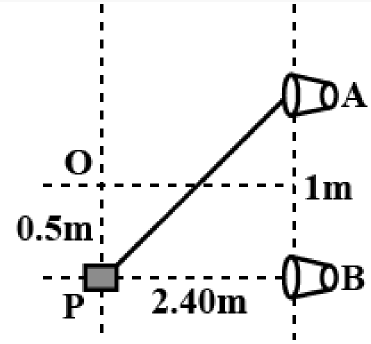
EXERCISES INTERFERENCE & STANDING WAVE

1/ Two speakers A and B are placed 1 m apart, each produces sound waves of frequency 1800 Hz in phase. A detector moving parallel to the line joining the speakers at a distance of 2.4 m away detects a maximum intensity at O and then at P. Find the speed of the sound wave.



Solution

At point O path difference is zero.

At point P path difference, = AP – BP = $\sqrt{1^2 + 2.4^2} - 2.4 = 0.2$ m

Path difference from first bright to second bright equal to λ

Path Difference = λ = 0.2

Velocity, v = λν = 0.2 × 1800 = 360 ms^{-1} $v = \lambda f$ $\lambda = vT = \frac{v}{f}$

Hence, velocity is 360 ms^{-1}.

$AP = \sqrt{1^2 + 2.4^2}$
$= 2.6$

2/ Two identical loudspeakers are placed on a wall 2.00 m apart. A listener stands 3.00 m from the wall directly in front of one of the speakers. A single oscillator is driving the speakers at a frequency of 300 Hz.

(a) What is the phase difference in radians between the waves from the speakers when they reach the observer?

(b) What is the frequency closest to 300 Hz to which the oscillator may be adjusted such that the observer hears minimal sound?

Solution 3.61m

speed of sound in the air: 343 m/s

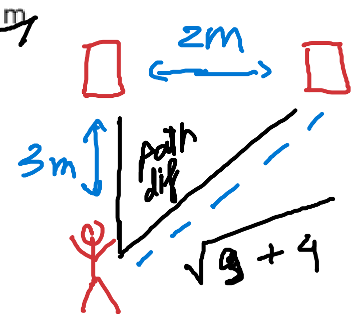
(a) $\Delta x = \sqrt{9.00\ \text{m}^2 + 4.00\ \text{m}^2} - 3.00\ \text{m} = \sqrt{13\ \text{m}^2} - 3.00\ \text{m} = 0.606\ \text{m}$

$\Delta\phi = \frac{2\pi f \Delta x}{v}$

The wavelength is $\lambda = \frac{v}{f} = \frac{343\ \text{m/s}}{300\ \text{Hz}} = 1.14$ m.

Thus, $\frac{\Delta x}{\lambda} = \frac{0.606}{1.14} = 0.530$ of a waves,

or $\Delta\phi = 2\pi(0.530) = \boxed{3.33\ \text{rad}}$.



$= \sqrt{13} \approx 3.61$ m

(b) For destructive interference, we want

$$\frac{\Delta x}{\lambda} = 0.500 \rightarrow \lambda = \frac{\Delta x}{0.500} = 2\Delta x$$

The frequency is $f = \frac{v}{\lambda} = \frac{v}{2\Delta x} = \frac{343\ \text{m/s}}{2(0.606\ \text{m})} = \boxed{283\ \text{Hz}}$.

$\lambda = \frac{v}{f}$

$K = \frac{2\pi}{\lambda}$ $\phi = K\Delta x$

3/ Two identical loudspeakers are driven in phase by a common oscillator at 800 Hz and face each other at a distance of 1.25 m. Locate the points along the line joining the two speakers where relative minima of sound pressure amplitude would be expected.

speed of sound : 343 m/s

Solution

The facing speakers produce a standing wave in the space between them, with the spacing between nodes being

$$d_{NN} = \frac{\lambda}{2} = \frac{v}{2f} = \frac{343 \text{ m/s}}{2\left(800 \text{ s}^{-1}\right)} = 0.214 \text{ m}$$

If the speakers vibrate in phase, the point halfway between them is a antinode of pressure at a distance from either speaker of

$$\frac{1.25 \text{ m}}{2} = 0.625 \text{ m}$$

Then there is a node one-quarter of a wavelength away at

$$0.625 - \frac{0.214}{2} = \boxed{0.518 \text{ m}}$$

from either speaker, after which, there is a node every half-wavelength:

	a node at	$0.518 \text{ m} - 0.214 \text{ m} = \boxed{0.303 \text{ m}}$
	a node at	$0.303 \text{ m} - 0.214 \text{ m} = \boxed{0.089\,1 \text{ m}}$
	a node at	$0.518 \text{ m} + 0.214 \text{ m} = \boxed{0.732 \text{ m}}$
	a node at	$0.732 \text{ m} + 0.214 \text{ m} = \boxed{0.947 \text{ m}}$
and	a node at	$0.947 \text{ m} + 0.214 \text{ m} = \boxed{1.16 \text{ m}}$ from either

speaker.

L m = 0.137kg T

4/ A wire of length 4.35 m and mass 137 g is under a tension of 125 N. A standing wave has formed which has seven nodes including the endpoints. n = 7

a/ What is the frequency of this wave? Which harmonic is it? $x = 7\frac{\lambda}{2}$

b/ What is the fundamental frequency? n = 1

c/ The maximum amplitude at the antinodes is 0.0075 m, write an equation for this standing wave.

A =

$$v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{F}{m/L}} = 63\ m/s$$

Solution

a/

The equations for a string fixed at both ends are $f_n = n\frac{v}{2L}$ and $\lambda_n = \frac{2L}{n}$. Examining the sketch, we see that n = #node - 1 = 6, so that this is the **sixth** harmonic. We are given L, so we need the speed of the wave v to determine f_n. The speed of the wave can be found from the formula $v = \sqrt{F_{tension}/\mu}$, where μ is the linear density given by $\mu = M/L$. Using the given data, the speed may be computed

$$v = \sqrt{\frac{125N}{(0.137kg/4.35m)}} = 63.0\,m/s.$$

Hence $f_6 = 6\frac{(63.0m/s)}{2(4.35m)} = 6 \times 7.24Hz = 43.4Hz.$

$$\frac{63}{2\times 4.35}$$

b/

The fundamental, or $n = 1$, frequency is $f_1 = 7.24$ Hz.

$$f = \frac{n}{2L}\sqrt{\frac{F}{\mu}}$$

$$= \frac{1}{2\times 4.35} \times \sqrt{\frac{125}{0.135/4.33}}$$

$$\approx 7.29\ Hz$$

c/

y $y_n = A_n \sin(\frac{2\pi}{\lambda_n}x)\cos(2\pi f_n t).$]

$$y_6 = 0.0075\sin(4.33x)\cos(273t)$$