9.4 THE RIPPLE TANK AS A WAVE MODEL

The ripple tank is an ingenious device which permits us to study the behaviour of waves, using a water wave model. If a series of waves is generated by moving a piece of wood dowelling back and forth in a regularly repeating motion, the waves will look like the ones in **Figure 9.4** if seen from the side. The actual water waves are **transverse** in nature.

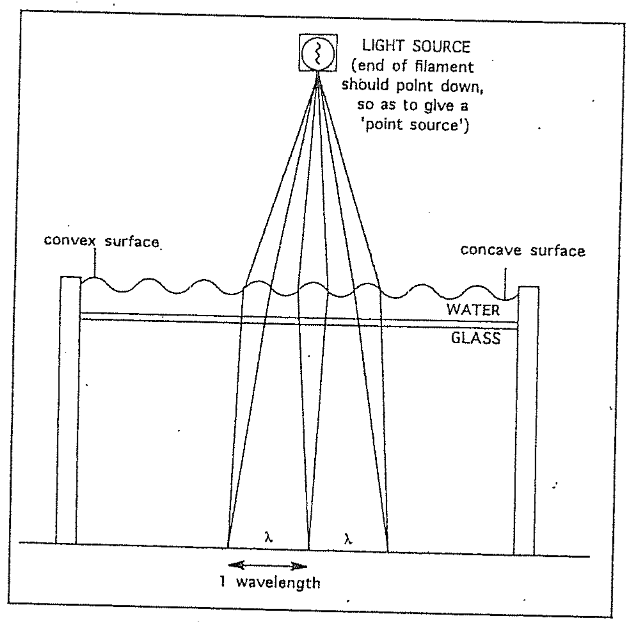


Figure 9.4

If light from a point source (the end of the filament of a straight-filament, clear light bulb) is allowed to pass through the waves and fall on a large sheet of white paper, then (with some focusing) the light passing through the waves can be made to form bright lines on the paper underneath the crests of the waves. The crests act as convex lenses and make the light from the source converge (come together). The troughs, on the other hand, act as concave lenses and make the light from the source diverge (spread out). The image you see on the white screen consists of a series of bright lines with dark spaces between successive bright lines. The bright lines represent crests, and the dark areas troughs. The waves you see on the screen are longitudinal waves, whereas the actual water waves were transverse.

INVESTIGATION 9-3
WAVELENGTH, FREQUENCY, AND SPEED OF WATER WAVES

Purpose: To investigate the relationship among wavelength, frequency and wave speed.

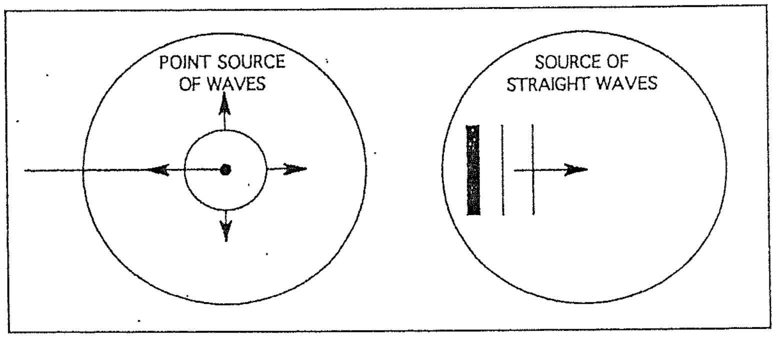


Figure 9.5

Procedure

1. Fill your ripple tank with water to a depth of approximately 2 cm. If your tank requires them, make sure the screen dampers are in place.

2. To generate a circular wave, touch the surface of the water at the centre of the tank with the tip of your finger. Is there any evidence that the wave speeds up or slows down as it travels from the centre of the tank to its perimeter?

3. Imagine a single point on one of the crests that you see moving out from the centre of the tank. What path would this ***point*** on the crest take?

4. Set up your wave generator so that it generates circular waves at regular intervals. Start with a low **frequency**. Note the **wavelength** of the circular waves (the distance between successive crests). Increase the frequency of the wave generator and observe how the wavelength changes.

5. Set up your wave generator so that it produces straight waves instead of circular waves. Try different frequencies to see the effect of frequency on wavelength.

Concluding Questions

1. Does a circular wave travel out at the same speed in all directions? How do you know this?

2. Describe what happens to the wavelength of a water wave when the frequency of the waves increases.

9.5 THE WAVE EQUATION

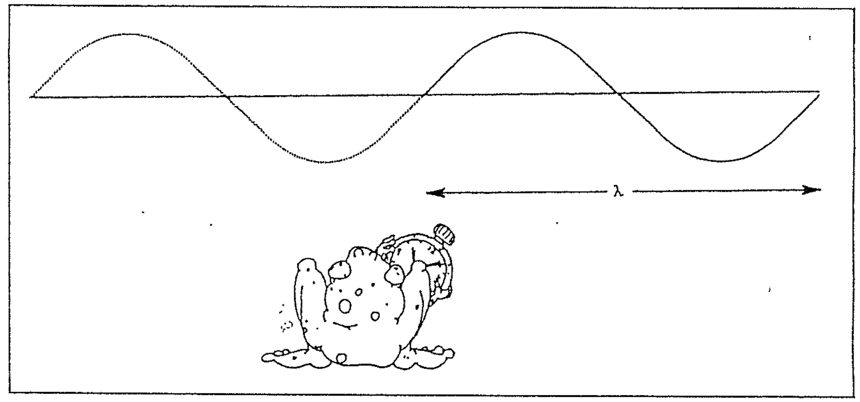


Figure 9.6

Fred the frog is sitting on the edge of a wavetank, watching the waves go by. See **Figure 9.6**. He knows that the waves were produced by a wave generator, which vibrates up and down with a frequency f and a period $T = 1/f$.

Being a dedicated physicist, he wants to know what the speed of the waves is. He watches a wave travel its own length (wavelength λ) and times exactly how long the wave takes to travel its own length. Since the waves are generated once every T seconds by the generator, then this T should be the period of the waves. To calculate the speed v of the waves, all he has to do is divide the wavelength by the period of the wave! In symbolic form, $v = \lambda / T$. Now, since $T = 1/f$, or $f = 1/T$, then

$$v = \lambda f.$$

This relationship is a very important one, because it is true for *any kind of waves.* This includes sound waves, earthquake waves, waves in the strings of musical instruments, or any kind of electromagnetic wave (light, infrared, radio, X-radiation, ultraviolet, gamma radiation, etc.)!

In words, the wave equation says

wave speed = wavelength x frequency.

Example:

What is the speed of a sound wave if its frequency is 256 Hz and its wavelength is 1.29 m?

Solution: $v = \lambda f = (1.29\ m)(256\ s^{-1}) = 330\ m/s.$

EXERCISES

1. If waves maintain a constant speed, what will happen to their wavelength if the frequency of the waves is (a) doubled? (b) halved?
2. What is the frequency of a sound wave if its speed is 340 m/s and its wavelength is 1.70 m?
3. Waves of frequency 2.0 Hz are generated at the end of a long steel spring. What is their wavelength if the waves travel along the spring with a speed of 3.0 m/s?
4. A student measures the speed of water waves in her tank to be 25 cm/s. If the wavelength is 2.5 cm, what is the frequency of the waves?
5. The speed of light is 3.0×10^8 m/s. What is the frequency of light waves if their wavelength is 600 nm? (1 nm = 10^{-9} m) Consult a spectrum chart to see what colour of light this would be.
6. Some microwaves have a frequency of 3.0×10^{10} Hz. How long is a microwave of this frequency? (Microwave radiation travels at the speed of light.)

9.6 PROPERTIES OF WAVES

In the next *INVESTIGATION*, you will observe some of the properties of water waves. These properties apply to light and sound waves as well. The main purpose of the next investigation is to familiarize you with properties of waves that apply to **SOUND** and **LIGHT**, which are the topics of the chapters that follow.

INVESTIGATION 9-4 PROPERTIES OF WAVES

Purpose: **To observe important properties of waves, using water waves in a ripple tank as a model.**

Note! This investigation will require several periods to complete. Most observations can be made in the form of neat sketches showing what happens when the procedures are followed.

Part 1 **Reflection of Circular Water Waves**

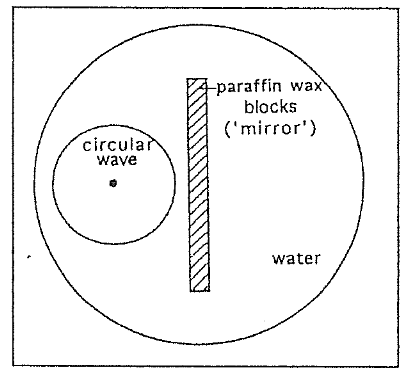


Figure 9.7

Procedure

1. Generate a circular wave by touching the surface of the water in the ripple tank at a distance of approximately 10 cm in front of a solid barrier, made of two paraffin wax blocks, standing on edge in the middle of the tank. (See **Figure 9.7**.) Observe the **curvature** of the wave as it arrives at the barrier and as it leaves. Is the wave less curved, more curved or does it have the same curvature after it reflects from the barriers? Sketch what you see.

2. From where does the **reflected** circular wave appear to come? Try generating a circular wave *behind* the barrier at the same time as you generate one in front of the barrier. Try different distances behind the barrier until you obtain a wave with the same curvature as the one that *reflects* from the other side of the barrier. (The wave from the point behind the barrier will look just as if it is passing through the barrier and joining the reflected wave on the other side!) If the waves were light waves and the waves were coming from an 'object', where would the 'image' of the object in the mirror (barrier) be located?

Concluding Question

How does the distance from the **object** to the **mirror** compare with the distance from the **mirror** to the **image**?

Part 2 Reflection of Straight Water Waves

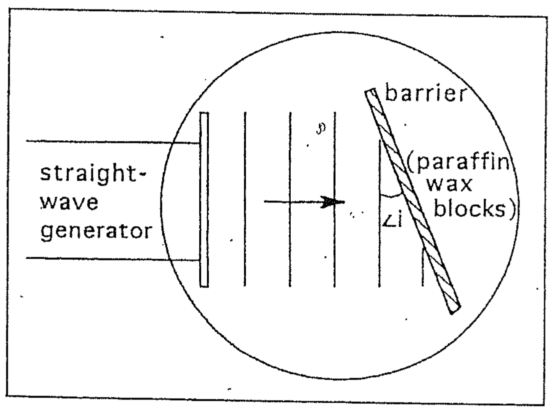


Figure 9.8

Procedure

1. Set up the straight-wave generator so that it sends parallel straight waves toward a barrier made of paraffin wax blocks. The angle formed where the incident waves strike the barrier (labelled ∠i in **Figure 9.8**) is called the **angle of incidence.** Measure both the angle of incidence and the **angle of reflection** (∠*r*). Sketch what you see.

2. Adjust the barrier to change the angle of incidence. Measure the angle of incidence and the angle of reflection for this new arrangement. Repeat for at least three other angles of incidence.

Concluding Questions

1. When straight waves strike a straight barrier, how does the angle of incidence compare with the angle of reflection?

2. When the waves reflect from the barrier, does their speed change? Does their frequency change? Does their wavelength change?

Part 3 Reflection of Waves from a Curved 'Mirror'

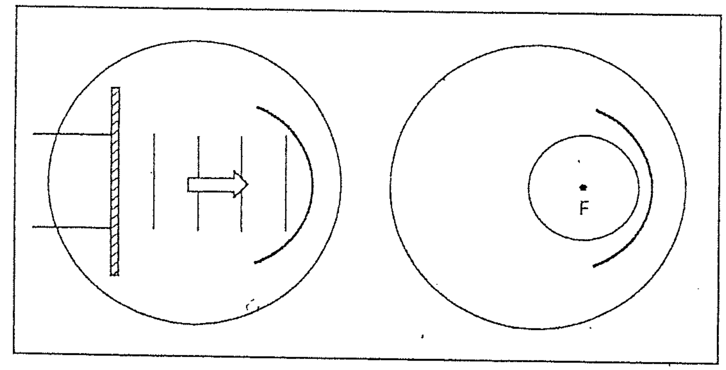


Figure 9.9 Figure 9.10

Procedure

1. This time, instead of a straight barrier, you will use a piece of rubber tubing, which curls into a shape that is approximately parabolic. Set up the rubber tubing 'mirror' so that it faces the straight-wave generator as in **Figure 9.9.**

2. Observe what happens when the incident straight waves reflect from the **parabolic mirror.** What shape do the waves have after the reflection? Locate the point to which the waves appear to converge. This point is called the **focus** or **focal point** of the mirror. Sketch what you see.

3. Turn off the straight-wave generator. Use the tip of your finger to generate circular waves at the focus of the mirror. What shape do the *reflected* waves have this time? Sketch what you see.

Concluding Questions

1. Describe what happens to straight waves when they reflect from a parabolic reflector. Are parabolic reflectors ever used to reflect (a) light? (b) sound? Give examples.

2. Describe what happens when circular waves originating at the focus of a parabolic mirror reflect from the mirror. Name a device that does this with light waves.

Part 4 Diffraction of Water Waves

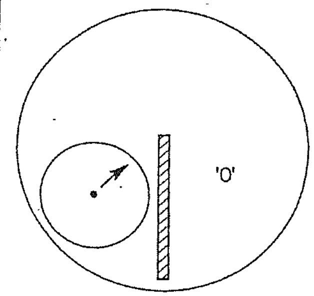


Figure 9.11

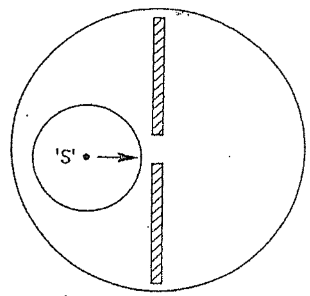


Figure 9.12

Procedure (Use sketches to describe what you observe.)

1. Set up a barrier (wall) near the middle of your ripple tank using a block of paraffin wax or similar object. See **Figure 9.11**. Use the tip of your finger to generate waves on one side of the wall. Observe what happens to the waves as they spread past the edge of the barrier. If these were **sound waves,** and you were standing at **O**, would you hear the sound?

2. Set up the arrangement in **Figure 9.12**, to simulate a doorway. Generate waves with the tip of your finger at **S**, and observe the waves as they pass through and beyond the door. If these were **sound waves,** could you hear the sound in the adjacent room?

3. Change the width of the 'doorway'. Does this affect the amount of spreading of the waves as they pass through?

4. Remove the barriers from the tank and place a small object near the centre of the tank. (Its shape is unimportant. A width of 2-3 cm would be appropriate.) Generate waves on one side of the obstacle using the tip of your finger. Let the waves pass by the object. Do they 'cast a shadow' as they pass it, or do they seem to carry on unaffected by the obstacle? What happens if you use an obstacle that is (a) bigger? (b) smaller?

The wave property you have been observing is common not only to water waves, but also to sound and light waves. In fact, any kind of waves exhibit the ability to spread out as they pass through narrow openings or around corners or small obstacles. The name of this property of waves is **diffraction.** You have probably seen examples of diffraction many times, perhaps without knowing what it was. If you look out at streetlights through a window screen or a fine mesh curtain, the *starburst* effect you see is due to diffraction of light waves as they pass by the screen. Diffraction is often used in television programs to obtain starburst effects in musical productions. Diffraction is commonplace with sound. You can hear someone talking around a corner mainly because of diffraction.

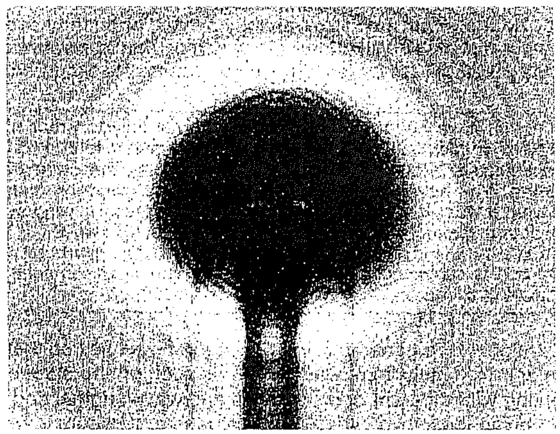
5. Set up your straight-wave generator and adjust the frequency so that the waves it produces are approximately 2 cm wavelength as seen on the screen on your table. By experimenting with different opening sizes and wavelengths, find out what the effect is of changing these two variables one at a time. Prepare a series of careful sketches showing how the wave forms look following diffraction.

6. Set up a small obstacle in the path of the straight waves. Experiment to see the effects of changing (a) wavelengths and (b) obstacle size. Sketch what you observe.

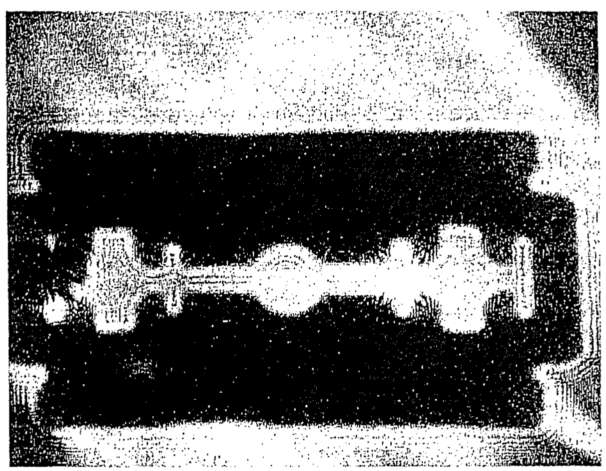
Concluding Questions

1. Is diffraction more noticeable with short wavelengths or long wavelengths?
2. Is diffraction more noticeable with small openings or large openings?
3. When straight waves pass through a small opening, what shape do the diffracted waves have? (Sketch a diagram.)
4. When straight waves pass by a small obstacle, what happens to the straight waves if the obstacle is (a) very small compared with the wavelength of the waves? (b) about the same size as the wavelength? (c) very large compared with the wavelength?
5. Describe at least three examples of situations you encounter on a daily basis that involve diffraction of waves of one sort or another. These might involve water waves, sound or light.

Diffraction of Light Waves: The photographs below illustrate diffraction of red light of a single wavelength, from a helium-neon laser. In the top photograph, a laser beam was spread out using a concave lens, and the beam of light was allowed to cast a shadow of a small pinhead directly on photographic film. The photograph was taken in a dark room, with the lens removed from a camera so that light shone directly on the film when the shutter was opened. The bottom photograph was taken in a similar fashion, except that a simple sheet of film was used as a screen upon which to cast a shadow of a razor blade. No camera was involved. (A totally dark room must be used, of course.)



t from a laser is diffracted as it passes by the head of a pin.



The shadow of a razor blade in red laser light shows evidence of diffraction of light.

Part 5 Refraction of Water Waves

(a) The Effect of Water Depth on Wave Speed

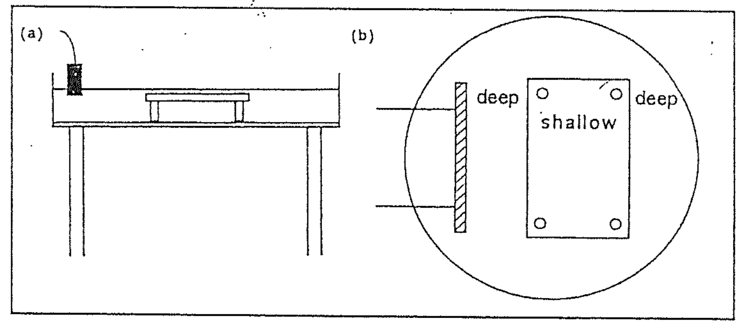


Figure 9.13

Procedure (Sketch what you observe.)

1. To observe the effect of water depth on wave speed, you must arrange the ripple tank so that there is a region of deep water and also a region of shallow water over which water waves can pass. To do this, a rectangular sheet of transparent plastic is mounted in the tank using coins or washers to prop it up. Water is added to the tank until the level is approximately 1-2 mm above the top of the plastic sheet. **Figure 9.13** illustrates side and top views. The straight wave generator is used to provide the waves.

2. Generate continuous waves with the straight wave generator. Observe the wavelength of the waves in the deep water, and compare this with the wavelength in shallow water. What happens when the waves re-enter the deep water? Measure the wavelengths in deep and shallow water and record them.

> You will recall that wave speed, wavelength and frequency are related by $v = \lambda f$. The frequency f is determined by the rate of vibration of the wave generator, and *will not change during transmission of the waves.* This means that the wave speed v is proportional to the wavelength λ. If you observe the wavelength changing, this means the wave speed is changing proportionally.

3. Calculate the ratio of the wavelength in shallow water to the wavelength in deep water, and thus calculate the ratio of the wavespeed in shallow water to the wavespeed in deep water.

(b) Refraction of Water Waves

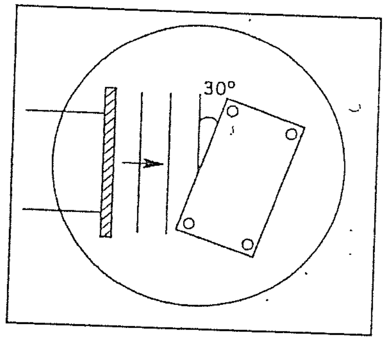


Figure 9.14

Procedure

1. Arrange the 'shallow' water region as in **Figure 9.14**, so that straight waves entering the shallow region meet its edge at an angle such as 30°. Adjust the generator frequency to obtain waves of long wavelength. Observe the waves as they pass into the shallow region.

2. Make the following measurements on the water waves:

   (a) What is the wavelength in the deep water? in the shallow water?
   (b) What is the *ratio* of the wavelength in shallow water to the wavelength in deep water?
   (c) What is the *ratio* of the wave speed in shallow water to the wave speed in deep water? Where does the *change in speed* actually occur?
   (d) What angle does the incident wave make with the boundary between the deep water and the shallow water? (This is the **angle of incidence.**) What angle does the wave inside the shallow water make with the boundary? (This is the **angle of refraction.**)

3. Make a neat sketch illustrating what happens to water waves coming from deep water into shallow water. Show what happens to the waves when they again leave the shallow water.

4. Try different **angles of incidence**, such as 40° and 50°. Measure and record the angles at which the waves leave the boundary (**angles of refraction**).

When waves change direction on entering a different medium, the phenomenon is called **refraction.** Refraction is a very important property in nature, especially as it relates to visible light. In a later chapter you will learn how refraction is involved in the working of optical lenses. Refraction occurs with sound waves, when sound travels through different media, or when it travels through layers of air at different temperatures.

Concluding Questions

1. What happens to the speed of water waves when the waves pass from deeper water into shallower water?

2. You did not actually measure the wave speeds. How did you know the speeds had changed and by how much they had changed?

3. Why can you assume the wave frequency is constant as the waves proceed across the water in your wave tank?

4. When water waves enter shallow water in a direction such that the waves are parallel to the boundary, does the direction of the waves change?

5. When water waves enter shallow water from deep water in such a direction that the waves form an angle greater than 0° with the boundary, does their direction change? If so, in what way does it change? Is the **angle of refraction** greater than, equal to or less than the **angle of incidence**?

6. When water waves leave shallow water and return to deep water, how does their direction change? For the water waves leaving the shallow water, how does the **angle of refraction** compare with the **angle of incidence** for the water waves that were coming into the shallow water in the first place?

Part 6 Interference

You have observed several properties exhibited by water waves. You have seen reflection, diffraction and refraction of waves in a ripple tank. We shall now look at what happens when two waves interact with one another. For example, waves approaching a barrier may encounter waves reflecting from that barrier. What happens when the incoming waves meet the reflected waves? Also, waves from two entirely different sources may encounter each other. What happens when they do? When waves do interact with each other, the phenomenon is called **interference.**

(a) Interference in a Stretched Spring

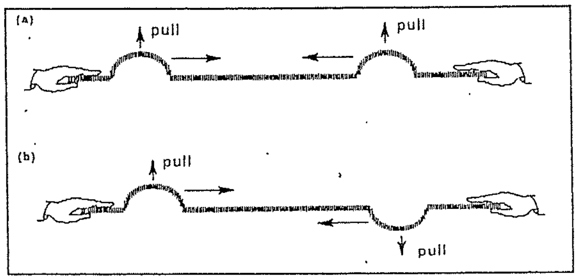


Figure 9.15

Procedure: (Sketch what you observe.)

1. To observe interference of waves in a slinky, hold one end of the slinky yourself and have your partner hold the other end of the stretched spring. Simultaneously, generate **transverse** disturbances in the same direction and with the same amplitude, as in **Figure 9.15(a)**. Observe what happens when the two pulses pass through each other near the centre of the slinky.

2. Repeat **Procedure 1**, but this time generate simultaneous disturbances that have the same magnitude but opposite amplitudes, as in **Figure 9.15(b)**.

Concluding Questions

1. When the two pulses pass through each other such that a crest passes through a crest, as would happen in **Figure 9.15(a)**, what happens to the **amplitude** of the combined waves?

2. When a crest arrives at the same point as a trough, as would happen in **Figure 9.15(b)**, what happens to the amplitude of the combined waves?

(b) Interference in Water Waves

Procedure

1. Set up the arrangement in **Figure 9.16**. Straight waves are generated by the generator, but as they pass through the twin slits, each slit causes **diffraction** and the two sets of circular waves are produced at the slits. Observe how the two sets of circular waves **interfere** with each other.

2. Each source of circular waves sends out successive crests and troughs, and the two sets of waves interfere with one another. Describe what you see on the screen where the **troughs** from one source of waves arrive simultaneously with the **crests** from the other source. What do you see in the areas where crests and troughs from one source arrive simultaneously with crests and troughs from the other source?

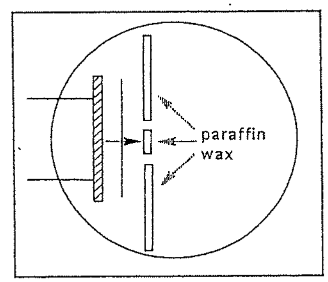


Figure 9.16

3. Replace the two-slit barrier with a twin point-source generator. Set up the twin point-source generator so that both vibrating point sources are **in phase,** which means that they both vibrate up and down in synchronization. (If one point source vibrated upward while the other vibrated downward, they would be **out of phase.**) This arrangement usually gives much better waves than the double slit arrangement.

Concluding Questions

1. When crests from one wave source arrive simultaneously with troughs from another wave source, what will you see on the screen at that point? Why?

2. When crests arrive with crests and troughs with troughs from two different wave sources, what will you see at that spot on the screen? Why?

3. Regions of zero disturbance on the screen appear as nearly straight lines called **nodal lines.** If a point on such a nodal line was a distance of $n\lambda$ from one point source of waves, where λ is the wavelength and n is an integer, how far would the same point be from the other point source? (Is there more than one answer to this question?)

4. Regions of maximum disturbance on the screen, sometimes called **maxima,** occur when the distance from one source is, say, $m\lambda$, where m is an integer and λ is the wavelength. What is the distance to the other source? Is there more than one possible answer? Explain.

CONSTRUCTIVE AND DESTRUCTIVE INTERFERENCE

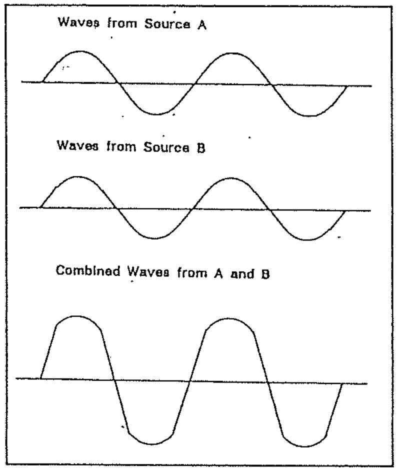


Figure 9.17

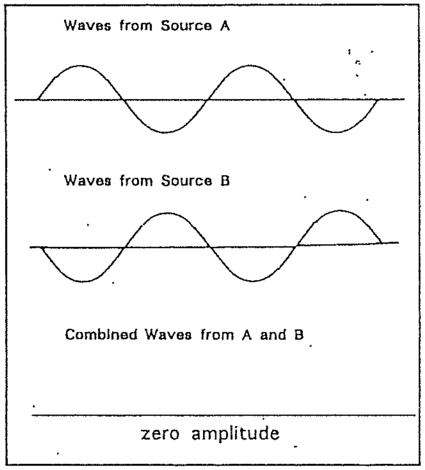


Figure 9.18

Figure 9.17 shows waves coming from two different sources --- A and B. What happens if the two sets of waves arrive simultaneously at the same place? The result is shown in the third diagram. The amplitudes of the two sets of waves are additive. Since the waves from source A are *in phase* with the waves from source B, the resultant waves have *twice* the amplitude of the individual waves from A or B.

This is an example of what is called **constructive interference.** Notice that crests are twice as high and troughs are twice as deep. In a ripple tank, you see **maxima** where there is constructive interference like this.

In **Figure 9.18,** the waves from source A are exactly *out of phase* with the waves from source B. A crest from source A arrives simultaneously with a trough from source B. The two sets of waves exactly cancel each other. This is an example of **destructive interference.** In a ripple tank, you see **nodal lines** where there is destructive interference like this.

Interference of waves occurs with all sorts of waves. You have seen interference of water waves in the ripple tank. You can hear interference of sound waves if you simply listen to a tuning fork as you rotate it slowly near your ear. Each tine of the fork produces a set of sound waves. Listen for constructive interference (extra loud sound) and destructive interference (minimum sound) as you slowly rotate the tuning fork.

OMIT

9.7 YOUNG'S EXPERIMENT

The interference property of waves was first used to measure the wavelength of light by the English scientist **Thomas Young (1773-1829).** Young's interference experiment, done in the year 1801, has great historical importance since it seemed to suggest very strongly that light is a **wave** phenomenon.

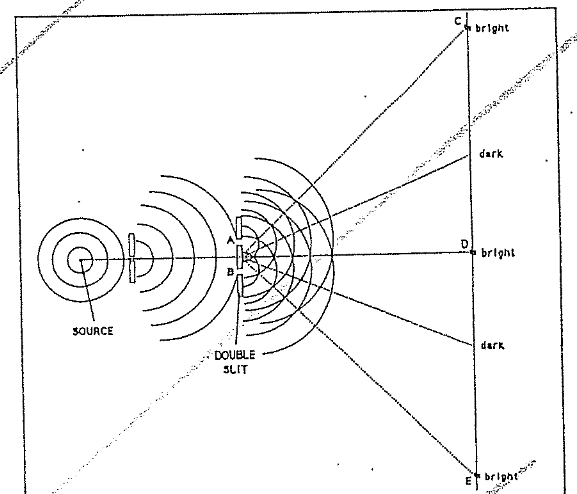


Figure 9.19

Figure 9.19 illustrates how Young's experiment was done. A single slit was illuminated by a source of light of one 'colour' (wavelength). Circular waves spread out from the single slit. When the wavefront hits the double slit, each of these two slits acts as a new source of circular waves which travel toward a vertical screen. On the screen one sees a series of bright and dark bands of light. (A sheet of photographic film can be substituted for the screen.)

The Young's interference experiment can be illustrated very easily now using a classroom laser. The laser automatically produces one single wavelength, and the interference pattern is bright enough to see even in a well lit room.

INTERFERENCE PATTERN IN YOUNG'S EXPERIMENT

In Figure **9.19**, the concentric circles represent successive **peaks** of light waves coming from the slits. **Troughs** are midway between the peaks, of course, and are not shown in the diagram because it becomes too cluttered with detail.

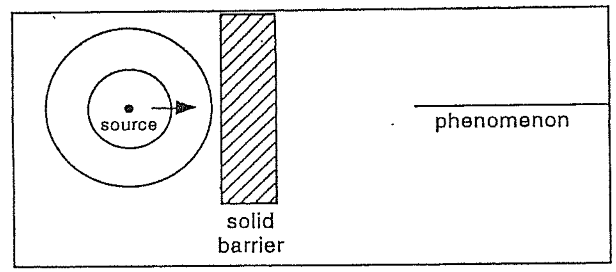
CHAPTER REVIEW QUESTIONS

1. What is the difference between a pulse and periodic waves?
2. Explain, with the help of a sketch, what each of these terms means with respect to waves: (a) crest; (b) trough; (c) wavelength; (d) frequency; (e) amplitude.
3. What is a Hertz?
4. How are frequency and period related?
5. A dog wags its tail 50 times in 20 s. What is (a) the frequency and (b) the period of vibration of the tail?
6. What is the difference between a transverse wave and a longitudinal wave?
7. For any kind of wave motion, how are wave speed, wavelength and frequency related to one another?
8. Alternating current in power lines produces electromagnetic waves of frequency 60 Hz that travel outward at the speed of light, which is 3.0×10^8 m/s. What is the wavelength of these waves?
9. If the speed of sound is 330 m/s, what wavelength does a sound of frequency 512 Hz have?
10. Name at least three properties of light that can be explained adequately with a wave theory.
11. Explain the difference between refraction and diffraction. Give an example of each phenomenon from everyday experience.
12. When waves slow down on entering a new medium, what happens to (a) their wavelength? (b) their frequency? and (c) their direction? Under what conditions will the direction *not* change?
13. What is (a) constructive interference? (b) destructive interference?
14. In a ripple tank, what causes a nodal line? a maximum?
15. Violet light of a single wavelength is made to pass through a pair of slits spaced 0.100 mm apart. On a film 6.0 m away, there are 10 uniformly spaced bright interference bands in a space of 24 cm. What is the wavelength of the violet light? Express your answer in nanometres.

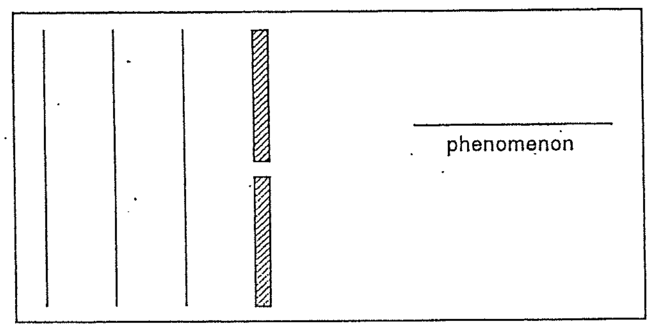
Test Yourself!

(1-2) Please *complete* these diagrams, to show what happens to waves after they encounter the barrier or other obstacle. Also, *name the phenomenon* that occurs in each situation (refraction, diffraction, interference, or reflection).

1.



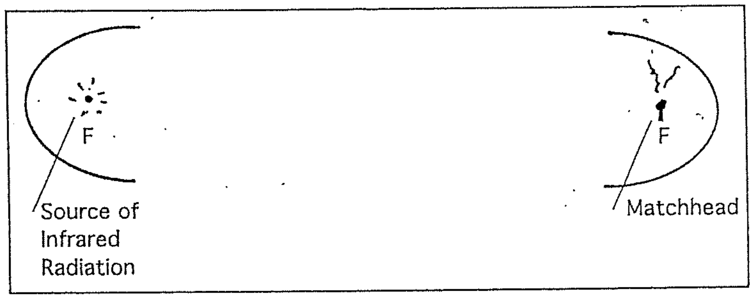
2.

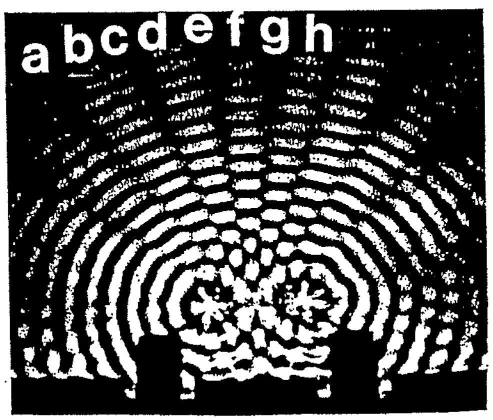


3. An observer counts 36 waves arriving at the shore of a beach, in a time of 3.00 min.
(a) What is the **frequency** of the waves?
(b) What is the **period** of the waves?

4. A small spider, which became lost while looking for its web site, is on the surface of an old phonograph record, which is spinning at 33 rpm (rotations per minute). It is trying to escape by jumping on the needle of the phonograph player. The spider misses the needle on the first try. How long will it have to wait for the next try?

5. The following diagram shows two parabolic reflectors. A small source of infrared heat is placed at the **focus** of one of the mirrors. Soon after, a match at the **focus** of the other reflector lights on fire. Draw a diagram showing how the wave model explains this.





6. (a) What wave property is illustrated by this photograph of water waves?

(b) Imagine the waves were sound waves travelling across an open field from two loudspeakers. What would you **hear** as you walk across the field from left to right? Be specific about what you would hear at positions **a, b, c, d,** etc.

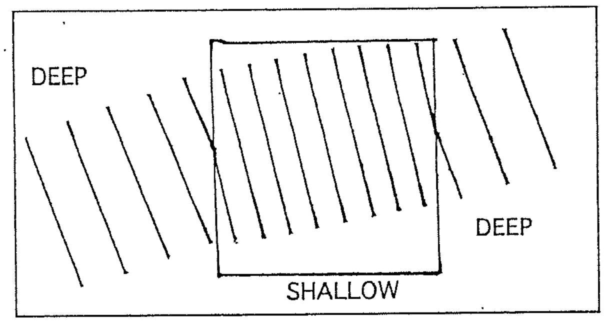
7. At room temperature, sound has a speed of 3.4×10^2 m/s. What is the wavelength of sound from a tuning fork that vibrates at 256 Hz?

8. Light travels with a speed of 3.00×10^8 m/s. What is the frequency of red light, if its wavelength is 610 nm. (1 nm = 1 nanometre = 10^{-9} m)

Multiple Choice Questions

1. If you look at streetlights through a fine mesh curtain, you will see a 'starburst' effect. What phenomenon is involved in this situation?
   A. reflection
   B. refraction
   C. transmission
   D. diffraction

(2-4)



2. The above diagram shows water waves in a wave tank moving from deep water into shallow water, then back into deep water. What property of waves does this model illustrate?
   A. reflection
   B. refraction
   C. diffraction
   D. interference
   E. dispersion

3. What measurable property of the waves does not change as the waves move from one medium into another?
   A. wavelength
   B. frequency
   C. wave speed
   D. direction

4. According to the diagram, what can you conclude happens to the waves when they enter the shallow water?
   A. Wave frequency is reduced by about one half.
   B. Wave frequency is approximately doubled.
   C. Wave speed is approximately doubled.
   D. Wave speed is reduced by about one half.

5. You are leaning against a large, lonely tree in an empty field. You can hear a dog barking on *the other side* of the tree, a hundred metres away. What property of waves makes this possible?
   A. refraction
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CHAPTER REVIEW QUESTIONS

1. What is the difference between a pulse and periodic waves?

2. Explain, with the help of a sketch, what each of these terms means with respect to waves: (a) crest; (b) trough; (c) wavelength; (d) frequency; (e) amplitude.

3. What is a Hertz?

4. How are frequency and period related?

5. A dog wags its tail 50 times in 20 s. What is (a) the frequency and (b) the period of vibration of the tail?

6. What is the difference between a transverse wave and a longitudinal wave?

7. For any kind of wave motion, how are wave speed, wavelength and frequency related to one another?

8. Alternating current in power lines produces electromagnetic waves of frequency 60 Hz that travel outward at the speed of light, which is 3.0×10^8 m/s. What is the wavelength of these waves?

9. If the speed of sound is 330 m/s, what wavelength does a sound of frequency 512 Hz have?

10. Name at least three properties of light that can be explained adequately with a wave theory.

11. Explain the difference between refraction and diffraction. Give an example of each phenomenon from everyday experience.

12. When waves slow down on entering a new medium, what happens to (a) their wavelength? (b) their frequency? and (c) their direction? Under what conditions will the direction *not* change?

13. What is (a) constructive interference? (b) destructive interference?

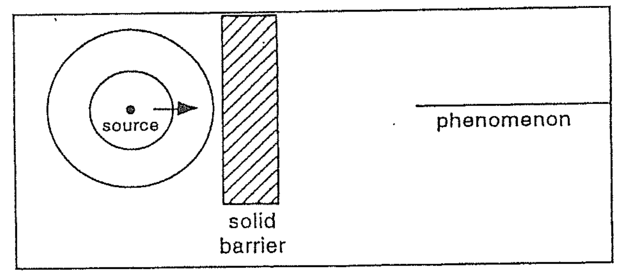
14. In a ripple tank, what causes a nodal line? a maximum?

15. Violet light of a single wavelength is made to pass through a pair of slits spaced 0.100 mm apart. On a film 6.0 m away, there are 10 uniformly spaced bright interference bands in a space of 24 cm. What is the wavelength of the violet light? Express your answer in nanometres.

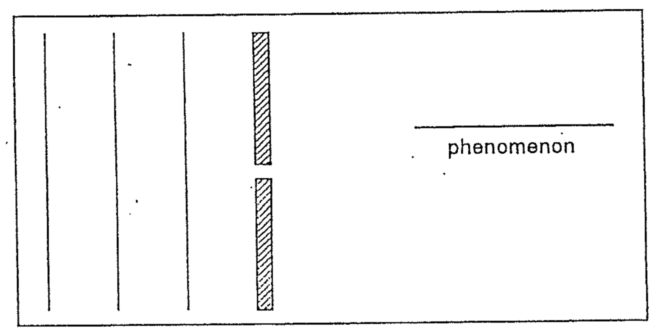
Test Yourself!

(1-2) Please *complete* these diagrams, to show what happens to waves after they encounter the barrier or other obstacle. Also, *name the phenomenon* that occurs in each situation (refraction, diffraction, interference, or reflection).

1.



2.



3. An observer counts 36 waves arriving at the shore of a beach, in a time of 3.00 min.
   (a) What is the **frequency** of the waves?
   (b) What is the **period** of the waves?

4. A small spider, which became lost while looking for its web site, is on the surface of an old phonograph record, which is spinning at 33 rpm (rotations per minute). It is trying to escape by jumping on the needle of the phonograph player. The spider misses the needle on the first try. How long will it have to wait for the next try?

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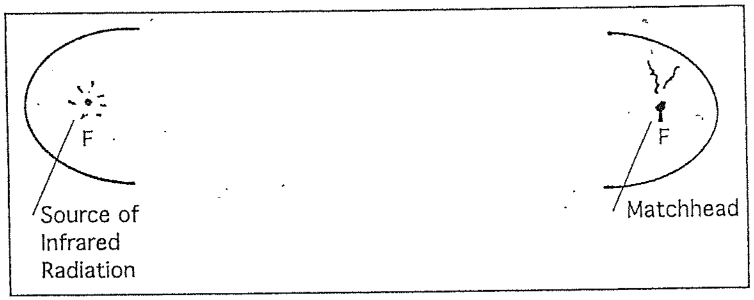

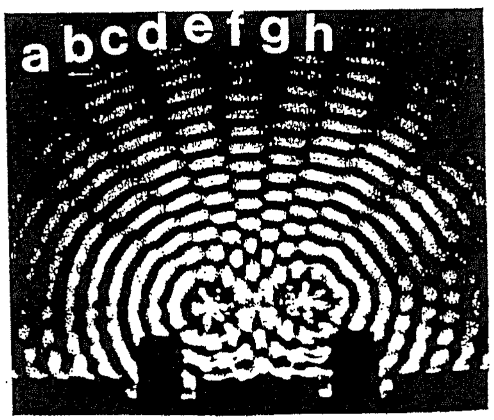

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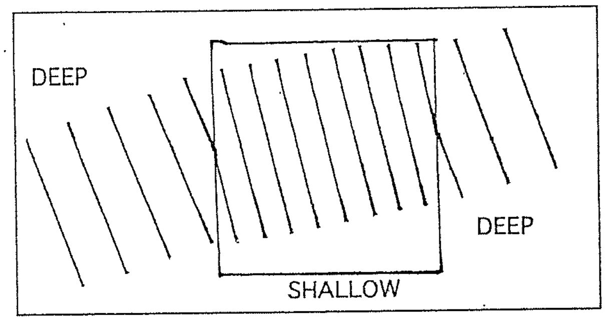

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