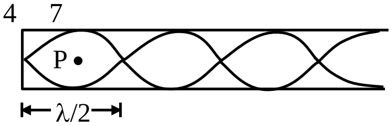
Q.1 A closed organ pipe has length 'ℓ' The air in it is vibrating in 3rd overtone with maximum amplitude 'a'. The amplitude at a distance of $\ell/7$ from closed end of the pipe is equal to–

(A) a (B) a/2

(C) $\frac{a\sqrt{3}}{2}$ (D) zero **[A]**

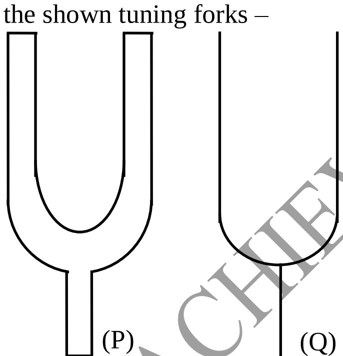
Sol. The figure shows variation of displacement of particles in a closed organ pipe for 3rd overtone. For third overtone $\ell = \frac{7\lambda}{4}$ or $\lambda = \frac{4\ell}{7}$

or $\frac{\lambda}{4} = \frac{\ell}{7}$



Hence the amplitude at P at a distance $\ell/7$ from closed end is 'a' because there is an antinode at that point

Q.2 Which relation is giving the correct information for the shown tuning forks –



(A) $n_P > n_Q$ (B) $n_P < n_Q$
(C) $n_P = n_Q$ (D) None of these
[A]

Sol. $n \propto \frac{t}{\ell^2}$ so $n_P > n_Q$

Q.3 The speed of sound in air at N.T.P is 300 m/s. If pressure of air is increased to four times keeping the temperature constant, the speed of sound will becomes –

(A) 150 m/s (B) 300 m/s
(C) 600 m/s (D) 1200 m/s **[B]**

Sol. Since velocity is independent of pressure so no change

Q.4 In a resonance pipe the first and second resonance are obtained at lengths 22.7 cm and 70.2 cm respectively. What will be the end correction -

(A) 1.05 cm (B) 115.5 cm
(C) 92.5 cm (D) 113.5 cm
[A]

Sol. $e = \frac{\ell_2 - 3\ell_1}{2}$

$e = \frac{70.2 - 3 \times 22.7}{2} = \frac{70.2 - 68.1}{2} = \frac{2.1}{2}$

= 1.05 cm

Q.5 An unknown fork produces 4 beats per second with a tuning fork of frequency 288 Hz. When unknown fork is loaded with wax it again produces 4 beats per second. The unknown frequency of tuning fork is -

(A) 284 Hz (B) 292 Hz
(C) 290 Hz (D) 288 Hz **[B]**

Sol.

Unknown	known	Beats
292 or 284	288	4
284		4

Q.6 A wave of frequency ν = 1000 Hz, propagates at a velocity v = 700 m/sec along x-axis. Phase difference at a given point x during a time interval $\Delta t = 0.5 \times 10^{-3}$ sec is -

(A) π (B) $\pi/2$
(C) $3\pi/2$ (D) 2π **[A]**

Sol. $y = A \sin (kx - \omega t)$

ϕ = phase = $kx - \omega t$

$\phi_1 = kx - \omega t_1$

$\phi_2 = kx - \omega t_2$

Phase : $\Delta\phi = \phi_2 - \phi_1 = \omega(t_1 - t_2)$

difference $\Delta\phi = \phi_2 - \phi_1 = -\omega(t_2 - t_1)$

$\Delta\phi = -\omega\Delta t$

$= -2\pi \times 10^3 \times 0.5 \times 10^{-3}$

$= -2\pi \times \frac{1}{2} = -\pi$

Q.7 Consider a plane standing sound wave of frequency 10^3 Hz in air at 300 K. Suppose the amplitude of pressure variation associated with this wave is 1 dyne/cm^2. The equilibrium pressure is 10^6 dyne/cm^2. The amplitude of displacement of air molecules associated with this wave is :
(Given speed of sound : 340 m/s
Molar mass of air : 29×10^{-3} kg/mol)

(A) 4×10^{-6} m (B) 40×10^{-6} m
(C) 400×10^{-6} m (D) 40000×10^{-6} m

[C]

Sol. $y = A \sin(\omega t - kx)$

$$\Delta P = -B\frac{\partial y}{\partial x} = +BAk\cos(\omega t - kx)$$

$$\Delta P = \Delta P_m \cos(\omega t - kx)$$

$$\Delta P_m = BAk = \frac{BA\omega}{v}$$

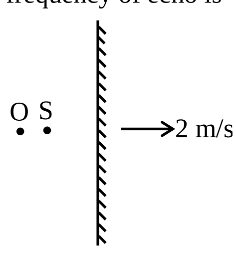
$$A = \frac{\Delta P_m v}{B\omega} = \frac{\Delta P_m v}{\rho v^2 \omega}$$

$$A = \frac{\Delta P_m}{\rho v 2\pi f}$$

$f = 10^3$ Hz
$\Delta P_m = 1$ dyne/m^2
$v = 340$ m/s
$M = 29 \times 10^{-3}$ kg/mole
$T = 300$ K

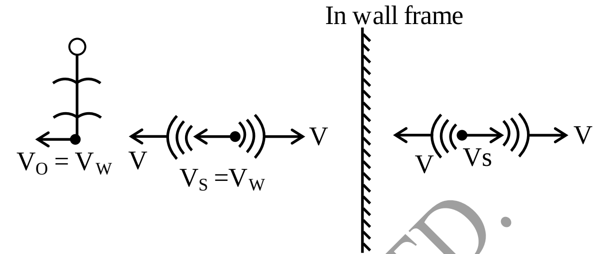
where $\boxed{\rho = \frac{PM}{RT}}$

Q.8 A stationary sound source S of frequency 334 Hz and a stationary observer O are placed near reflecting surface moving away from the source with velocity 2m/s as shown in figure. Velocity of sound waves in air v = 330 m/s. The apparent frequency of echo is –



(A) 332 Hz (B) 326 Hz
(C) 334 Hz (D) 330 Hz

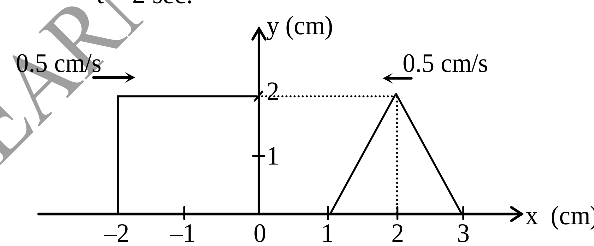
Sol. **[D]**



$$F_{echo} = f_{ac}\left[\frac{V - V_0}{V + V_S}\right] = 334\left[\frac{330 - 2}{330 + 2}\right]$$

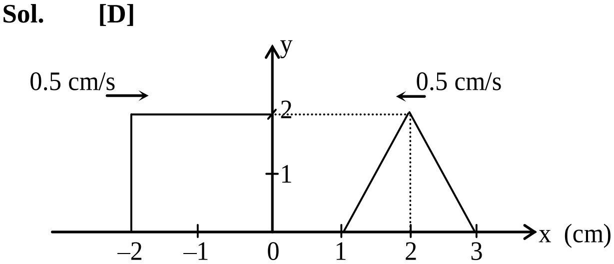
$$= 334 \times \frac{328}{332} = 330 \text{ Hz}$$

Q.9 Figure shows a rectangular pulse and a triangular pulse approaching each other along x-axis. The pulse speed is 0.5 cm/s. What is the resultant displacement of medium particles due to superposition of waves at x = 0.5 cm and t = 2 sec.

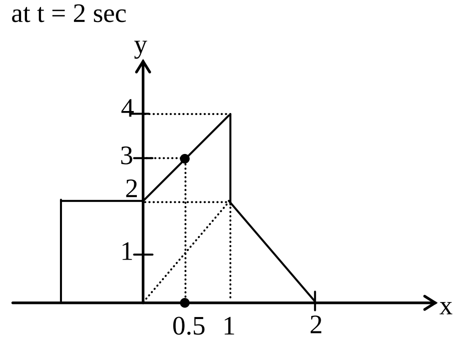


(A) 3.5 cm (B) 2.5 cm
(C) 4 cm (D) 3 cm

Sol. **[D]**



$x_1 = 0.5 \times t = 0.5 \times 2 = 1$cm
$x_2 = 0.5 \times t = 0.5 \times 2 = 1$cm
at t = 2 sec



at x = 0.5 cm, y = 3 cm

Q.10 A sine wave is travelling in a medium. The minimum distance between the two particles, always having same speed, is -

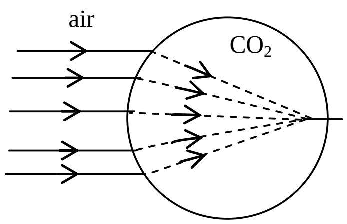
(A) $\lambda/4$ (B) $\lambda/3$
(C) $\lambda/2$ (D) λ **[C]**

Sol. Particle which vibrate in opposite phase having different velocity but having same speed.

Q.11 A balloon filled with CO_2, then for sound wave this will behave as a -

(A) converging lens
(B) diverging lens
(C) both of the above
(D) none of the above **[A]**

Sol.



$V_s = \sqrt{\dfrac{\gamma R T}{M_w}}$

$M_{wco_2} > M_{wair}$

$V_{CO_2} < V_{air}$, velocity of sound decrease when sound propagate from air to CO_2 gas means CO_2 behave as a denser medium So wave bends towards normal, and CO_2 gas balloon behave as converging lens.

Q.12 A big explosion on the moon cannot be heard on the earth because -

(A) the explosion produces high frequency sound waves which are inaudible
(B) sound waves require a material medium for propagation
(C) sound waves are absorbed in the atmosphere of moon
(D) sound waves are absorbed in the earth's atmosphere **[B]**

Sol. As the sound waves are mechanical waves they requires medium for propagation.

Q.13 A boat at anchor is rocked by waves whose crests are 100 m apart and velocity is 25 m/s. The boat bounces up once in every -

(A) 2500 sec (B) 75 sec
(C) 4 sec (D) 0.25 sec **[C]**

Sol. Wavelength $\rightarrow$ Distance between the crests
so $\lambda = 100$ m , $v = 25$ m/sec

$v = n\lambda$

or $25 = n(100)$ $\therefore$ $n = \dfrac{1}{4}$ per sec

$T = \dfrac{1}{n} = 4$ sec

Q.14 A tuning fork and an air column in resonance tube whose temperature is 51°C produces 4 beats in 1 second when sounded together. When the temperature of the air column decreases, the number of beats per second decreases. When the temperature remains 16°C, only 1 beat per second is produced. Then the frequency of the tuning fork is -

(A) 55 Hz
(B) 50 Hz
(C) 68 Hz
(D) none of the above **[B]**

Sol. $v \propto n \propto \sqrt{T}$ because λ = constant

$\dfrac{N+4}{N+1} = \sqrt{\dfrac{324}{289}} = \dfrac{18}{17}$

$17N + 68 = 18N + 18$

$50 = N$

Q.15 A closed organ pipe and an open organ pipe of same length produce four beats in their fundamental mode when sounded together. If length of the open organ pipe is increased, then the number of beats will -

(A) increase (B) decrease
(C) remain constant
(D) may increase or decrease

Sol. **[D]** $n_o - n_c = 4$

where $n_o = \dfrac{V}{2L}$, $n_c = \dfrac{V}{4L}$ so if length of open organ pipe increases its frequency $\downarrow$
so no. of beats also decreases

Q.16 The path difference between the two waves :

$y_1 = a_1 \sin(\omega t - kx)$
and $y_2 = a_2 \cos(\omega t - kx + \phi)$ is -

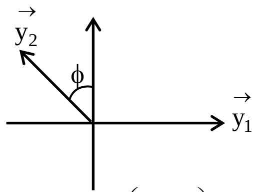
(A) $(\lambda/2\pi)\phi$ (B) $\lambda\left(\dfrac{\phi + (\pi/2)}{2\pi}\right)$

(C) $\dfrac{2\pi}{\lambda}\left(\phi - \dfrac{\pi}{2}\right)$ (D) $\left(\dfrac{2\pi}{\lambda}\right)\phi$ **[B]**

Sol. Relation between phase difference and path difference

$\Delta\phi = \dfrac{2\pi}{\lambda}\Delta x$

$y_1 = a_1 \sin(\omega t - kx)$
$y_2 = a_2 \cos(\omega t - kx + \phi)$
From phasor diagram : -



$$\Delta\phi = \left(\frac{\pi}{2} + \phi\right)$$

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

$$= \frac{1}{2\pi}\left(\frac{\pi}{2} + \phi\right)\lambda$$

Q.17 An observer standing at the seacoast observes 54 waves reaching the coast per minute. If the wavelength of the waves is 10 m, its velocity is -
(A) 90 m/s (B) 90 cm/s
(C) 9 m/s (D) 900 m/s **[C]**

Sol. Frequency of waves $n = \frac{54}{60}$ per second
$\lambda = 10\,m$
$\therefore v = n\lambda$
$= \frac{54}{60} \times 10 = 9$ m/sec.

Q.18 If fundamental frequency of closed pipe is 50 Hz. then frequency of 2^{an} overtone is :
(A) 100 Hz (B) 50 Hz
(C) 250 Hz (D) 150 Hz **[C]**

Q.19 Tube A has both ends open while tube B has one end closed, otherwise they are identical. The ratio of fundamental frequency of tube A and B is :
(A) 1 : 2 (B) 1 : 4
(C) 2 : 1 (D) 4 : 1 **[C]**

Q.20 In one meter long open pipe what is the harmonic of resonance obtained with a tuning fork of frequency 480 Hz
(A) First (B) Second
(C) Third (D) Fourth **[C]**

Q.21 Fundamental frequency of an open pipe of length 0.5 m is equal to the frequency of the first overtone of a closed pipe of length ℓ_c . The value of ℓ_c is (m)
(A) 1.5 (B) 0.75
(C) 2 (D) 1 **[B]**

Q.22 What is the base frequency if a pipe gives notes of frequencies 425, 255 and 595 and decide whether it is closed at one end or open at both ends :
(A) 17, closed (B) 85, closed
(C) 17, open (D) 85, open **[B]**

Q.23 A closed organ pipe and an open organ pipe are tuned to the same fundamental frequency. What is the ratio of lengths :
(A) 1 : 2 (B) 2 : 1
(C) 2 : 3 (D) 4 : 3 **[A]**

Q.24 Consider the three waves z_1, z_2 and z_3 as
$z_1 = A \sin(kx - \omega t)$, $z_2 = A \sin(kx + \omega t)$
and $z_3 = A \sin(ky - \omega t)$. Which of the following represents a standing wave :
(A) $z_1 + z_2$ (B) $z_2 + z_3$
(C) $z_3 + z_1$ (D) $z_1 + z_2 + z_3$ **[A]**

Q.25 An open pipe of length 33 cm resonates with frequency of 100 Hz. If the speed of sound is 330 m/s, then this frequency is :
(A) Fundamental frequency of the pipe
(B) Third harmonic of the pipe
(C) Second harmonic of the pipe
(D) Fourth harmonic of the pipe **[C]**

Q.26 Stationary waves are set up in air column. Velocity of sound in air is 330 m/s and frequency is 165 Hz. Then distance between the nodes is -
(A) 2m (B) 1m (C) 0.5 m (D) 4m

Sol. **[B]** Distance between the nodes = $\lambda/2$
$v = \nu\lambda \Rightarrow \lambda = \frac{330}{165} = 2$
$\therefore$ 1m

Q.27 In open organ pipe, if fundamental frequency is n then the other frequencies are :

(A) n, 2n, 3n, 4n (B) n, 3n, 5n

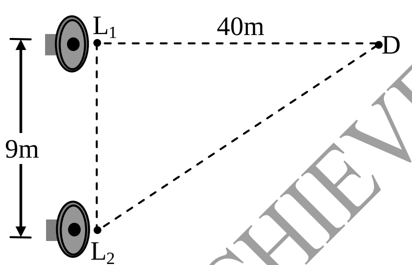
(C) n, 2n, 4n, 8n (D) None of these **[A]**

Q.28 In a resonance pipe the first and second resonances are obtained at depths 22.7 cm and 70.2 cm respectively. What will be the end correction :

(A) 1.05 cm (B) 115.5 cm

(C) 92.5 cm (D) 113.5 cm **[A]**

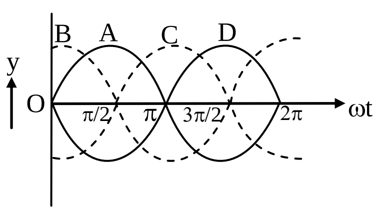
Q.29 Two loudspeakers L_1 and L_2 driven by a common oscillator and amplifier, are arranged as shown. The frequency of the oscillator is gradually increased from zero and the detector at D records a series of maxima and minima. If the speed of sound is 330 ms^{-1} then the frequency at which the first maximum is observed is :



(A) 165 Hz (B) 330 Hz

(C) 496 Hz (D) 660 Hz **[B]**

Q.30 The figure shows four progressive waves A, B, C and D with their phases expressed with respect to the wave A. If can be concluded from the figure that :



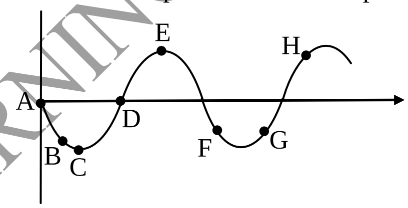
(A) The wave C is ahead by a phase angle of $\pi/2$ and the wave B lags behind by a phase angle of $\pi/2$

(B) The wave C lags behind by a phase angle of $\pi/2$ and the wave B is ahead by a phase angle of $\pi/2$

(C) The wave C is ahead by a phase angle of π and the wave B lags behind by a phase angle of π

(D) The wave C lags behind by a phase angle of π and the B ahead by a phase of π **[B]**

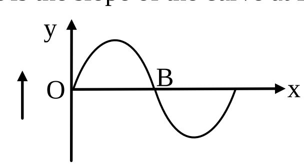
Q.31 The diagram below shows the propagation of a wave. Which points are in same phase :



(A) F, G (B) C and E

(C) B and G (D) B and F **[D]**

Q.32 Fig. below shows the wave $y = A \sin(\omega t - kx)$ at any instant traveling in the +ve x-direction. What is the slope of the curve at B



(A) ω/a (B) k/A

(C) kA (D) ωA **[A]**

Q.33 The absolute temperature of air in a region linearly increases from 0°C to 819°C in a space of width 'd'. Time taken by sound wave to travel through this space is: [Velocity of sound at 0°C is v_0]

(A) $\frac{2d}{\sqrt{5}v}$ (B) $\frac{6d}{v}$

(C) $\frac{2d}{3v}$ (D) None of these **[C]**

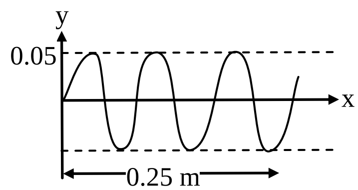
Sol. Velocity of sound at a distance 'x' is given by

$$v(x) = \sqrt{\frac{273 + \frac{x}{d} \times 819}{273}}\,.v$$

$\therefore$ Time taken

$$t = \int_0^d \frac{dx}{v(x)} = \frac{2d}{3v}$$

Q.34 If the speed of the wave shown in the figure is 330 m/s in the given medium, then the equation of the wave propagating in the positive x-direction will be (all quantities are in M.K.S units) :



(A) $y = 0.05 \sin 2\pi(4000t - 12.5x)$

(B) $y = 0.05 \sin 2\pi(4000t - 122.5x)$

(C) $y = 0.05 \sin 2\pi(3300t - 10x)$

(D) $y = 0.05 \sin 2\pi(3300x - 10t)$ **[C]**

Q.35 In a resonance tube the first resonance with a tuning fork occurs at 16 cm and second at 49 cm. If the velocity of sound is 330 m/s, the frequency of tuning fork is :

(A) 500 (B) 300

(C) 330 (D) 165 **[A]**

Q.36 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 **[D]**

Q.37 Velocity of sound in He at certain temperature is 'v_0'. Velocity of sound in N_2 at that temperature will be -

(A) $\frac{\sqrt{3}}{5}\, v_0$ (B) $\frac{\sqrt{3}}{7}\, v_0$

(C) $\frac{1}{\sqrt{7}}\, v_0$ (D) $\sqrt{\frac{3}{7}}\, v_0$ **[A]**

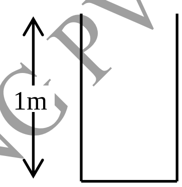
Sol. $\frac{v_2}{v_1} = \sqrt{\frac{\gamma_2}{\gamma_1} \cdot \frac{m_1}{m_2}}$

v_2 = velocity in nitrogen

v_1 = velocity in helium

$\Rightarrow v_2 = \frac{\sqrt{3}}{5}\, v_0$

Q.38 Velocity of sound in air is 320 ms^{-1}. The pipe is shown in figure can not vibrate with a sound of frequency –



(Fig.)

(A) 80 Hz (B) 240 Hz

(C) 320 Hz (D) 400 Hz **[C]**

Sol. Fundamental frequency $n = \frac{v}{4L} = \frac{320}{4 \times 1} = 80$ Hz

frequency which can produces from this pipe is = n, 3n, 5n, 7n ……..

= 80, 240, 400 Hz…….

Q.39 Two closed end pipes when sounded together produce 5 beat per second. If their length are in the ratio 100 : 101, then fundamental notes produced by them are –

(A) 245, 250 (B) 250, 255

(C) 495, 500 (D) 500, 505 **[D]**

Sol. $\frac{N}{N+5} = \frac{100}{101}$

101 N = 100 N + 500

N = 500 Hz

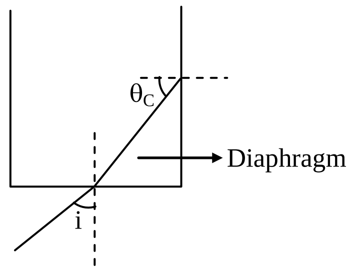
N + 5 = 505 Hz.

Q.40 One end of a thin metal tube is closed by thin diaphragm of latex and the tube is lower in water with closed end downward. The tube is filled with a liquid 'x'. A plane progressive wave inside water hits the diaphragm making an angle 'θ' with its normal. Assuming Snell's law to hold true for sound. Maximum angle 'θ' for which sound is not transmitted through the walls of tube is (velocity of sound in liquid x = $740\sqrt{3}$ m/s and in water = 1480 m/s)

(A) $\sin^{-1}\left(\frac{2}{3}\right)$ (B) $\sin^{-1}\left(\frac{\sqrt{2}}{\sqrt{3}}\right)$

(C) $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (D) $\sin^{-1}\left(\frac{1}{2}\right)$ **[C]**

Sol. Figure shows condition for just transmission of sound wave through the wall of tube.



$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$$

[v_1 = velocity of sound in water
v_2 = velocity of sound in liquid]

$$\Rightarrow \sin i = \frac{1480}{740\sqrt{3}} . \sin(90° - \theta_C)$$

$$\Rightarrow i = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$$

Q.41 A wave is represented by $y = A \sin^2 (kx - \omega t + \phi)$. The amplitude and wavelength of wave is given by -

(A) $2A, \frac{2\pi}{k}$ (B) $A, \frac{2\pi}{k}$

(C) $\frac{A}{2}, \frac{2\pi}{k}$ (D) $\frac{A}{2}, \frac{\pi}{k}$ **[D]**

Sol. $y = A \sin^2 (kx - \omega t + \phi)$ can be rewritten as

$$y = \frac{A}{2} - \frac{A}{2} \cos (2kx - 2\omega t + 2\phi)$$

Q.42 Four waves are represented by $y_1 = A_1 \sin \pi t$, $y_2 = A_2 \sin (\pi t + \pi/2)$, $y_3 = A_1 \sin (2\pi t + \pi/2)$ and $y_4 = A_2 \sin (\pi t - \pi/3)$. Interference will happen with –

(A) y_1, y_2 and y_3 only (B) y_1, y_2 and y_4 only

(C) y_1 and y_3 only (D) y_1, y_2, y_3 and y_4

[D]

Sol. Interference is phenomena of more than one wave reaching at same point in space simultaneously.

Q.43 Intensity and phase of three sound wave reaching at some point in space is I_0, 4 I_0, I_0 and 10°, 130° and 250° respectively. Resultant intensity at that point will be –

(A) 6 I_0 (B) $2I_0$

(C) I_0 (D) $\left(\frac{2+\sqrt{3}}{\sqrt{2}}\right)I_0$ **[C]**

Sol. Amplitude of the three sound wave would be in ratio 1 : 2 : 1. Let amplitude of first wave be A.

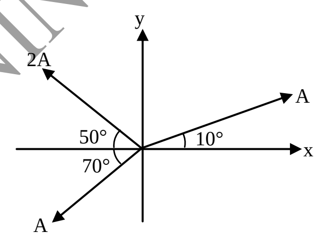


Figure 1

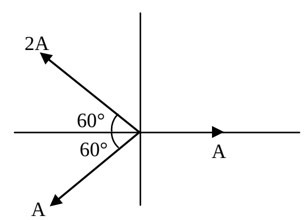


Figure 2

$\therefore$ $A_R = A$
$\Rightarrow$ $I_R \propto A^2$
$\therefore$ $I_R = I_0$

Q.44 The nature of sound waves in gases is-

(A) Transverse
(B) Longitudinal
(C) Transverse and longitudinal
(D) None of these **[B]**

Q.45 Sound waves of wavelength greater than that of audible sound are called-

(A) Seismic waves (B) Sonic waves

(C) Ultrasonic waves (D) Infrasonic waves

[D]

Q.46 The wavelength of ultrasonic waves in air is of the order of-

(A) 5×10^{-5} cm (B) 5×10^{-8} cm

(C) 5×10^{5} cm (D) 5×10^{8} cm **[A]**

Q.47 Two tuning forks A and B are in unison with strings of length 0.96 m and 0.97 m respectively produces 2 beats per half second. The frequency of A and B are in (Hz) –

(A) 384, 388 (B) 384, 386

(C) 388, 384 (D) 388, 386 **[C]**

Sol. For natural frequency of string

$$\nu_n \propto \frac{1}{L}$$

$$\Rightarrow \frac{\nu_A}{\nu_B} = \frac{97}{96} \quad \text{... (i)}$$

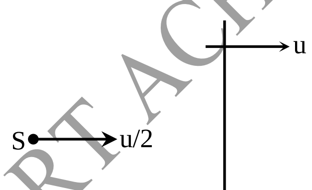
Also, $\nu_A - \nu_B = 4$ ... (ii)

$\because$ Beat frequency = 4

From (i) and (ii),

$\nu_A = 388, \nu_B = 384$

Q.48 A wall is moving with velocity u and a source of sound moves with velocity u/2 in the same direction as shown in the figure. Assuming that the sound travels with velocity 10u. The ratio of incident sound wavelength on the wall to the reflected sound wavelength by the wall, is equal to -



(A) 9 : 11 (B) 11 : 9

(C) 4 : 5 (D) 5 : 4 **[A]**

Sol. λ_i = wavelength of the incident sound

$$= \frac{10u - \frac{u}{2}}{f} = \frac{19u}{2f}$$

f_i = frequency of the incident sound

$$= \frac{10u - u}{10u - \frac{u}{2}} f = \frac{18}{19} f = f = f_r$$ = frequency of the reflected sound

λ_r = wavelength of the reflected sound = $\frac{10u + u}{f_r} = \frac{11u}{18f} \times 19 = \frac{11 \times 19}{18} \cdot \frac{u}{f}$

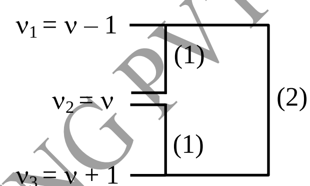
$$\frac{\lambda_i}{\lambda_r} = \frac{19u}{2f} \times \frac{18f}{11 \times 19u} = \frac{9}{11}$$

Q.49 Three sound waves of equal amplitudes have frequencies $(v - 1)$, v, $(v + 1)$. They superpose to give beats. The number of beats produced per second will be –

(A) 4 (B) 3

(C) 2 (D) 1 **[C]**

Sol.



Three sound wave of equal amplitude superpose and produce "2" beats.

Q.50 A point source is emitting sound in all directions. The ratio of distance of two points from the point source where the difference in loudness levels is 3dB, is ($\log_{10} 2 = 0.3$) -

(A) $\frac{1}{2}$ (B) $\frac{1}{\sqrt{2}}$

(C) $\frac{1}{4}$ (D) $\frac{2}{3}$ **[B]**

Sol. $dB = 10 \log \left[\frac{I}{I_0}\right] = 10 \log \left[\frac{K/r^2}{I_0}\right]$

$= 10 [\log (K') - 2 \log r]$

$dB_1 = 10 (\log K' - 2 \log r_1)$

$dB_2 = 10 (\log K' - 2 \log r_2)$

$3 = dB_1 - dB_2 = 20 \log \left[\frac{r_2}{r_1}\right] \Rightarrow (0.3) = \log \left[\frac{r_2}{r_1}\right]^2$

$$\Rightarrow \left(\frac{r_1}{r_2}\right) = \frac{1}{\sqrt{2}}$$