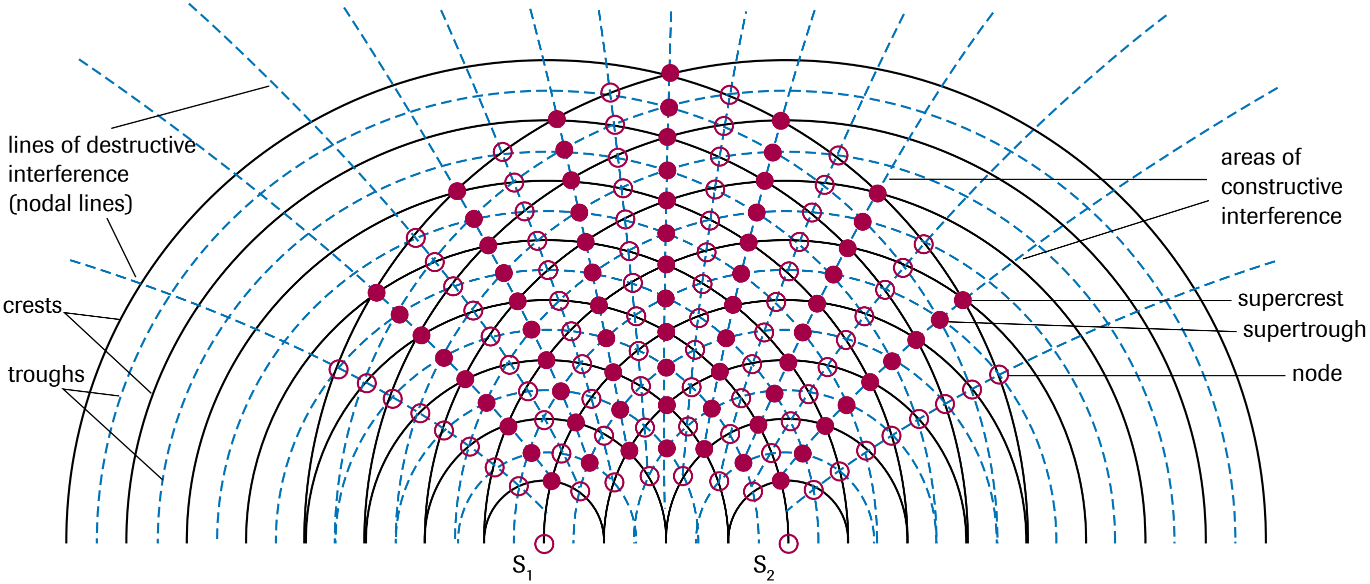
lines of destructive interference (nodal lines)
crests
troughs
areas of constructive interference
supercrest
supertrough
node
S1
S2

SAMPLE problem 2

Two identical point sources 5.0 cm apart, operating in phase at a frequency of 8.0 Hz, generate an interference pattern in a ripple tank. A certain point on the first nodal line is located 10.0 cm from one source and 11.0 cm from the other. What is (a) the wavelength of the waves and (b) the speed of the waves?

Solution

$d = 5.0\text{ cm}$ $\quad PS_2 = 10.0\text{ cm}$ $\quad \lambda = ?$

$f = 8.0\text{ Hz}$ $\quad PS_1 = 11.0\text{ cm}$ $\quad v = ?$

(a)

$$|PS_1 - PS_2| = \left(n - \frac{1}{2}\right)\lambda$$

$$|11.0\text{ cm} - 10.0\text{ cm}| = \left(1 - \frac{1}{2}\right)\lambda$$

$$\lambda = 2.0\text{ cm}$$

The wavelength of the waves is 2.0 cm.

(b)

$$v = f\lambda$$

$$= (8.0\text{ Hz})(2.0\text{ cm})$$

$$v = 16\text{ cm/s}$$

The speed of the waves is 16 cm/s.

Practice

Understanding Concepts

1. Two point sources, S_1 and S_2, oscillating in phase send waves into the air at the same wavelength, 1.98 m. Given that there is a nodal point where the two waves overlap, find the smallest corresponding path length difference.
2. In a ripple tank, a point on the third nodal line from the centre is 35.0 cm from one source and 42.0 cm from another. The sources are 11.2 cm apart and vibrate in phase at 10.5 Hz. Calculate the wavelength and the speed of the waves.
3. An interference pattern is set up by two point sources of the same frequency, vibrating in phase. A point on the second nodal line is 25.0 cm from one source, 29.5 cm from the other. The speed of the waves is 7.5 cm/s. Calculate the wavelength and the frequency of the sources.

Answers

1. 0.99 m
2. 2.80 cm; 29.4 cm/s
3. 3.0 cm; 2.5 Hz

Up to this point, we have discussed two-point-source wave interference in the abstract, with formulas and geometrical diagrams, and have inspected some photographs. However, we have not studied this phenomenon first hand. Investigation 9.3.1 in the Lab Activities section at the end of this chapter provides you with the opportunity to confirm the analysis of two-point-source interference in the lab.

INVESTIGATION 9.3.1

Interference of Waves in Two Dimensions (p. 482)

How can you test our analysis of two-point wave interference? What equipment will you need?

SUMMARY Interference of Waves in Two Dimensions

- A pair of identical point sources operating in phase produces a symmetrical pattern of constructive interference areas and nodal lines. The nodal lines are hyperbolas radiating from between the two sources.
- Increasing the frequency (lowering the wavelength) of the sources increases the number of nodal lines.

- Increasing the separation of the sources increases the number of nodal lines.
- Changing the relative phase of the sources changes the position of the nodal lines but not their number.
- The relationship $\sin\theta_n = \left(n - \frac{1}{2}\right)\frac{\lambda}{d}$, or $\frac{x_n}{L} = \left(n - \frac{1}{2}\right)\frac{\lambda}{d}$, can be used to solve for an unknown in a two-point-source interference pattern.

Section 9.3 Questions

Understanding Concepts

1. List three conditions necessary for a two-point-source interference pattern to remain stable.

2. By how much must path lengths differ if two waves from identical sources are to interfere destructively?

3. What ratio of $\frac{\lambda}{d}$ would produce no nodal line?

4. Explain why the interference pattern between two point sources is difficult to see
(a) if the distance between the sources is large
(b) if the relative phase of the two sources is constantly changing

5. Two point sources, 5.0 cm apart, are operating in phase, with a common frequency of 6.0 Hz, in a ripple tank. A metre stick is placed above the water, parallel to the line joining the sources. The first nodal lines (the ones adjacent to the central axis) cross the metre stick at the 35.0-cm and 55.0-cm marks. Each of the crossing points is 50.0 cm from the midpoint of the line joining the two sources. Draw a diagram of the tank, and then calculate the wavelength and speed of the waves.

6. Two sources of waves are in phase and produce identical waves. These sources are mounted at the corners of a square. At the centre of the square, waves from the sources produce constructive interference, no matter which two corners of the square are occupied by the sources. Explain why, using a diagram.

7. In a large water tank experiment, water waves are generated with straight, parallel wave fronts, 3.00 m apart. The wave fronts pass through two openings 5.00 m apart in a long board. The end of the tank is 3.00 m beyond the board. Where would you stand, relative to the perpendicular bisector of the line between the openings, if you want to receive little or no wave action?

8. A page in a student's notebook lists the following information, obtained from a ripple tank experiment with two point sources operating in phase: $n = 3$, $x_3 = 35$ cm, $L = 77$ cm, $d = 6.0$ cm, $\theta_3 = 25°$, and 5 crests $= 4.2$ cm. Calculate the wavelength of the waves using three methods.

9. Two very small, identical speakers, each radiating sound uniformly in all directions, are placed at points S_1 and S_2 as in **Figure 8**. The speakers are connected to an audio source in such a way that they radiate in phase, at the common wavelength of 2.00 m. Sound propagates in air at 338 m/s.
(a) Calculate the frequency of the sound.
(b) Point M, a nodal point, is 7.0 m from S_1 and more than 7.0 m from S_2. Find three possible distances M could be from S_2.
(c) Point N, also a nodal point, is 12.0 m from S_1 and 5.0 m from S_2. On which nodal line is N located?

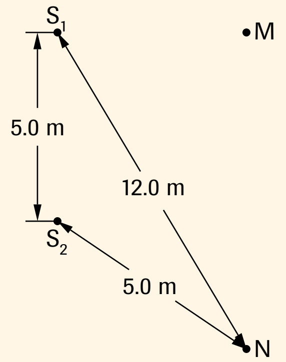

Figure 8

Applying Inquiry Skills

10. We have said that waves in a ripple tank are a "reasonable approximation" to true transverse waves.
(a) Research the Internet or other sources and report on how the behaviour of a particle in a water wave does not exhibit strict transverse wave characteristics.

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(b) When water waves enter very shallow water, for example as they approach a beach, they not only slow down but also curl and "break." Explain this behaviour using the information you obtained in (a).
(c) If water waves are not true transverse waves, how can we justify using them to discover the properties of transverse waves?

Making Connections

11. Two towers of a radio station are 4.00×10^2 m apart along an east–west line. The towers act essentially as point sources, radiating in phase at a frequency of 1.00×10^6 Hz. Radio waves travel at 3.00×10^8 m/s.
(a) In which directions is the intensity of the radio signal at a maximum for listeners 20.0 km north of the transmitter (but not necessarily directly north of it)?
(b) In which directions would you find the intensity at a minimum, north of the transmitter, if the towers were to start transmitting in opposite phase?