PHYSICS

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Problem Solving Class

(Waves)

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P-Q2231

There is a destructive interference between the two waves of wavelength ***l*** coming from two different paths at a point. To get maximum sound or constructive interference at that point, the path of **one** wave is to be increased by

(A) $\frac{\lambda}{4}$ ✓(B) $\frac{\lambda}{2}$

(C) $\frac{3\lambda}{4}$ (D) λ

Destructive inter

$\Delta x = (2n-1)\frac{\lambda}{2}$

Const. inter.

$\Delta x = n\lambda$

$\frac{3\lambda}{2} + \frac{\lambda}{2} = 2\lambda$

$\frac{3\lambda}{2} - \frac{\lambda}{2} = \lambda$

P-Q2231-Solution

Ans [B]

With path difference $\frac{l}{2}$, waves are out of phase at the point of observation.

$$For\ Constructive\ interference\ phase\ difference\ =\ (2n\pi)\ :\ n\ =\ 0,1,2,3, \ldots ..$$

$$For\ destructive\ interference\ phase\ difference\ =\ (n\pi)\ :\ n\ =\ 1,3,5, \ldots ..$$

$$And\ path\ difference\ of \lambda\ =\ phase\ difference\ of\ 2\pi$$

P-Q2232

When two sound waves with a phase difference of $p / 2$, and each having amplitude A and frequency W, are superimposed on each other, then the maximum amplitude and frequency of resultant wave is

(A) $\frac{A}{\sqrt{2}} : \frac{\omega}{2}$

(B) $\frac{A}{\sqrt{2}} : \omega$

(C) $\sqrt{2}\,A : \frac{\omega}{2}$

(D) $\sqrt{2}\,A : \omega$

freq. remains same

$A_{res} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\Delta\phi}$

$= \sqrt{A^2 + A^2 + 2AA\cos\pi/2}$

$= \sqrt{2A^2}$

$A_{res} = \sqrt{2}\,A$

P-Q2232-Solution

Ans [D]

$A_{max} = \sqrt{A^2 + A^2} = A\sqrt{2},$ frequency will remain same *i.e. w.*

$A = \sqrt{{A_1}^2 + {A_2}^2 + 2A_1A_2\cos\phi} : where\ \phi\ is\ phase\ difference.$

P-Q2233

If the phase difference between the two wave is 2*p* during superposition, then the resultant amplitude is

(A) Maximum ✓

(B) Minimum

(C) Maximum or minimum

(D) None of the above

$\Delta\phi = 2\pi$

constructive interference

$\Delta\phi = 2n\pi$

$A_{max} = A_1 + A_2$

$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$

P-Q2233-Solution

Ans [A]

Phase difference is $2p$ means constrictive interference so resultant amplitude will be maximum.

$$For\ Constructive\ interference\ phase\ difference = (2n\pi) : n = 0,1,2,3, \ldots\ldots$$

$$For\ destructive\ interference\ phase\ difference = (n\pi) : n = 1,3,5, \ldots\ldots$$

$$And\ path\ difference\ of \lambda = phase\ difference\ of\ 2\pi$$

P-Question

Two tuning forks A and B give 6 beats per second. A resonates with a closed column of air 15 cm along and B with an open column of air 30.5 cm along in their fundamental harmonics. Their frequencies are.......

✓ **a) $n_A = 366$ Hz, $n_B = 360$ Hz**

b) $n_A = 466$ Hz, $n_B = 460$ Hz

c) $n_A = 566$ Hz, $n_B = 560$ Hz

d) $n_A = 766$ Hz, $n_B = 760$ Hz

$$f_A = \frac{v}{4L} = \frac{v}{60\text{ cm}}$$

$$f_B = \frac{v}{2L} = \frac{v}{61\text{ cm}}$$

$$f_A - f_B = 6$$

$$\frac{v}{60} - \frac{v}{61} = 6$$

$$v\left(\frac{61-60}{60\times 61}\right) = 6$$

$$v = \frac{6\times 60\times 61}{1}$$

$$f_A = \frac{v}{60} = 6\times 61$$

$$= 366$$

P-Solution

Ans [A]

no. of beats

$$\Delta n = n_c - n_o$$

$$6 = \frac{V}{4l_c} - \frac{V}{2l_o}$$

P-Q2234

The superposition takes place between two waves of frequency ***f*** and amplitude ***a***.

The total intensity is directly proportional to

(A) a (B) 2a

(C) $2a^2$ (D) $4a^2$ ✓

$I_1 = I_2 = I_0$

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\Delta\phi$$

$$I_1 = I_0 + I_0 + 2I_0\cos\Delta\phi$$

$$= 2I_0(1+\cos\Delta\phi)$$

$$= 2I_0\left(2\cos^2\frac{\Delta\phi}{2}\right)$$

$$I = 4I_0\cos^2\frac{\Delta\phi}{2}$$

$1+\cos 2\theta = 2\cos^2\theta$

$1+\cos 2\left(\frac{\Delta\phi}{2}\right) = 2\cos^2\frac{\Delta\phi}{2}$

$I \propto a^2$

$I \propto 4a^2$

P-Q2234-Solution

Ans [D]

Resultant amplitude

$$A = \sqrt{a^2 + a^2 + 2aa\cos\phi} = \sqrt{4a^2\cos^2\left(\frac{\phi}{2}\right)}$$

$$\because\ I \propto A^2 \Rightarrow I \propto 4a^2$$

$$A = \sqrt{{A_1}^2 + {A_2}^2 + 2A_1A_2\cos\phi} : where\ \phi\ is\ phase\ difference.$$

$$And\ \ intensity \propto amplitude^2$$

P-Q2235

If two waves of same frequency and same amplitude respectively, on superimposition produced a resultant disturbance of the same amplitude, the waves differ in phase by

(A) π (B) $2\pi/3$

(C) $\pi/2$ (D) Zero

$A_1 = A_2 = A_0$

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\Delta\phi}$$

$$A_0^2 = A_0^2 + A_0^2 + 2A_0^2\cos\Delta\phi$$

$$-A_0^2 = 2A_0^2\cos\Delta\phi$$

$$\cos\Delta\phi = -\frac{1}{2}$$

$$\Delta\phi = 120^\circ = \frac{2\pi}{3}$$

P-Q2235-Solution

Ans [B]

$$A^2 = a^2 = a^2 + a^2 + 2a^2\cos\theta \Rightarrow \cos\theta = -\frac{1}{2} \Rightarrow \theta = \frac{2\pi}{3}$$

$$A = \sqrt{A_1{}^2 + A_2{}^2 + 2A_1A_2\cos\phi} : where\ \phi\ is\ phase\ difference.$$

P-Question

A whistle producing sound waves of frequencies 9500 Hz and above is approaching a stationary person with speed V ms^{-1}. The velocity of sound in air is 300 ms^{-1}. If the person can bear frequencies up to a maximum of 10,000 Hz, the maximum value of v up to which he can hear the whistle is

A) $15\sqrt{2}\,ms^{-1}$ **B)** $\frac{15}{\sqrt{2}}\,ms^{-1}$ **C)** $15ms^{-1}$ **D)** $30ms^{-1}$

$f' = \frac{c}{c - v_s} \cdot f$

$10000 = \frac{300}{300 - v} \times 9500$

$300 - v = 285$

$v = 300 - 285$

$= 15\ m/s$

P-Solution

Ans [C]

$$n^1 = n\left(\frac{V}{V - V_s}\right)$$

$$10000 = 9500\left(\frac{300}{300 - V_s}\right)$$

$$\frac{100}{75} = \frac{300}{300 - V_s}$$

$$300 - V_s = 285$$

$$V_s = 300 - 285$$

$$V_s = 15 m/s$$

P-Q2237

Two waves of same frequency and intensity superimpose with each other in opposite phases, then after superposition the

(A) Intensity increases by 4 times ✗

(B) Intensity increases by two times ✗

(C) Frequency increases by 4 times ✗

✓ (D) None of these

destructive interf.

$I_{min} = 0$

$I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

freq. remains same

P-Q2237-Solution

Ans [D]

This is a case of destructive interference.

P-Question

A closed pipe and an open pipe of same length produce 2 beats, when they are set into vibration simultaneously in their fundamental mode. If the length of the open pipe is halved, and that of closed pipe is doubled, and if they are vibrating in the fundamental mode, then the number of beats produced is

A) 4 **B) 7** **C) 2** **D) 8**

$$f_c = \frac{v}{4L} \; ; \; f_o = \frac{v}{2L}$$

$$f_o - f_c = 2 \Rightarrow \frac{v}{2L} - \frac{v}{4L} = 2$$

$$\frac{v}{4L} = 2 \Rightarrow \frac{v}{L} = 8$$

$$f_o' = \frac{v}{2\left(\frac{L}{2}\right)} = \frac{v}{L} \; ; \; f_c' = \frac{v}{4(2L)} = \frac{v}{8L}$$

$$\text{Beat freq.} = \frac{v}{L} - \frac{v}{8L} = \frac{7v}{8L} = \frac{7}{8} \times 8 = 7$$

P-Solution

Ans [B]

$$\Delta n = \frac{V}{4l_c} - \frac{V}{2l_0} = 2 \qquad here\ l_0 = l_C$$

$$\Delta n^1 = \frac{V}{2\left(\frac{l_0}{2}\right)} - \frac{V}{4(2l_c)} = \frac{7v}{8l} = \frac{7}{2}\left[\frac{v}{4l}\right]$$

$$= \frac{7}{2} \times 2 = 7$$

No . of beats produced =7

P-Q2238

Two waves are propagating to the point P along a straight line produced by two sources A and B of simple harmonic and of equal frequency. The amplitude of every wave at P is ‘a’ and the phase of A is ahead by $\frac{p}{3}$ than that of B and the distance AP is greater than BP by 50 cm. Then the resultant amplitude at the point P will be, if the wavelength is 1 meter

(A) 2a

(B) $a\sqrt{3}$

(C) $a\sqrt{2}$

(D) a

$AP - BP = 50\ cm$

$$\Delta\phi = K\Delta x + \Delta\phi_0$$

$$= \frac{2\pi}{\lambda}.\Delta x + \Delta\phi_0$$

$$= \frac{2\pi}{1} \times \frac{1}{2} + \frac{\pi}{3}$$

$$= \pi + \frac{\pi}{3}$$

$$A = \sqrt{a^2 + a^2 + 2a^2\cos(\pi + \pi/3)}$$

$$= \sqrt{2a^2 + 2a^2\left(-\frac{1}{2}\right)} = \sqrt{a^2}$$

$$= a$$

\

P-Q2238-Solution

Ans [D]

Path difference $(\Delta x) = 50\ cm = \frac{1}{2} m$

$$\frac{Path\ Difference}{Wavelength} = \frac{Phase\ Difference}{2\pi} = \frac{Time\ Difference}{T}$$

Phase difference

$$\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x \Rightarrow \phi = \frac{2\pi}{1} \times \frac{1}{2} = \pi$$

Total phase difference $= \pi - \frac{\pi}{3} = \frac{2\pi}{3}$

$$\Rightarrow A = \sqrt{a^2 + a^2 + 2a^2 \cos(2\pi / 3)} = a$$

$$A = \sqrt{{A_1}^2 + {A_2}^2 + 2A_1A_2\cos\phi} : where\ \phi\ is\ phase\ difference.$$

P-Q2241

Two sound waves (expressed in CGS units) given by

$y_1 = 0.3 \sin \frac{2p}{l}(vt - x)$ and $y_2 = 0.4 \sin \frac{2p}{l}(vt - x + q)$ interfere.

The resultant amplitude at a place where phase difference is $p/2$ will be

(A) 0.7 *cm* (B) 0.1 *cm*

(C) 0.5 *cm* (D) $\frac{1}{10}\sqrt{7}$ *cm*

$a_1 = 0.3$

$a_2 = 0.4$

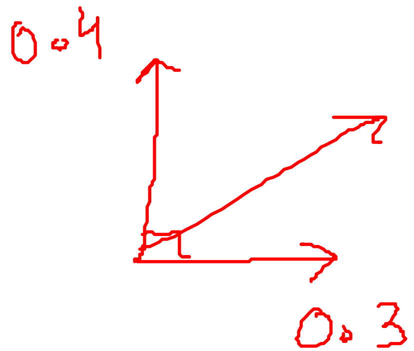
$\Delta\phi = \pi/2$

$A = \sqrt{a_1^2 + a_2^2}$

$= \sqrt{0.09 + 0.16}$

$= \sqrt{0.25}$

$= 0.5$ cm



P-Q2241-Solution

Ans [C]

$$\text{Resultant amplitude} = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$$

$$= \sqrt{0.3^2 + 0.4^2 + 2\times0.3\times0.4\times\cos\frac{\pi}{2}} = 0.5\ cm$$

$A = \sqrt{{A_1}^2 + {A_2}^2 + 2A_1A_2\cos\phi}$: *where* ϕ *is phase difference.*

P-Q2242

If two waves having amplitudes **2A** and **A** and same frequency and velocity, propagate in the same direction in the same phase, the resulting amplitude will be

(A) $3A$ (B) $\sqrt{5}A$

(C) $\sqrt{2}A$ (D) A

$A_{max} = A_1 + A_2$

$= 2A + A$

$= 3A$

P-Q2242-Solution

Ans [A]

In the same phase ∅ = 0 so resultant amplitude = $a_1 + a_2 = 2A + A = 3A$

$A = \sqrt{A_1{}^2 + A_2{}^2 + 2A_1A_2\cos\phi}$: *where* ϕ *is phase difference.*

P-Q2249

The amplitude of a wave represented by displacement equation $y = \frac{1}{\sqrt{a}} \sin \omega t \pm \frac{1}{\sqrt{b}} \cos \omega t$ will be

(A) $\frac{a+b}{ab}$

(B) $\frac{\sqrt{a}+\sqrt{b}}{ab}$

(C) $\frac{\sqrt{a} \pm \sqrt{b}}{ab}$

(D) $\sqrt{\frac{a+b}{ab}}$ ✓

$a_1 = \frac{1}{\sqrt{a}}$

$a_2 = \frac{1}{\sqrt{b}}$

$y_1 = \frac{1}{\sqrt{a}} \sin \omega t$

$y_2 = \frac{1}{\sqrt{b}} \cos \omega t$

$= \frac{1}{\sqrt{b}} \sin(\omega t + \pi/2)$

$A = \sqrt{a_1^2 + a_2^2}$

$= \sqrt{\frac{1}{a} + \frac{1}{b}}$

$= \sqrt{\frac{a+b}{ab}}$

P-Q2249-Solution

Ans [D]

$$y = \frac{1}{\sqrt{a}}\sin \omega t \pm \frac{1}{\sqrt{b}}\sin\left(\omega t + \frac{\pi}{2}\right)$$

Here phase difference is $\frac{\pi}{2}$

The resultant amplitude =

$$\sqrt{\left(\frac{1}{\sqrt{a}}\right)^2 + \left(\frac{1}{\sqrt{b}}\right)^2} = \sqrt{\frac{1}{a} + \frac{1}{b}} = \sqrt{\frac{a+b}{ab}}$$

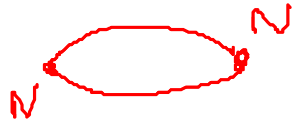
$A = \sqrt{{A_1}^2 + {A_2}^2 + 2A_1A_2\cos\phi}$: *where* ϕ *is phase difference.*

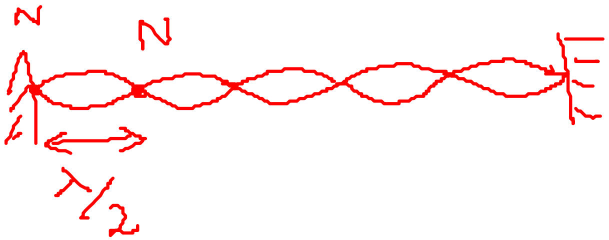
P-Q2251

Standing waves are produced in a 10 *m* long stretched string. If the string vibrates in 5 segments and the wave velocity is 20 *m*/*s*, the frequency is

(A) 2 *Hz* (B) 4 *Hz*

(C) 5 *Hz* (D) 10 *Hz*





$$5\frac{\lambda}{2} = 10$$

$$\lambda = 4\,m$$

$$v = f\lambda$$

$$f = \frac{v}{\lambda} = \frac{20}{4} = 5\,Hz$$

P-Q2251-Solution

Ans [C]

String vibrates in five segment so $\frac{5}{2}\lambda = l \Rightarrow \lambda = \frac{2l}{5}$

Hence $n = \frac{v}{\lambda} = 5 \times \frac{v}{2l} = 5 \times \frac{20}{2 \times 10} = 5 \ Hz$

$v = f\lambda$ and Length of one segment = Node to Node length = $\lambda/2$

P-Q2252

Two similar sonometer wires given fundamental frequencies of 500*Hz*. These have same tensions. By what amount the tension be increased in one wire so that the two wires produce 5 *beats*/*sec*

(A) 1% (B) 2% ✓

(C) 3% (D) 4%

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}} \Rightarrow f \propto T^{1/2}$$

$$T\uparrow, \; f\uparrow$$

$$f' - 500 = 5$$

$$f' = 505$$

$$\frac{\Delta f}{f} = \frac{1}{2}\frac{\Delta T}{T}$$

$$\frac{\Delta f}{f}\times 100 = \frac{1}{2}\left(\frac{\Delta T}{T}\times 100\right)$$

$$\frac{5}{500}\times 100 = \frac{1}{2}\left(\frac{\Delta T}{T}\times 100\right)$$

$$\frac{\Delta T}{T}\times 100 = 2\%$$

P-Q2252-Solution

Ans [B]

To produce 5 *beats/sec.* Frequency of one wire should be increase up to 505 . *i.e*. increment of 1% in basic frequency.

$$n \ \mu \ \sqrt{T}$$

$$T \ \mu \ n^2$$

$$\frac{\mathrm{D}T}{T} = 2\frac{\mathrm{D}n}{n}$$

percentage change in Tension= $2(1\%) = 2\%$

$$v = f\lambda = \sqrt{\frac{T}{\mu}} \propto f \propto \sqrt{T}$$

P-Q2253

A string is producing transverse vibration whose equation is $y = 0.021 \sin(x + 30t)$,
Where *x* and *y* are in meters and is in seconds. If the linear density of the string is 1.3×10^{-4} *kg*/*m*, then the tension in the string in will be

(A) 10 (B) 0.5

(C) 1 (D) 0.117

$y = A \sin(Kx + \omega t)$

μ

$K = 1$

$\omega = 30$

$v = \frac{\omega}{K} = 30\ m/s$

$v = \sqrt{\frac{T}{\mu}}$

$T = \mu v^2 = 1.3 \times 10^{-4} \times 900$

$= 11.7 \times 10^{-2}$

$= 0.117\ N$

P-Q2253-Solution

Ans [D]

$$y = 0.021 \sin(x + 30t)$$

$$v = \frac{w}{k} = \frac{30}{1} = 30\ m/s$$

$$v = \sqrt{\frac{T}{m}} \Rightarrow 30 = \sqrt{\frac{T}{1.3 \times 10^{-4}}} \Rightarrow T = 0.117$$

$$v = f\lambda = (2\pi f)\left(\frac{\lambda}{2\pi}\right) = \frac{\omega}{k} = \sqrt{\frac{T}{\mu}}$$

P-Q2268

If v is the speed of sound in air then the shortest length of the closed pipe which resonates to a frequency n

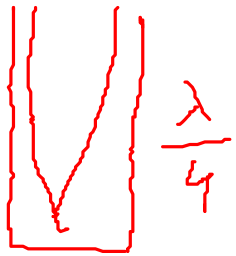
(A) $\frac{v}{4n}$ ✓

(B) $\frac{v}{2n}$

(C) $\frac{2n}{v}$

(D) $\frac{4n}{v}$

$\frac{\lambda}{4} = L$



$v = f\lambda$

$\lambda = vT$

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

$= \frac{v}{n}$

$L = \frac{\lambda}{4} = \frac{v}{4n}$

P-Q2268-Solution

Ans [A]

For shortest length of pipe mode of vibration must be fundamental *i.e.,*

$$n = \frac{v}{4l} \Rightarrow l = \frac{v}{4n}.$$

$$fundamental\ frequency\ or\ First\ harmonic\ (Closed\ pipe) = \frac{v}{4l}$$

P-Q2269

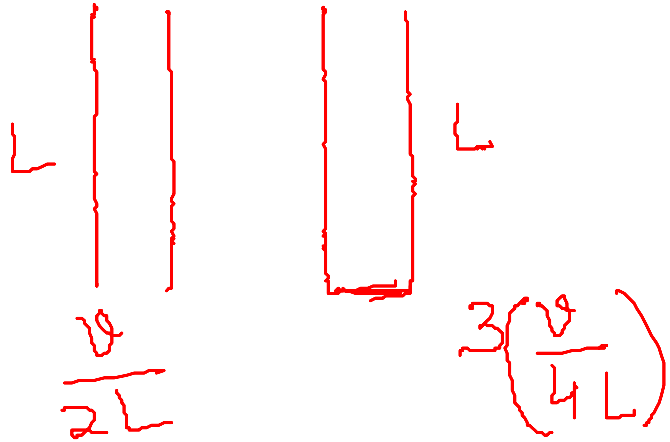
An open pipe is suddenly closed at one end with the result that the frequency of third harmonic of the closed pipe is found to be higher by 100 *Hz*, then the fundamental frequency of open pipe is:

(A) 480 *Hz*

(B) 300 *Hz*

(C) 240 *Hz*

(D) 200 *Hz* ✓



$$\frac{3v}{4L} - \frac{v}{2L} = 100$$

$$\frac{3v - 2v}{4L} = 100$$

$$\frac{v}{4L} = 100$$

$$\Rightarrow \boxed{\frac{v}{2L} = 200\,Hz}$$

P-Q2269-Solution

Ans [D]

Fundamental frequency of open organ pipe $= \dfrac{v}{2l}$

Frequency of third harmonic of closed pipe $= \dfrac{3v}{4l}$

$$\therefore \ \frac{3v}{4l} = 100 + \frac{v}{2l}$$

$$\Rightarrow \ \frac{3v}{4l} - \frac{2v}{4l} = \frac{v}{4l} = 100$$

$$\Rightarrow \ \frac{v}{2l} = 200\ Hz.$$

$$fundamental\ frequency\ or\ First\ harmonic\ (Open\ pipe) = \frac{v}{2l}$$

$$First\ overtone\ or\ third\ harmonic\ (Closed\ pipe) = \frac{3v}{4l}$$