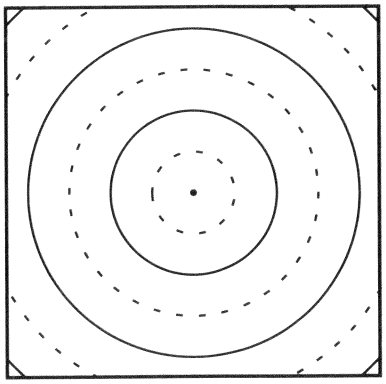
I. Periodic circular waves: single source

The circles at right represent wavefronts of a periodic circular wave in a portion of a ripple tank. The dark circles represent crests; the dashed circles, troughs. The diagram shows the locations of the wavefronts at one instant in time, as a photograph would.



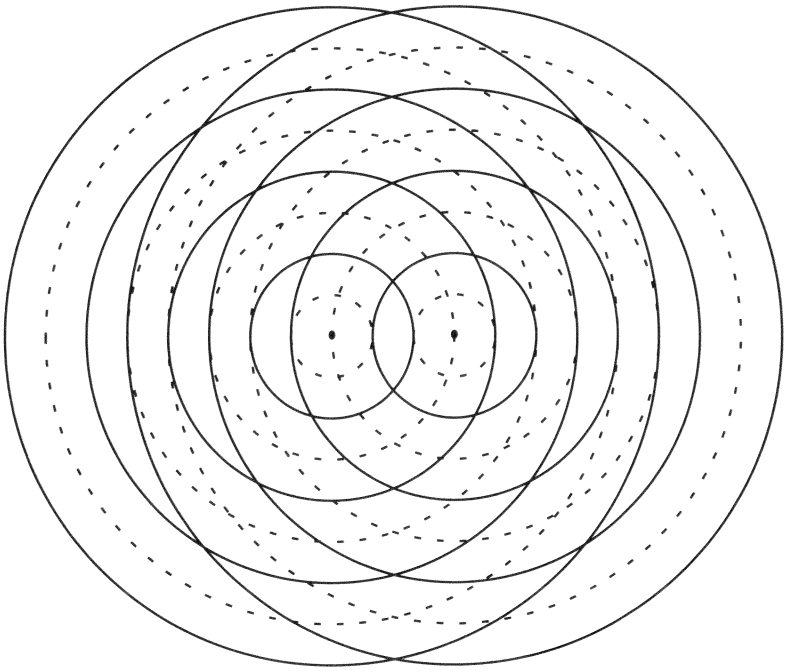
How, if at all, would the diagram differ:

- one-quarter period later? Explain.

- one period later? Explain.

II. Periodic circular waves: two sources

A. The diagram at right illustrates the wavefronts due to each of two small sources.



How do the frequencies of the two sources compare? Explain how you can tell from the diagram.

Are the two sources in phase or out of phase with respect to each other? Explain how you can tell from the diagram.

What is the source separation? Express your answer in terms of the wavelength.

B. Describe what happens at a point on the surface of the water where:

- a crest meets a crest
- a trough meets a trough
- a crest meets a trough

For each of the above cases, describe how your answer would differ if the amplitudes of the two waves were *not* equal. Explain your reasoning.

If the waves from two identical sources travel different distances to reach a particular point, the amplitudes of the waves from the two sources will not be the same at that point. For points that are sufficiently far from the sources, however, the difference in the amplitudes of the waves is small. For the remainder of this tutorial, we will *ignore* any such amplitude variations.

C. You have been provided a larger version of the diagram of the wavefronts due to two sources.

Use different symbols (or different colors) to mark the places at which *for the instant shown:*

- the displacement of the water surface is zero (*i.e.*, at its equilibrium level)
- the displacement of the water surface is the greatest above equilibrium
- the displacement of the water surface is the greatest below equilibrium

(*Hint:* Look for patterns that will help you identify these points.)

What patterns do you notice? Sketch the patterns on the diagram in part A.

D. The representation that we have been using indicates the shape of the water surface at one particular instant in time.

Consider a point on your diagram where a crest meets a crest.

How would the displacement of the water surface at this point change over time? (*e.g.*, What would the displacement be one-quarter period later? What would it be one-half period later?)

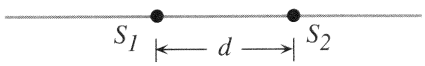
Consider what happens at a point on your diagram where a crest meets a trough.

How will the displacement of the water surface at this point change over time?

TWO-SOURCE INTERFERENCE

Name _____

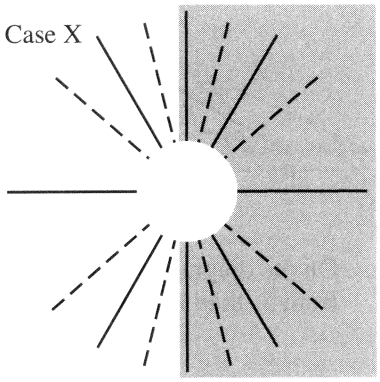
1. The top view diagram at right illustrates two point sources, S_1 and S_2.

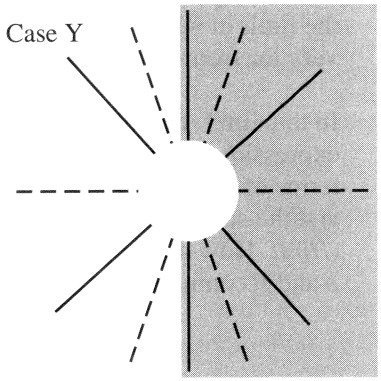


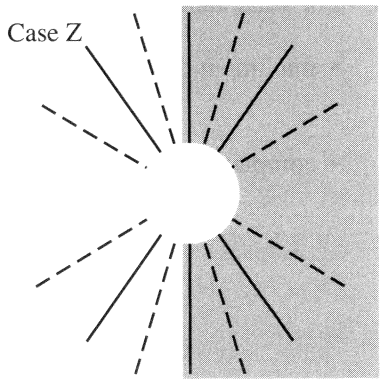
   a. On the diagram, indicate points for which the value of ΔD is (i) largest and (ii) smallest. (ΔD is the difference in distances to the sources.)

   b. What are the largest and smallest values of ΔD for this situation? Explain your reasoning.

2. Each of the diagrams at right shows all the nodal lines (dashed) and all the lines of maximum constructive interference (solid) due to two point sources. The wavelength, λ, is the same in all three cases; the source separation is different. (The sources, which are not shown, lie along a horizontal line.)





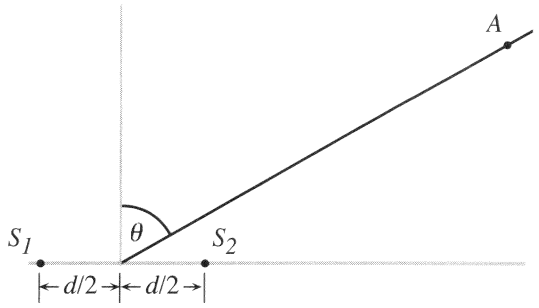


   a. Label each nodal line and line of maximum constructive interference in the shaded region with the appropriate value of ΔD (in terms of λ).

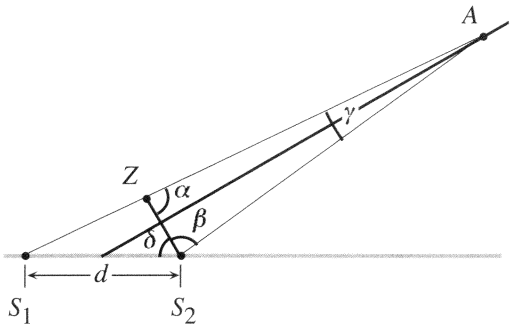
   b. For each case, determine the source separation (in terms of λ). For any case(s) for which it is not possible to determine the source separation *exactly*, determine the source separation as closely as you can, *i.e.*, give the smallest range into which the source separation must fall. (*Hint:* You may find it helpful to first rank the cases by source separation.)

      Explain how you determined the source separations.

3. The diagram at right shows an arbitrary point, point *A*, that lies near two point sources of waves. In this problem, we consider how the phase difference at point *A* changes as point *A* is moved outward along the dark line, away from the sources.



Point *Z* on the diagram below is the same distance from point *A* as is the source S_2.



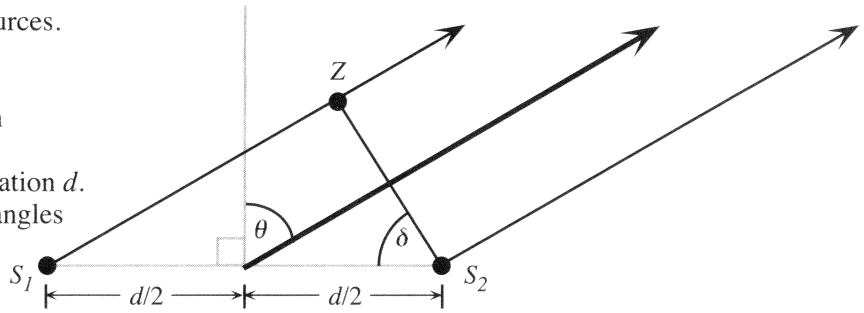
a. How do the angles α and β compare? Explain.

b. Suppose that point *A* is moved away from the sources along the dark line. In the limit that point *A* is very far from the sources, what values do the angles α, β, and γ approach?

c. On the diagram above, indicate the line segment that represents how much farther point *A* is from S_1 than it is from S_2. Label this distance ΔD.

d. The enlarged diagram at right illustrates the limit in which point *A* is moved very far from the sources.

In this limit, find an expression for ΔD in terms of the angle θ and the source separation *d*. (*Hint:* How do the angles δ and θ compare?)



e. For what values of ΔD (in terms of λ) will there be:

- maximum constructive interference?

- complete destructive interference (*i.e.*, a node)?