EDU-LAB
SCIENTIFIC RESOURCES

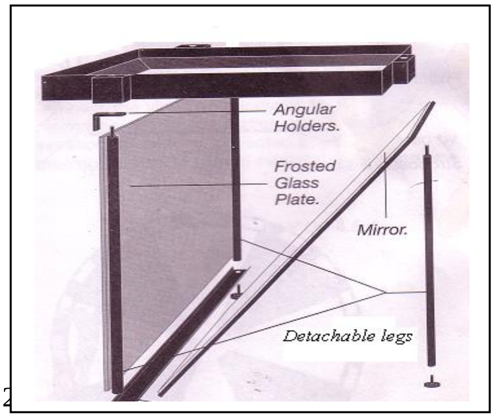
Ripple Tank:
Instruction Manual

Contents:

Water Tank	1pcs
Detachable legs	3pcs
Angular holders	2pcs
Plate fitting	1pcs
Fixing rods for Strobe-unit and vibration generator	1
Mirror	1pcs
Strobe-unit	1pcs
Vibration-Generator	1pcs
Frequency Controlling-Unit	1pcs
Single dipper	1pcs
Double dipper	1pcs
Triple dipper	1pcs
Dipper for parallel waves	1pcs
Acrylic block, concave	1pcs
Acrylic block, rectangle	1pcs
Acrylic block, semi-circle	1pcs
Connection wire for Strobe–Unit	1pcs
Connection wire for Vibration-Generator	1pcs
Transparent Ruler for measuring	1pcs
Pipette flask with special solvent	1pcs
Frosted glass plate	1pcs

Required additional equipment: Power Supply：10-15V DC/1.5-2A

Assembly of the ripple tank:



RT-

Users can assemble the ripple rank according to the figure 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 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.
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 third 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.

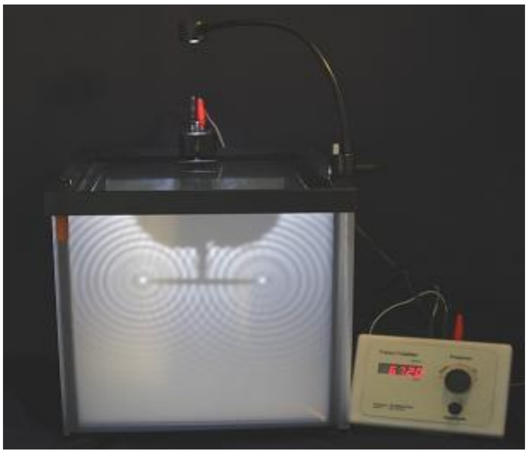
Mount the fixing rods for the Vibration-Gener-or and Strobe-Unit. Connect the Vibration-Generator and Strobe-Unit to the Controlling-unit. N.B. always connect the connection wire’s red banana plug to the positive terminal.
Connect the Controlling-Unit to an appropriate power supply capable of supplying 10-15V DC/1.5A.

Filling water:

Distilled or demineralized water is recommended in order to avoid problems related to limescale. Fill with approximately 500ml of water. ie. A water depth of approx. 6-7mm. Problems in relation to surface tension are avoided by adding 2-3 drops of the special solvent supplied in the pipette flask. Disperse the solvent along the foam liners on the tank with the finger tip. Likewise it is advisable to apply just a little of this solvent to the dippers before using them.

Accessories

1, Acrylic blocks, 3 types
2, Vibration Generator
3, Dropping Pipette
4, Single dipper
5, Double dipper
6, Triple dipper
7, Dipper for parallel waves



Ripple tank in use

There is a lock on the vibration-generator, it is used for keeping the generator undamaged during transport or when changing the dipper. So the vibration -generator must be locked when you change dipper.

The single dipper:

Utilized for experimental demonstration of the wave formula and the Doppler Effect.

The double dipper:

A good tool to demonstrate interference patterns.

The plane wave dipper:

This dipper may be used for the demonstration of reflection and refraction.

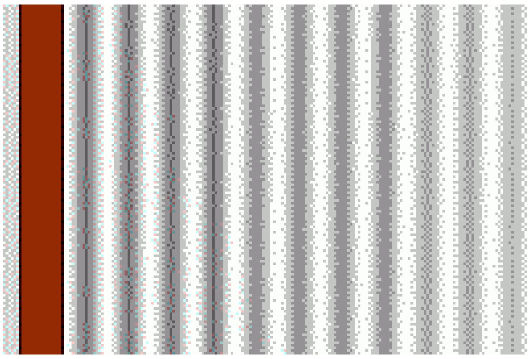
The acrylic blocks:

The acrylic block is a set of 3 transparent blocks used to demonstrate that the velocity of propagation will vary with different depths. Place the block in the tank so that the depth over the block is shallower than the other areas. By letting plane parallel waves pass over different shapes of acrylic blocks, it is possible to demonstrate how the shape of the blocks influences the refraction of the waves. By lowering the water depth, the same blocks can be used to demonstrate reflection.

Demonstrating wave properties:

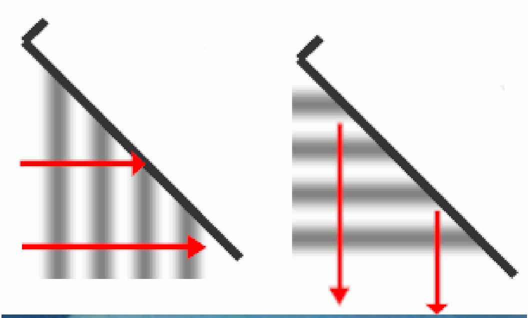
A number of wave properties can be demonstrated with a ripple tank. These include plane waves, reflection, refraction, interference and diffraction.

Plane waves:

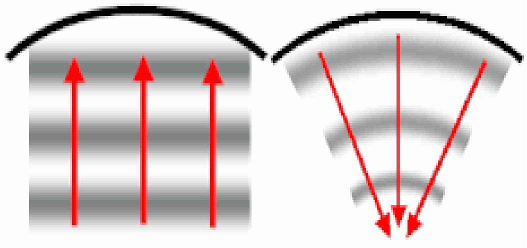


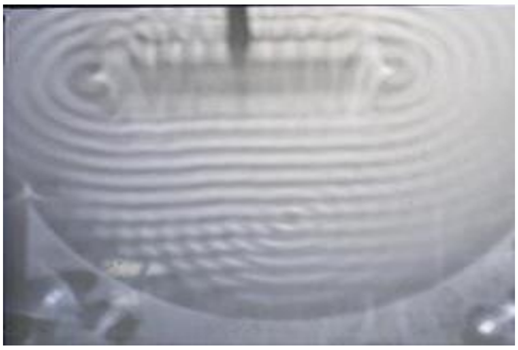
Use the dipper for parallel waves to generate plane waves.

Reflection:



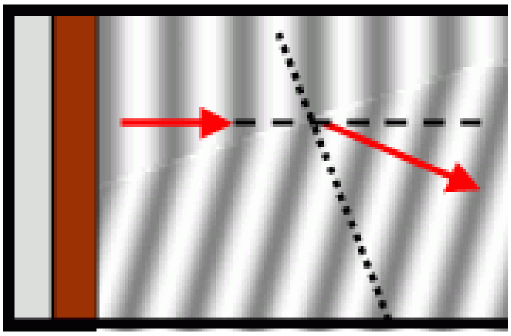
Place a bar in the tank. The ripples will reflect from the bar. If the bar is placed at an angle to the wave front the reflected waves can be seen to obey the law of reflection.





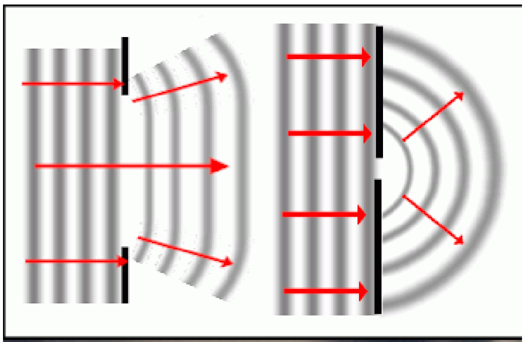
If the concave acrylic block is used, a plane wave will converge on a point after reflection. This point is the focal point of the mirror. Circular waves can be produced by using the single dipper. If this is done at the focal point of the "mirror", plane waves will be reflected back.

Refraction



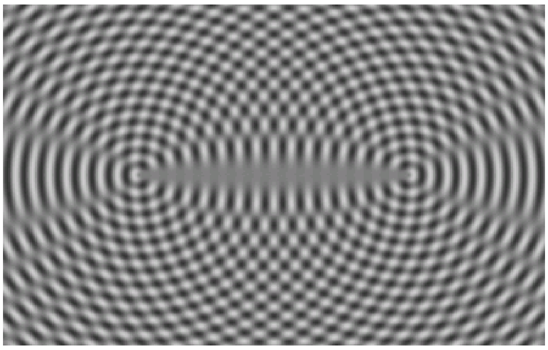
If a block is placed in the tank, the depth of water in the tank will be shallower over the block than elsewhere. The speed of a wave in water depends on the depth, so the ripples slow down as they pass over the block. This causes the wavelength to decrease. If the junction between the deep and the shallower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

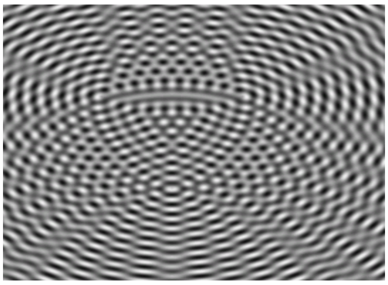
Diffraction



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 ripples.

Interference





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

The LED-stroboscope and controller

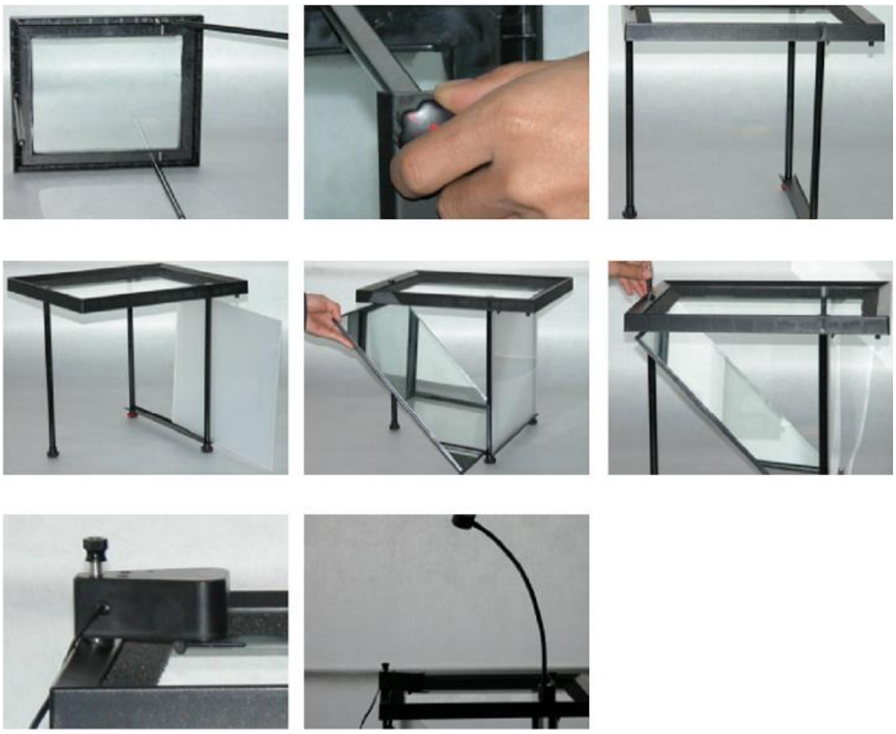
The operation of this unit is designed to be user friendly. Total power consumption is less than 10W.

1, Adjust frequency here
2, Adjust amplitude here
Frequency from 30Hz to 100Hz in 0.01 steps

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

1, Banana Socket
Connect to the vibration-generator
The connection wire’s red banana always plugs into the positive terminal
2, 3.5mm Socket
Connect to the LED-Stroboscope
The LED-stroboscope can work safely at 3-6.5V
3, DC Socket
Connect to 10-15V DC/1.5-2A power supply
4, Power switch
To turn on and off

Procedure of assembly



1. Attach the three detachable legs to the ripple tank.
2. Fix the plate holder or make sure the oblique edge points backwards in direction of the third leg.
3. Insert the leveling feet.
4. Insert the Frosted Glass Plate.
5. Insert the mirror.
6. Mount the fixing rods for the LED-stroboscope and the vibration-generator.
7. Fix the Vibration-Generator and use nut on it to fix to the unit.
8. Likewise, fix the LED-stroboscope.

WAVE TABLE EXPERIMENTS

Experimental series 1 of speed of propagation

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

The water table should be assembled and placed on a white tabletop. The wave generator should be mounted with a plane wave generator (a plane wave dipper) which generators plane, parallel waves.

A row of light and dark stripes will be observed on the table top due to wave peaks and troughs respectively. One wavelength λ is the distance between two lights 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 table. Also, be sure that there are no bubbles or other impurities in the water container or on the wave generator.

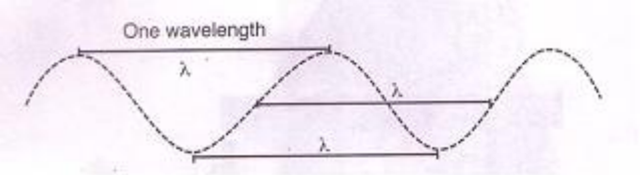


Figure 1: A harmonic wave

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

Exercise 1:

Using the ruler on the table to measure the wavelength in metres, and make a note of the corresponding frequency read from the strobe light. Choose another frequency and repeat the measurements of λ and f. Make five sets of measurements in all.

Data table:

a) Compute the speed $v = f \bullet \lambda$ for each pair of measurements, and write the result in the last row of the table.

f/Hz					
λ / m					
$v = f \bullet \lambda /(m/s)$					

b) Is the speed reasonably constant?
c) Compute the average value of v.

Exercise 2:

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

f^{-1} / s					
λ / m					

Draw a graph plotting in your data. Is the resulting graph a straight line through the origin (0,0)?
Find the slope of the line, and compare it with the average value of v which 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 5λ instead of λ. Do this for at least five sets of data.

Table for measurements and computations:

f/Hz					
$5\lambda / m$					
λ / m					
$v = f \bullet \lambda /(m/s)$					
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 water depth

Exercise 1:

The wave generator is still the plane wave generator. A piece of glass is placed in the water container. (NB: It can be difficult to lift the glass plate up again, as is sticks to the bottom of the water container. This problem can be alleviated by putting a small piece of paper under one corner of the glass plate.) Regulate the water depth so that there is only a thin layer of water above the glass plate. Place a piece of paper on the viewing table and draw what you see.

Figure 2: Wave table with an extra glass plate 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 e.g. five wavelengths as in Exercise 3 of Experimental Series 1. Compute the speed of the water wave using $v = f \bullet \lambda$.

c) Try placing a thicker glass plate in the water. Regulate the depth so that there is just a thin layer of water above the plate. Draw and explain.

Exercise 2:
Set up experiments in Exercise 3, Experimental Series 1 but with a different water depth.

Experimental series 3 refraction and reflection

Exercise 1:
Prepare the following experimental setup:

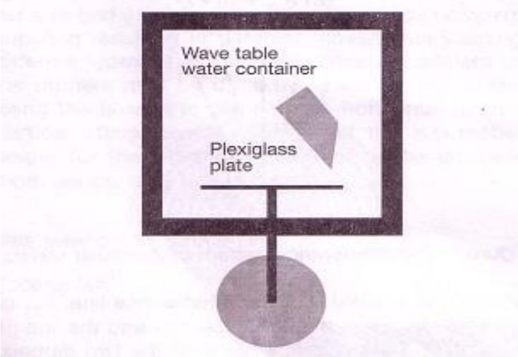


Figure 3: Setup for demonstrating the refraction of water waves

Choose a proper frequency.
Since the speed of propagation is lower in shallow water than in deep water, the wave will be refracted at the border between shallow and deep water. This means that the direction of propagation of the wave will change. The direction of propagation is always normal to the wave fronts.
Place a piece of paper on the table and trace the following: the border between deep and shallow water (i.e. the edge of the Plexiglas plate) and 3 to 5 wavefronts both for deep and for shallow water:

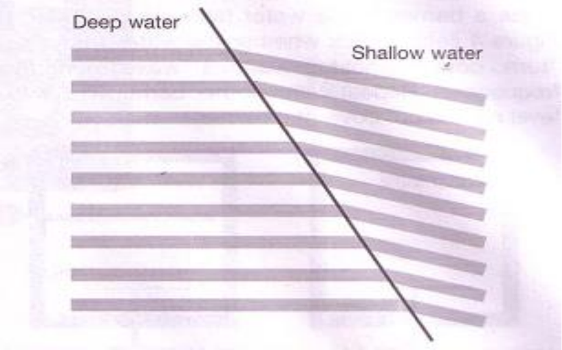


Figure 4: Refraction of water waves

Data analysis:
Use your drawing to determine the wave length both for the “shallow” water $\lambda_{shallow}$ and for the “deep” water λ_{deep}. Measure also the angle of incidence i of the water waves and the angle of refraction b using a protractor. Remember that i and b can be measured as the angle between the wavefronts and the interface border.

$$\frac{\sin i}{\sin b} = \frac{\lambda_{shallow}}{\lambda_{deep}}$$

According to the law of refraction (Snell’s law).

Exercise 2:

When waves strike a wall they will be reflected. In this case the law of reflection is valid. It can be expressed briefly as follows:

The angle of incidence equals the angle of reflection

It is quite difficult to observe the reflected wave in the water table. In this experiment it is important to adjust the amplitude until the reflection becomes clearly visible. The same setup should be used as in Exercise 1 (Figure 3), but the water level should be regulated so that the Plexiglas plate is not covered with water. Put a piece of paper on the table under the water table and draw the wave fronts and the surface which reflects the waves.

Measure the angle of incidence and the angle of reflection, and check to see if they are equal.

Experimental series 4 Wave diffraction by corners and holes

Exercise 1:

Place a barrier in the water table an 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 not cover the barrier.

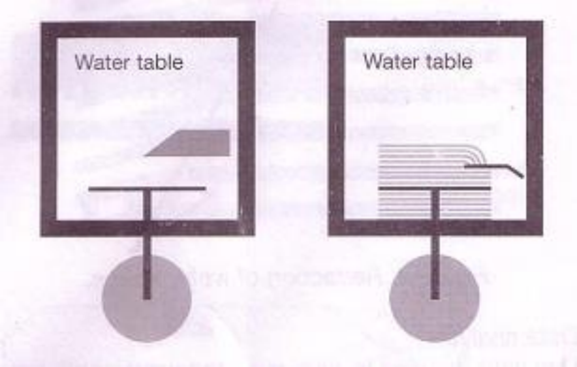


Figure 5: Water table with barriers

Exercise 2:

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

a) What happens to the waves at the corner or the hole when the frequency f is increased?

b) What do you observe happening to the waves?

c) Can you get the waves which leave the hole to look like ring-shaped waves?

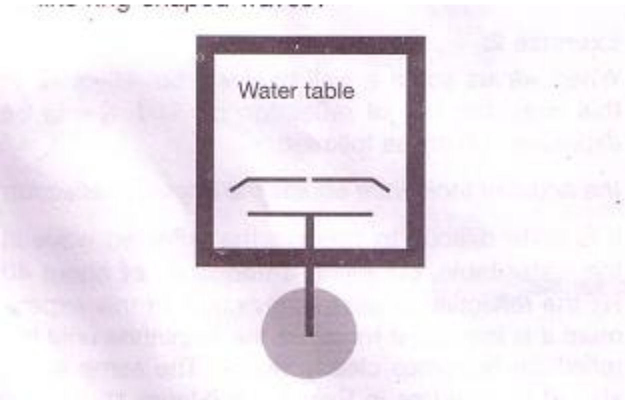


Figure 6: Plane waves striking a hole in a barrier

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.

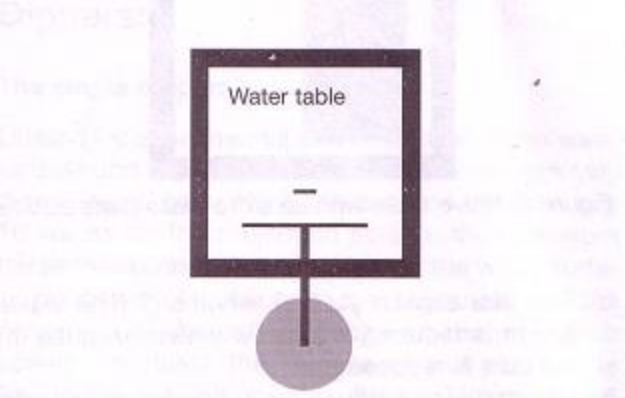


Figure 7: Water waves encountering a small barrier

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 create a pattern as shown in Figure 8, where the shin line indicate points of constructive interference.

The interference phenomenon can be described by the double slit equation:

$$\sin\theta_m = \frac{m \bullet \lambda}{d}$$

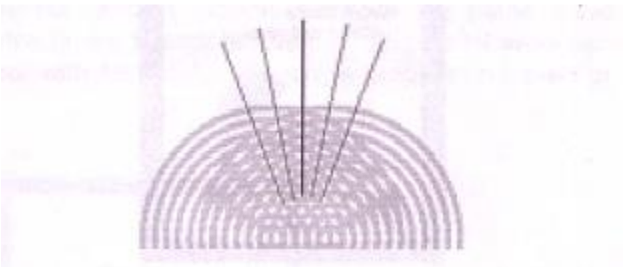


Figure 8: The interference pattern of 2 circular waves

Where 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 id difficult to measure in the interference pattern, this should de done waves is determined using just 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 to use can be found by using the equation:

$$v = f \bullet \lambda \Leftrightarrow \lambda = v / f$$

Where the frequency can be read on the stroboscope

Exercise 1:

Mount the wave generator with two dippers. Measure the distance d between them. When the interference pattern is clearly visible on the table below the water table (it may be necessary to adjust the amplitude), trace it on a piece of paper. There are some clear, light stripes-that is where there 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 the 0^{th} order line. Read off the frequency f from the stroboscope, and measure the angles θ_m between the various interference lines and the 0^{th} order line. Check whether the condition that $\sin\theta_m$ equals the value $m \bullet \lambda / d$ is fulfilled. Repeat for several frequencies. Use the table to collect the measured data and for calculations:

$v_{wave} = m/s$ d= m

	Exp.1	Exp.2	Exp.3	Exp.4	Exp.5
f/Hz					
λ / m					
m					
$m \bullet \lambda / d$					
θ_m					
$\sin\theta_m$					

Exercise 2:

This experiment can also be performed by sending plane waves towards a barrier with two apertures (i.e. openings) as shown in Figure 9. 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. The interference pattern will appear as shown in Figure 10.

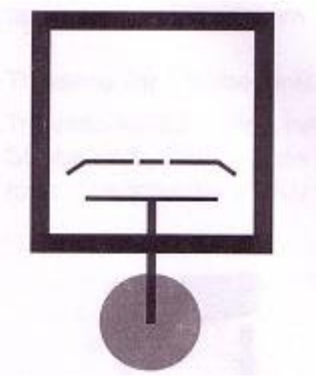


Figure 9:
The water table with a barrier with two apertures

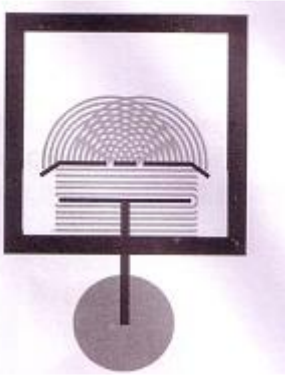


Figure 10:
The interference pattern from a double slit

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

	Exp.1	Exp.2	Exp.3	Exp.4	Exp.5
f/Hz					
λ / m					
m					
$m \bullet \lambda / d$					
θ_m					
$\sin \theta_m$					

Experimental series 6, the Doppler Effect

The Doppler Effect can be demonstrated using the water table. 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 water table as illustrated in Figure 11. It will require some experimentation to determine the right speed to use for a given generator frequency.

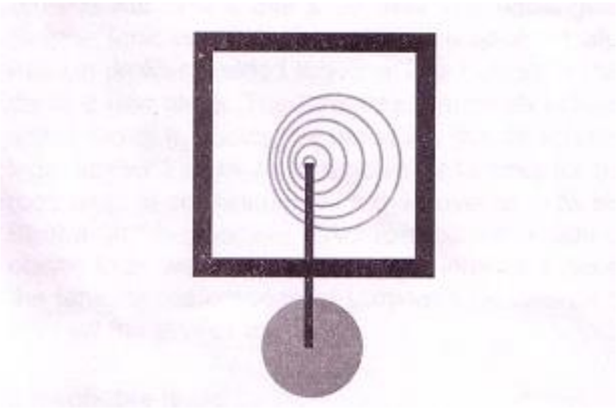


Figure 11: The Doppler Effect