Ripple Tank
Exploring the Properties of Waves Using a Ripple Tank

The ripple tank is a shallow, glass-bottomed container that is filled with water to a depth of 1 or 2 centimeters. There is a light source that is placed above the ripple tank that will project an image of the waves onto a screen on the table below. At the same time that it projects the waves it also magnifies the distance between the waves, thereby making them easier to see and to measure. A diagram of the set-up is shown in Figure 1.

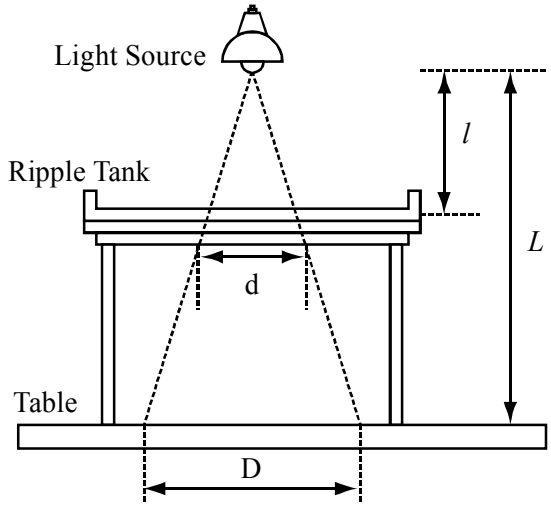

Figure 1

The magnification is usually a factor of 2, since the distance from the light to the ripple tank *l* is half the distance from the light to the table *L*.

PURPOSE

This experiment is divided into four parts. In Part I, you will use the ripple tank to study reflection of waves. In Part II, you will study refraction. In Part III, you will study diffraction, and finally, in Part IV, you will study interference.

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MATERIALS

ripple tank
point, high intensity light source
variable wave generator & accompanying apparatus
screen
metric ruler
hand held stroboscope
protractor
wooden blocks
aluminum concave/convex barrier
glass plate
pennies or washers
container to carry water
3 foam beaches if needed

PROCEDURE

PART I: REFLECTION

Reflection is the behavior of a wave as it meets the boundary between two media and bounces back.

1. Fill the ripple tank to a depth of approximately 1.5 cm.

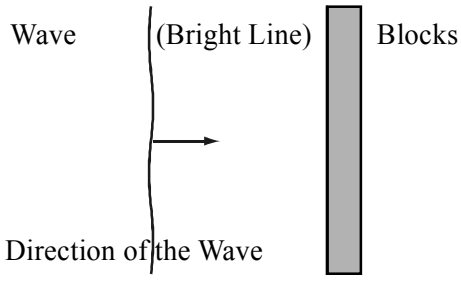
2. Use a ruler to level the ripple tank by putting the end into the water and adjusting each leg until the depth of the water is the same in all areas of the tank.

3. Place the screen on the tabletop below the tank so that you can see the shadows of the waves and the bright and dark lines clearly.

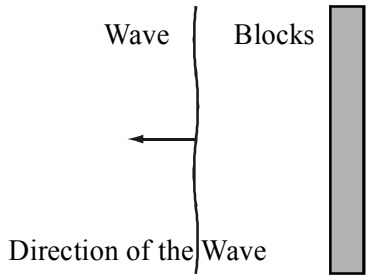
4. Adjust the light source so that it illuminates the center of the ripple tank and gives as sharp as possible bright lines. The bright lines on the screen correspond to crests in the ripple tank and the dark lines correspond to troughs.

5. The result of each investigation is to be represented by a picture that is large and neat, as in the example below.

Before:



After:

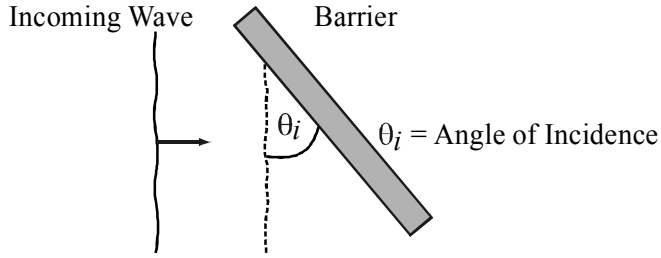


6. Stand the two blocks in the ripple tank so that you can see the shadow of the blocks clearly on the screen. The blocks should be touching each other.

7. You will use the long edge of the ruler to generate the initial waves. Take the ruler in both hands and place it in the water so that the long edge just breaks the surface of the water. It should not be touching the bottom of the tank.

8. The ruler should be parallel to the blocks. With a gentle, quick and small motion push the ruler forward. Water will be compressed in front of the ruler and a crest will be formed. Remember that a wave is a bright line on the screen. On the screen watch the wave make contact with the barrier and observe the wave before and after it hits the barrier. In the space provided in Part I on your student answer page, sketch the wave before and after it hits the barrier.

9. Move the blocks so that the "ruler" wave will intersect the barrier at an angle, as shown below.



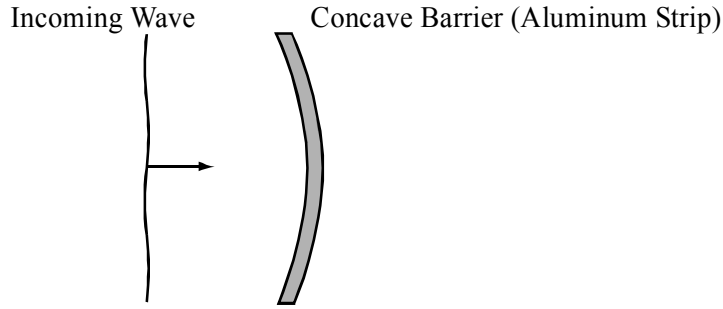
10. In the space provided in Part I of your student answer page, sketch the position of the wave and barrier before and after it hits the barrier.

11. Use the protractor to measure the angle between the incoming wave and the barrier. Record this as the angle of incidence.

12. Use the protractor to measure the angle between the outgoing wave and the barrier. Record this as the angle of reflection.

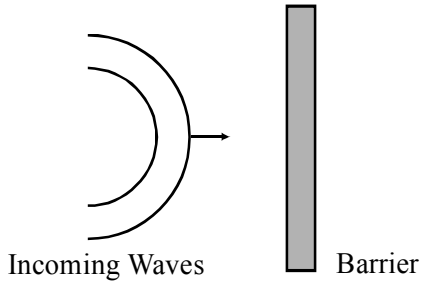
13. Remove the blocks from the ripple tank and dry them thoroughly.

14. Position the curved strip of aluminum as shown below. The curved aluminum will act as a concave barrier to the waves. Use the ruler to send a straight wave toward the barrier and sketch the pattern of waves you see after the wave encounters the barrier. Be very careful in your observations. There are three distinct areas of the outgoing waves that you should note.



15. Turn the aluminum around to face in the opposite direction, forming a convex barrier. Use the ruler to send a straight wave toward the barrier and sketch the pattern of waves you see after the wave encounters the barrier. Be very careful in your observations. There are three distinct areas of the outgoing waves that you should note.

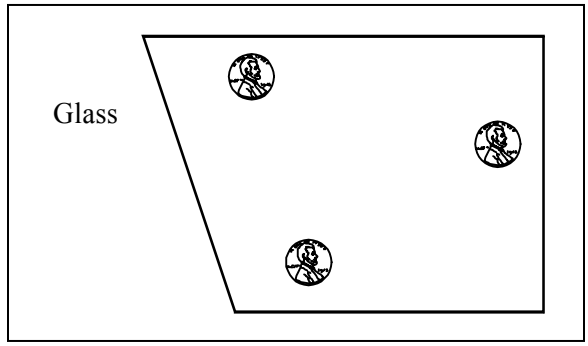
16. Put the blocks back in the water and use your finger or the tip of a pencil to generate a circular wave by tapping the water as shown below. Sketch the reflected wave on your student answer page.



PART II: REFRACTION

Refraction is the behavior of a wave as it passes from one medium into a second medium at an angle. In this exercise the waves will pass between deep and shallow water media.

1. Position three pennies on the bottom of the ripple tank. Place the glass plate carefully on top of the pennies, as shown. Be sure to position the plate such that the incoming waves will strike it at an angle. This will create a shallow area and a deep area for the waves to travel through.



2. Very carefully, add or remove water from the ripple tank so that the depth over the piece of glass is as shallow as possible yet covers all of the glass.

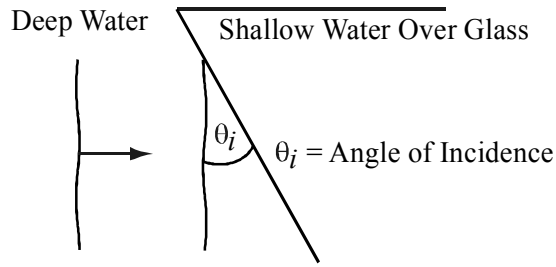
3. Set up the wave generator with the straight wave source attached. The straight edge should just break the surface of the water, and should not be touching the bottom of the tank.

4. Set the frequency of the generator so that the straight edge vibrates as slowly as possible yet produces waves consistently.

5. In order to make the measurements in this part of the lab, it will be necessary to use the hand-held rotating stroboscope with one slit open. Like any stroboscope, this one is intended to interrupt the viewing of an object. As the cardboard disk rotates, the only time you view an object is when the slit is in front of your eye. You can control the time between views by rotating the stroboscope at various frequencies while it is held in front of one eye. If the rate of rotation is the same as the frequency of the wave, then it will appear that the wave has not moved. This apparent lack of motion will allow you to measure the wavelengths and the angles required below.

6. Measure the distance between two white lines in the area of the screen that is below the deep water. Then measure the distance between two white lines on the screen that is below the shallow water. If you use the stroboscope this will be relatively easy to do.

7. Use a ruler and a pencil to mark the edge of the glass on the screen. Measure the angle between the incoming waves and the edge of the glass (the angle of incidence) and the angle between the waves in the shallow water and the edge of the glass (the angle of refraction). Record this information on your student answer page.



PART III: DIFFRACTION

Diffraction is the behavior of a wave as it passes through a small opening or around a small obstacle. The word "small" is relative, and in this situation it means the size of an opening between the two blocks (as seen on the screen) relative to the distance between two white (crest) lines in the ripple tank.

1. Remove the glass plate and pennies from the tank. Restore the depth of the water to about 1.5 centimeters.

2. Set up the wave generator with the straight wave source as you did in Part II. Make sure that the straight edge just breaks the surface of the water, but does not touch the bottom of the tank.

3. Position the two blocks in the water so that there is a space of approximately 1 centimeter between them. Make sure that you can see both the area in front of and behind the blocks on the screen.

4. Starting with the two blocks in this position, observe the waves after they have passed through the opening. Hint: Look particularly at the area alongside the opening. Make careful drawings of your observations in Part III space provided on your student answer page.

5. Increase the distance between the two blocks to approximately 4 centimeters and observe the waves on the opposite side of the opening. Make careful drawings of your observations in the space provided on your student answer page.

PART IV: INTERFERENCE

Interference is the behavior of two or more waves occupying the same space at the same time. When two or more waves occupy the same location in a medium at the same time the medium responds to the waves by moving in a manner that is the algebraic sum of each individual disturbance. If there are two waves of equal magnitude and the crest from one meets the trough from the other the disturbance will be cancelled or nullified. This point of no disturbance is called a node. A series of nodes will form a pattern called a nodal line. The nodal lines will form a nodal pattern. It is this pattern that you are trying to observe on the screen beneath the ripple tank. Where two crests meet or two troughs meet the disturbance of the medium is enhanced. Such a location is called an anti-node.

1. Set up the wave generator with two point sources. Arrange them so that they just barely break the surface of the water.

2. Keeping the frequency of the motor constant, vary the distance from very close to very far apart between the two point sources. Sketch your observations in the Part IV space provided on your student answer page.

3. Now, position the two sources moderately far apart. Observe the nodal pattern produced at both a high and low frequency of your choice. Sketch the nodal patterns for each on your student answer page.

4. The phase of two waves refers to their relative time of production. If the two sources enter the water simultaneously they are said to be in phase. If one source enters the water as the other is coming out of the water they are said to be completely out of phase.

5. Set the phase control so that the waves are in phase. Observe the nodal pattern. It should be similar to the ones that you have already sketched.

6. Slowly change the phase control so that the waves become out of phase. Record your observations of the nodal patterns on your student answer page.

Name _____

Period _____

Ripple Tank
Exploring the Properties of Waves Using a Ripple Tank

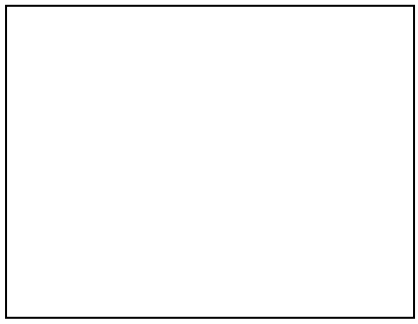
DATA AND OBSERVATIONS

Most of the data collected in this experiment will be recorded as pictures. These pictures should be large, simple and labeled. They are to represent the physical phenomenon clearly.

PART I: REFLECTION

A straight wave moving straight into a barrier.

Before



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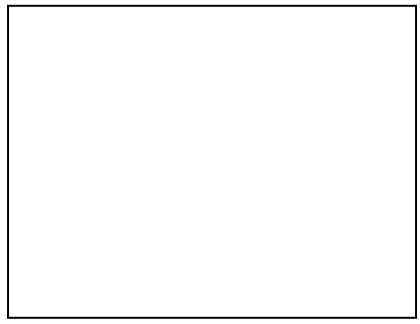
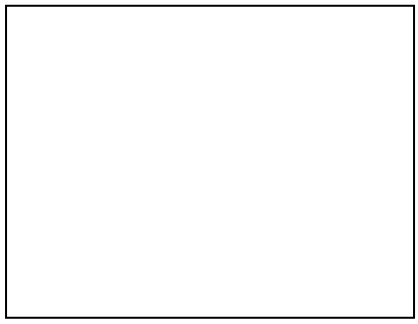


A straight wave moving into a straight barrier at an angle.

Indicate the angle of incidence and the angle of reflection on your diagram.

Before



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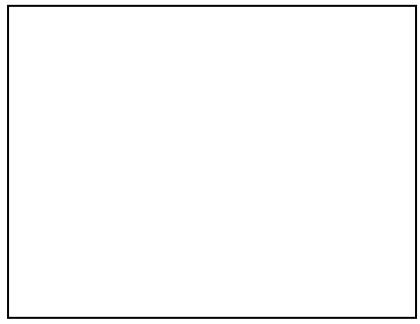
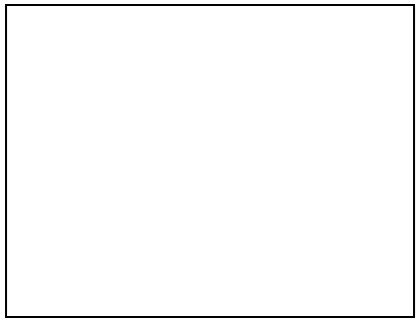


Angle of incidence _____ Angle of reflection _____

A straight wave moving into a concave barrier. (Remember, there are three distinct areas of the outgoing wave that are of interest.)

Before



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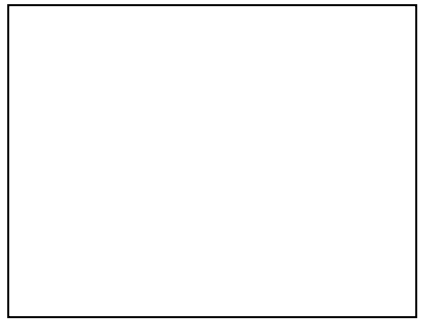
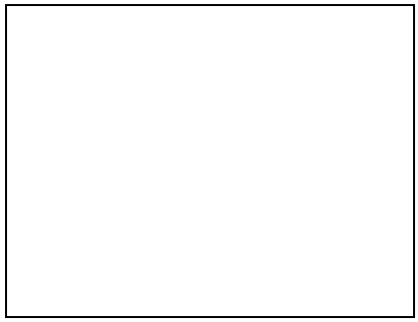


A straight wave moving into a convex barrier.

Before



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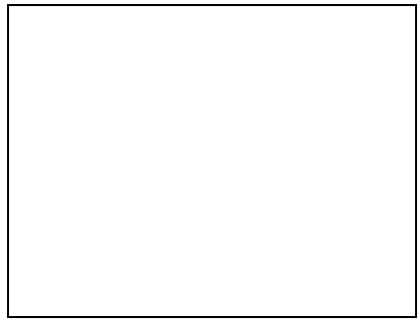
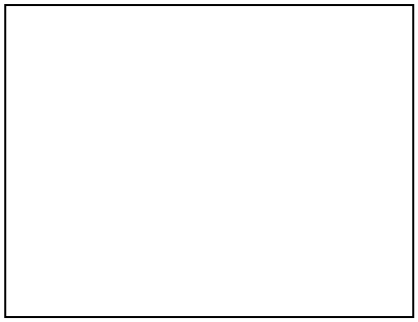


A curved wave moving into a straight barrier.

Before



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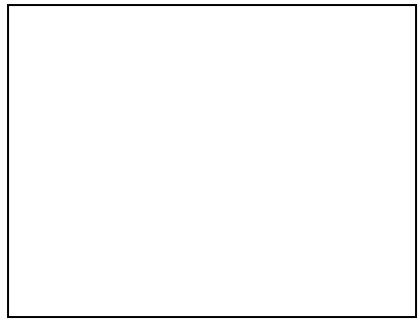
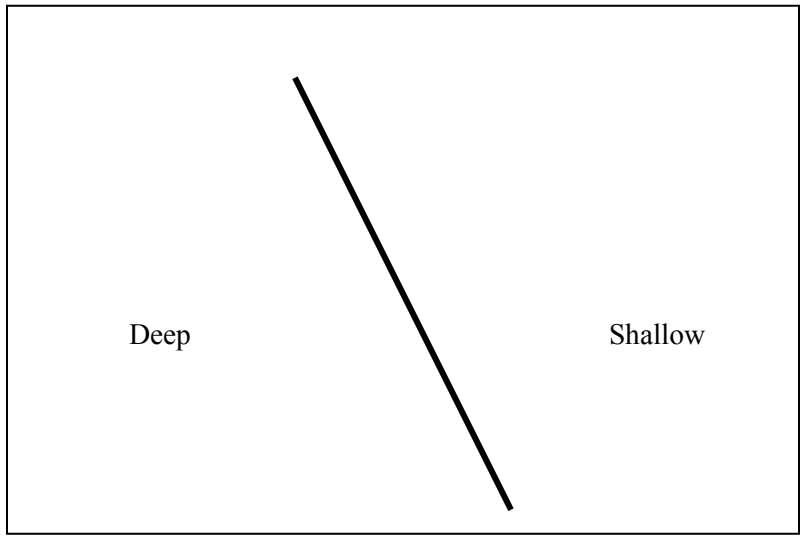


PART II: REFRACTION

Indicate the angle of incidence and the angle of refraction on your diagram. Also indicate on your diagram where you measured the distance between two bright lines in the deep and in the shallow water.



distance between two lines in the deep water _____ cm

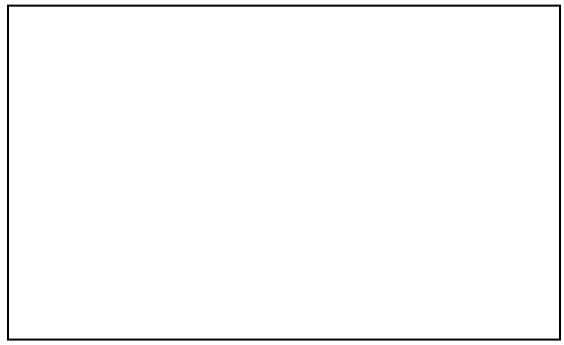
distance between two lines in the shallow water_____ cm

angle of incidence _____ angle of refraction _____

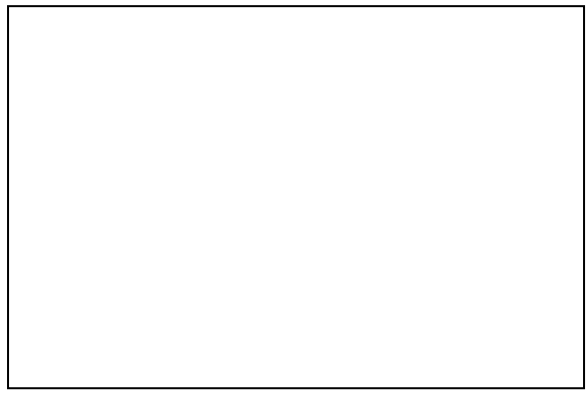
PART III: DIFFRACTION

The important observation in this part of the exercise is the behavior of the waves after they have passed through the opening.

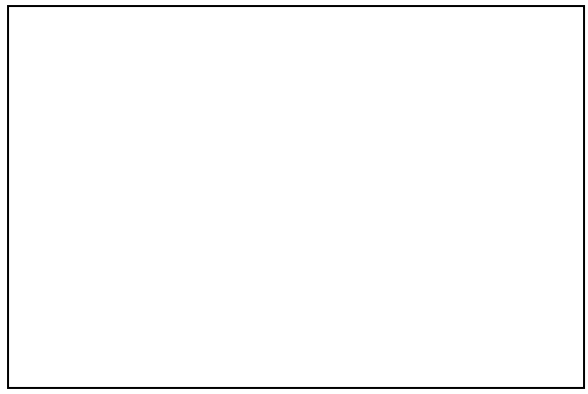
The opening is relatively small.



The opening is moderately wide.



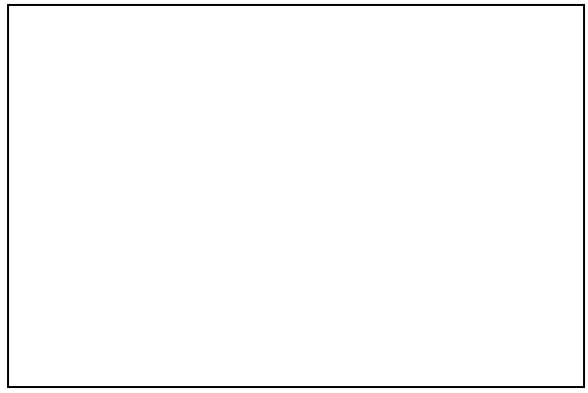
The opening is as wide as possible in the ripple tank.



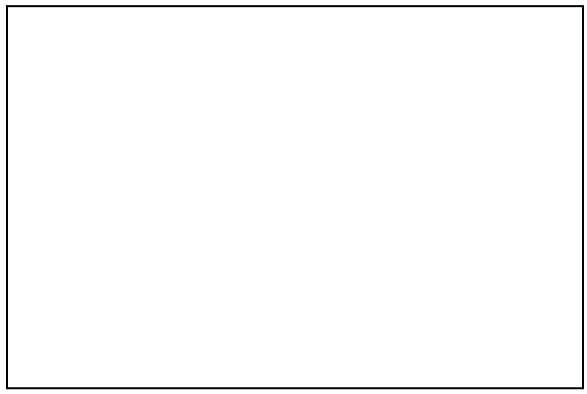
PART IV: INTERFERENCE

In each of the pictures drawn in this section, draw only the nodal pattern. Do not draw the waves.

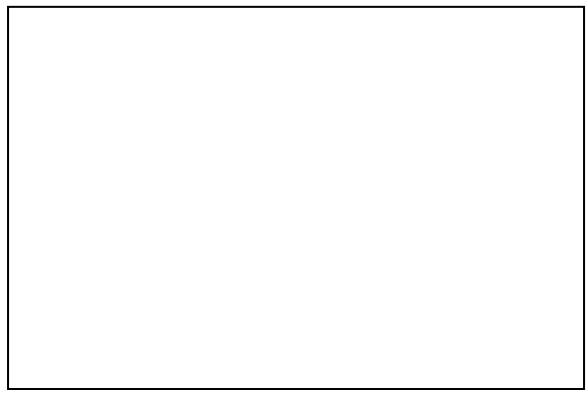
Two sources close together. The generator should be in phase and vibrating slowly.



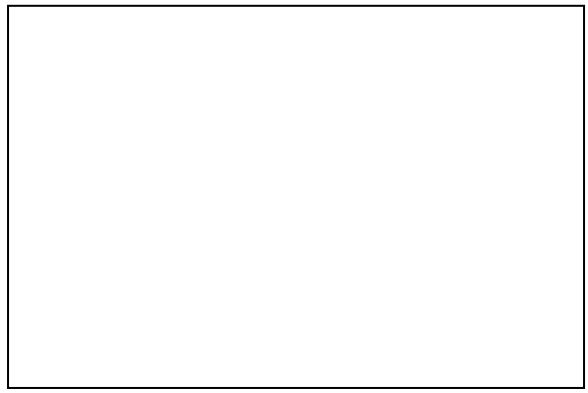
Two sources far apart. The speed of the generator must be the same as above.



Two sources vibrating quickly. The phase should be set at zero and the point sources should be about 4 or 5 cm apart.



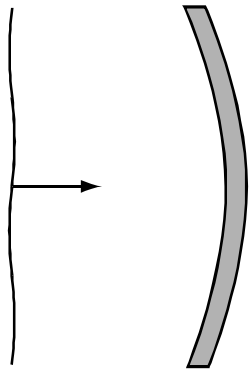
Two sources vibrating slowly. The point sources should be the same as in the previous part.



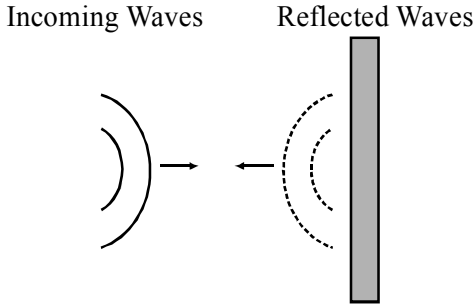
CONCLUSION QUESTIONS

1. Compare the angle of incidence and the angle of reflection. What do you think should be the relationship between these two angles?

2. What was the behavior of a straight wave as it bounced off the concave barrier? Consider the top of the straight wave. To where does it reflect as it comes off the barrier? To where does the bottom of the wave reflect? Show this on the following diagram.



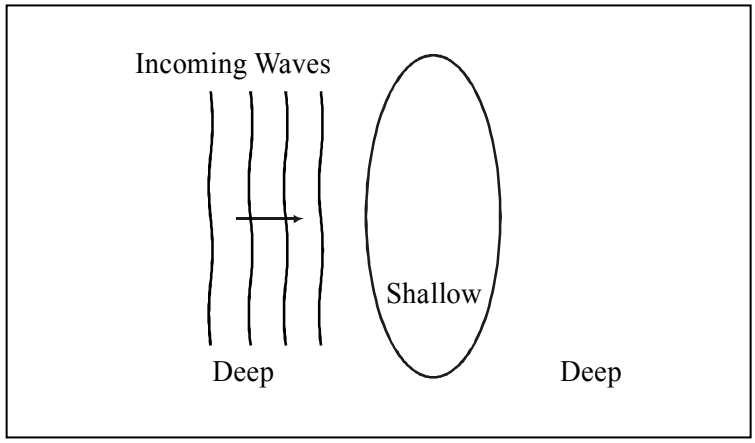
3. Point sources, such as the tip of your finger put into the water or a pebble thrown into a pond, generate circular waves. With this in mind, where do the reflected waves from a straight barrier for circular waves seem to originate? Show your answer on the following diagram.



4. The wave equation, $v = \lambda f$, gives a relationship between the speed of wave in a medium and the wavelength of the wave. The frequency of a wave is set by the oscillating source and cannot be changed once the wave is generated. Using these facts, do water waves travel faster or slower in shallow water than they do in deep water? Explain your answer.

5. Use the answer to question number 4 to explain how waves break as they approach the shore.

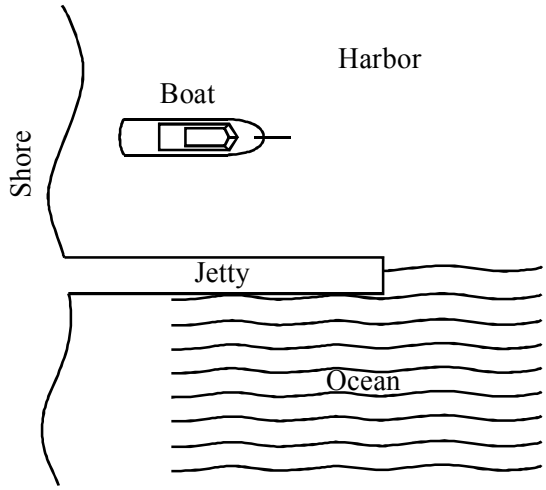
6. Using the diagram below and the information from Part II of this lab, show the possible path of the waves as they pass from the deep water into the shallow water and back into the deep water. The object that makes the transition between the deep and shallow water has the shape of a convex lens.



7. Studying the results of your diffraction experiment, state how the amount of diffraction depends on the relative width of the opening compared to the wavelength of the wave.

8. Using your answer to question 7 on diffraction, explain why you can *hear* a person speaking in a room but you cannot *see* the person if you are standing in the hall alongside the doorframe.

9. Using your observation of diffraction, describe and explain the motion of a boat anchored in a harbor protected by a jetty, as shown.



10. State in words what happened to the nodal pattern as the distance between the two sources increased.

11. State in words what happened to the nodal pattern as the frequency of the generator increased.

12. State in words what happened to the nodal pattern as the phase of the two sources changed.

13. Suppose that the ripple tank were large enough to allow you to row a boat around in it. Describe the motion of this boat if you rowed into a nodal line and what would happen if you rowed into the area between two nodal lines.

14. What could be a possible explanation for the fact that you do not get nodal lines in a room if it is illuminated by two lamps at either end of a sofa, as shown?