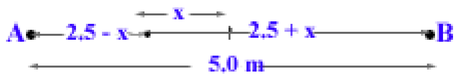
148.

Problem 20.33 (RHK)

Two sources of sound are separated by a distance of 5.0 m. *They both emit sound at the same amplitude and frequency,* 300 Hz, *but they are* 180^0 *out of phase. We have to find points along the line connecting them where the sound intensity will be the largest.*

Solution:

The points where the two sound waves interfere constructively will be located symmetrically about the mid-point. We depict this with the following diagram:



Let the equations of wave propagation of waves emitted by sources A and B be

$$y_1 = a\sin\left(kx_1 - \omega t\right),$$

and

$$y_2 = a\sin\left(kx_2 - \omega t + \pi\right),$$

where x_1 is the distance of a point measured from A and y_1 is a wave travelling from the left to the right, and x_2 is the distance of a point measured from B and y_2 is a wave travelling from the right to the left.

Resultant wave is obtained by the superposition of y_1 and y_2. It is

$$y = y_1 + y_2$$

$$= 2a\cos\left(\frac{k\left(x_2 - x_1\right)}{2} + \frac{\pi}{2}\right)\sin\left(\frac{k\left(x_1 + x_2\right)}{2} - \omega t + \frac{\pi}{2}\right).$$

As shown in the diagram if the distances x_1 and x_2 are given in terms of distance from the mid-point between the sources *A* and *B*, we have

$$x_1 = 2.5 - x,\ x_2 = 2.5 + x.$$

And

$$x_2 - x_1 = 2x.$$

Condition for constructive interference will be

$$\frac{2\pi}{\lambda} \times \frac{2x}{2} = \frac{n\pi}{2},\ \text{where } n = 1, 3, 5, \ldots$$

and

$$x = \frac{n\lambda}{4}.$$

Wavelength of the sound waves is

$$\lambda = \frac{343}{300} \text{ m} = 1.143 \text{ m},$$

and

$$\frac{\lambda}{4} = 0.286 \text{ m}.$$

The points along the line joining the two sources where the intensity will be a maximum are symmetrically located about the mid-point at

$$x = \pm 0.286\text{m}, \pm 0.853\text{m}, \pm 1.43\text{m}, \pm 2.0\text{m}.$$