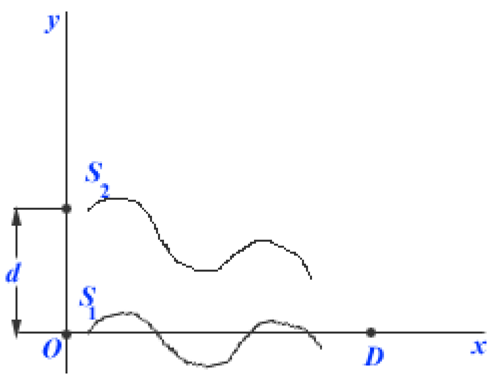
634.

<u>Problem 45.23 (RHK)</u>

As shown in the figure, S_1 *and* S_2 *are effective point sources of radiation, excited by the same oscillator. They are coherent and in phase with each other. Placed a distance* $d = 4.00\ \text{m}$ *apart, they emit equal amount of power in the form of* $1.00-\text{m}$ *wavelength electromagnetic waves.* (a) *We have to find the positions of the first* (*that is, the nearest*), *the second, and the third maxima of the received signal, as the detector D is moved out along Ox. We have to answer whether the intensity at the nearest minimum will be zero and give justification.*



<u>Solution:</u>

Let the distance of the detector *D*, which is moved along the *x-axis,* from the source S_1 be x_D. As the source S_2 is at a distance *d* from S_1, as shown in the figure, the distance from it to the detector *D* will be $\sqrt{x_D^2 + d^2}$. As the two sources emit equal amount of radiations are coherent, the phase difference between the waves reaching at D from S_2 and S_1 will be

$$\phi = \frac{2\pi}{\lambda}\left(\sqrt{x_D^2 + d^2} - x_D\right).$$

The intensity maxima at the detector will occur at locations where

$$\phi = 2m\pi, \; m = 0, \pm 1, \pm 2, \pm 3, ...$$

Therefore, three maxima will be at

$$\phi = 2\pi,$$
$$\phi = 4\pi,$$
$$\phi = 6\pi.$$

We solve these equations algebraically, and note that the first, second, and the third maxima will occur when detector *D* is at locations given below.

$$(x_D)_1 = \frac{d^2 - \lambda^2}{2\lambda},$$

$$(x_D)_2 = \frac{d^2 - 4\lambda^2}{4\lambda},$$

and

$$(x_D)_3 = \frac{d^2 - 9\lambda^2}{6\lambda}.$$

Substituting the values

$d = 4.00 \text{ m},$

and

$\lambda = 1.00 \text{ m}$, we find that the nearest maximum

corresponds to $\phi = 6\pi$, and

$x_D = 1.16 \text{ m}.$

The next one corresponds to $\phi = 4\pi$, and

$x_D = 3.0 \text{ m},$

And the third one corresponds to $\phi = 2\pi$, and

$x_D = 7.5 \text{ m}.$

Note for phase difference $\phi = 8\pi$, there is no interference as the detector will be on top of the source S_1.

(b)

As the intensity varies as the inverse of square of the distance from the source, at the first minimum the amplitude of the wave from the source S_2 and the amplitude of the wave from the source S_1 will not be equal and hence the intensity at the first minimum will not be zero.