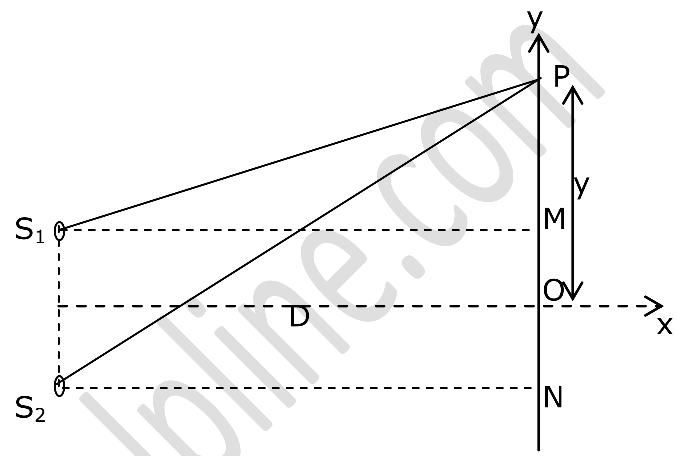
Q- Two in-phase loudspeakers are located at (x, y) coordinates (-2.5 m, +2.0 m) and (-2.5 m, -2.0 m). They emit identical sound waves with a 1.6 m wavelength and amplitude a. Determine the amplitude A of the sound at the five positions on the y-axis (x = 0) with the y values 0, 0.5 m, 1.0 m, 2.0 m.

The distance between the two sources $d = 2.0 - (-2.0) = 4.0$ m
Distance of the y axis from the line S_1S_2 $D = 0 - (-2.5) = 2.5$ m
The wavelength of sound $\lambda = 1.6$ m

Consider a point P at a distance y from the centerline x axis. Using the Pythagoras theorem the path S_1P and S_2P is given by



$$S_1P = \sqrt{PM^2 + S_1M^2}$$

Or $$S_1P = \sqrt{(y-2.0)^2 + D^2}$$

And $$S_2P = \sqrt{PN^2 + S_2N^2}$$

Or $$S_2P = \sqrt{(y+2.0)^2 + D^2}$$

Hence the path difference at P will be

$$S_2P - S_1P = \sqrt{(y+2.0)^2 + D^2} - \sqrt{(y-2.0)^2 + D^2}$$

Or $$\delta = \sqrt{(y+2.0)^2 + 2.5^2} - \sqrt{(y-2.0)^2 + 2.5^2}$$

As the two sources are in phase the phase difference between the waves at P is only due to path difference and hence is given by

$$\phi = \frac{2\pi * \delta}{\lambda}$$

Or $$\phi = \frac{2\pi\left[\sqrt{(y+2.0)^2 + 2.5^2} - \sqrt{(y-2.0)^2 + 2.5^2}\right]}{\lambda} \text{ radians}$$

Or $$\phi = \frac{360^0\left[\sqrt{(y+2.0)^2 + 2.5^2} - \sqrt{(y-2.0)^2 + 2.5^2}\right]}{1.6} \text{ degrees}$$

Now for the different points on the y axis substituting the values of y we have

(1) at y = 0

$$\phi = \frac{360^0\left[\sqrt{(0+2.0)^2 + 2.5^2} - \sqrt{(0-2.0)^2 + 2.5^2}\right]}{1.6} = 0^0$$

And hence resulting amplitude A is given by

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1 A_2 \cos\phi}$$

Or $$A = \sqrt{a^2 + a^2 + 2.a.a.\cos 0^0} = 2.a$$

Hence y = 0 ; A = 2a

(2) at y = 0.5

$$\phi = \frac{360^0\left[\sqrt{(0.5+2.0)^2+2.5^2}-\sqrt{(0.5-2.0)^2+2.5^2}\right]}{1.6} = \frac{360^0[3.535-2.915]}{1.6} = 139.5^0$$

And hence resulting amplitude A is given by

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1 A_2 \cos\phi}$$

Or $$A = \sqrt{a^2 + a^2 + 2.a.a.\cos 139.5^0} = 0.69.a$$

Hence y = 0.5; A = 0.69 a

(3) At y = 1.0

$$\phi = \frac{360^0\left[\sqrt{(1.0+2.0)^2+2.5^2}-\sqrt{(1.0-2.0)^2+2.5^2}\right]}{1.6} = \frac{360^0[3.905-2.692]}{1.6} = 272.9^0$$

And hence resulting amplitude A is given by

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1 A_2 \cos\phi}$$

Or $$A = \sqrt{a^2 + a^2 + 2.a.a.\cos 272.9^0} = 1.45.a$$

Hence y = 1.0; A = 1.45 a

(4) at y = 2.0

$$\phi = \frac{360^0\left[\sqrt{(2.0+2.0)^2+2.5^2}-\sqrt{(2.0-2.0)^2+2.5^2}\right]}{1.6} = \frac{360^0[4.72-2.5]}{1.6} = 498.8^0$$

And hence resulting amplitude A is given by

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1 A_2 \cos\phi}$$

Or $$A = \sqrt{a^2 + a^2 + 2.a.a.\cos 498.8^0} = 0.703.a$$

Hence y = 2.0 ; A = 0.703 a