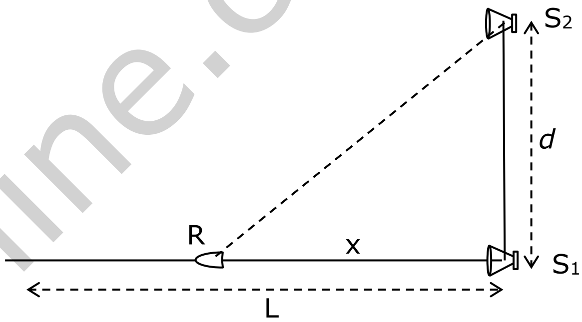
Q- Two speakers are driven by the same oscillator with frequency *f*. They are located a distance *d* from each other on a vertical pole. A receiver initially at a distance L moves straight toward the pole along the horizontal line through lower speaker. (a) How many times it records minimum intensity of sound? How far is it from the pole when he get minimum intensity? Let v represent the speed of sound, and assume that the ground does not reflect sound.

Answer:

As the same oscillator drives the speakers, the two waves are emitted in the same phase but there will be a phase difference at the point of receiver because of the path difference. When the receiver is at a horizontal distance x from the lower speaker the path travelled by the wave is

$S_1 R = x$



but the path travelled by the sound from the upper speaker will be

$S_2 R = \sqrt{d^2 + x^2}$

Hence the path difference for the two waves for point R is

$$\Delta l = \sqrt{d^2 + x^2} - x$$

For the intensity of sound at R to be the minimum, this phase difference must be an odd multiple of $\lambda/2$ i.e. $\lambda/2$, $3\lambda/2$, $5\lambda/2$, $7\lambda/2$ --------- $(2n - 1)\lambda/2$.

(a)

Thus if the number of minima received is N then

$$N\,\frac{\lambda}{2} = L$$

Or $N = \frac{2L}{\lambda} = \frac{2Lf}{c}$ $(c = f * \lambda)$

(in case if N is not integer, we have to take only integer value leaving the decimal part)

(b)

At a large distance from the speakers ($x \gg d$) the two waves are in phase and the path difference is nearly equal to zero. As we move towards the sources (x decreases) the path difference increases and at some point, it is $\lambda/2$. This will be the first order minima. Moving further the cross one by one maxima and minima and the first minima in just in the range (x is just less than L) will be the minima of r^{th} order than we have

$\sqrt{d^2 + x_1^2} - x_1 = (2r - 1)\frac{\lambda}{2}$ (r = 1, 2, 3, -----)

Or $\sqrt{d^2 + x_1^2} - x_1 = (2r - 1)\frac{C}{2f}$

From this equation we can adjust the value of x slightly less than L to find the value of r numerically

The next minima will be

Or $\sqrt{d^2 + x_2^2} = x_2 + (2r + 1)\frac{C}{2f}$

and $\sqrt{d^2 + x_3^2} = x_3 + (2r + 3)\frac{C}{2f}$

Using these equations, we can calculate the positions of minima $x_1,\ x_2,\ x_3, \dots x_N$ till x is less than L.