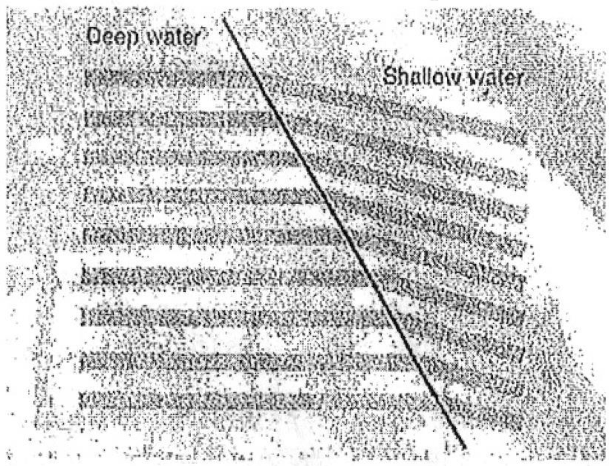


Fig. 4: Refraction of water waves.

Data analysis:

Use your drawing to determine the wavelength both for the "shallow" water, $\lambda_{shallow}$, and for the "deep" water, λ_{deep}. Also, using a protractor, measure the angle of incidence, i, of the water waves and the angle of refraction, b. Remember that i and b can be measured as the angle between the wave fronts and the interface border.

According to the law of refraction (Snell's law): $\frac{\sin i}{\sin b} = \frac{\lambda_{shallow}}{\lambda_{deep}}$

Exercise 2:

When waves strike a wall, they will be reflected back. The law of reflection states that: *The angle of incidence equals the angle of reflection.*

It is quite difficult to observe the reflected wave in the ripple tank. It is important that the amplitude is adjusted until the reflection becomes clearly visible. The same set up should be used as was just used in Exercise 1 (Fig. 3)but the water level should be adjusted so that the Plexiglas plate is not covered with water. Put a piece of paper on the screen and draw the wave fronts and the surface which reflects the waves.

Measure the angle of incidence and the angle of reflection to see if they are equal. Remember that both angle of incidence and angle of reflection are measured to the normal.

Experimental series 4: wave diffraction

Exercise 1:

Place a barrier in the ripple tank as illustrated in Figure 5. Check whether the water waves can "turn corners" using various wave generator frequencies. Repeat with another barrier. The water level should be such that it doesn't cover the barrier.

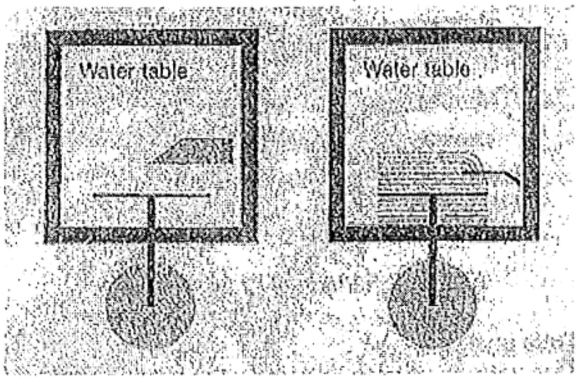


Fig. 5: Water table with barriers.

Exercise 2:

Place the two barriers as shown in figure 6. By changing the frequency, the wavelength can be changed.

a. What happens to the waves at the corner or the hole when the frequency is increased?
b. What do you observe happening to the waves?
c. Can you get the waves that leave the hole to look like ring-shaped waves?

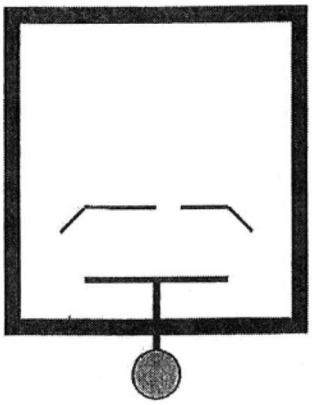


Fig. 6: Plane waves striking a hole in a barrier.

Exercise 3:
Check what happens to the waves when they encounter a small barrier, e.g. a "pole" or similar object. Make a setup like the one shown in Figure 7.

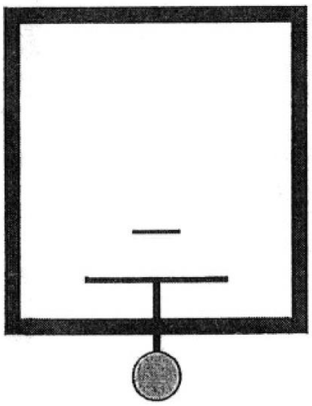


Fig. 7: Water waves encountering a small barrier.

Experimental series 5: wave interference

When two waves meet they will form an interference pattern. When the waves reinforce one another, it is called constructive interference, and when the waves cancel one another out, it is called destructive interference. This phenomenon can be examined by mounting a double dipper unit on the wave generator so that an interference pattern is created as shown in figure 8.

The interference phenomenon can be described by the double slit equation: $\sin \theta_m = \frac{m \cdot \lambda}{d}$

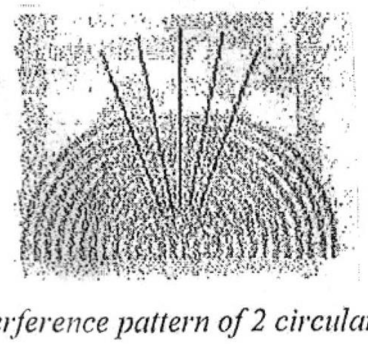


Fig. 8: The interference pattern of 2 circular waves.

When m is the order of the interference line, θ_m is the angle between the 0^{th} order line and the line of interest, d is the distance between the two dippers and λ is the wavelength. As wavelength is difficult to measure in an interference patter, this should be done using a single dipper and with no barriers in the water.

The speed of propagation is found just as in Experimental Series 1. Since this speed is constant for a constant water depth, the wavelength can be found using the equation:

$v = f \cdot \lambda \implies \lambda = v / f$ where frequency can be read on the controller.

Exercise 1:

Mount the wave generator with two dippers. Measure the distance d between them. When the interference pattern is clearly visible on the screen, trace it on a piece of paper. (It may be necessary to adjust the amplitude.)
There are some clear, light stripes – those are where this is destructive interference. The constructive interference occurs at the positions of the two dippers. Connect the two points on the drawing. The interference stripe which is normal to the line connecting the two dippers is termed the 0^{th} order line. Read off the frequency *f* from the controller, and measure the angles θ_m between the various interference lines and the 0^{th} order line. Check whether the condition that sin θ_m equals the value $(m \cdot \lambda) / d$ is fulfilled. Repeat for several frequencies. Use the table to collect the measured data and for calculations: v_{wave} = m/s d = m

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
***f* (Hz)**					
λ (m)					
m					
$(m \cdot \lambda) / d$					
θ_m					
sin θ_m					

Exercise 2:

This experiment can also be performed by sending plane waves towards a barrier with two apertures (i.e. openings) as shown in the figure below. The only change compared with Exercise 1 is that now d is the distance between the two apertures in the barrier instead of the distance between the two dippers. See the figures at the top of the next page. The interface pattern will appear as shown in Figure 10.

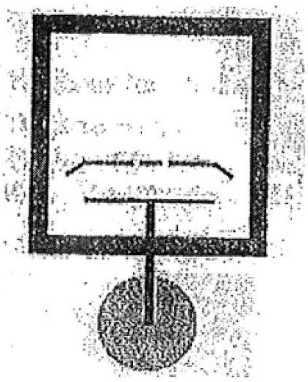


Fig. 9: The water table with a barrier with two apertures.

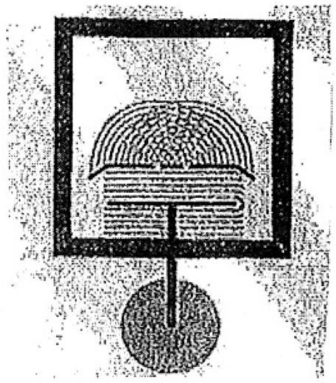


Fig. 10. The interference pattern from a double slit.

The measurements from Exercise 1 can be repeated, and it can be demonstrated that the double-slit formula is also valid for a barrier with two apertures. v_{wave} = m/s d = m

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
f (Hz)					
λ (m)					
m					
$(m \cdot \lambda) / d$					
θ_m					
$\sin \theta_m$					

Experimental series 6: the Doppler effect

The Doppler effect can be demonstrated using the ripple tank. Mount the wave generator with a single dipper. By moving the wave generator at a constant speed, the Doppler phenomenon can be observed in the ripple tank as illustrated below. It will require some experimentation to determine the right speed to use for a given generator frequency.

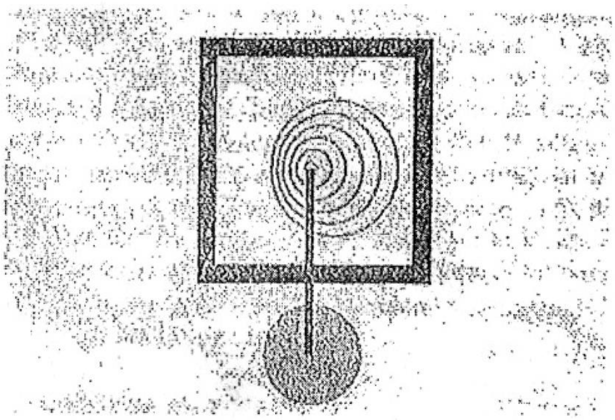


Fig. 11: The Doppler Effect