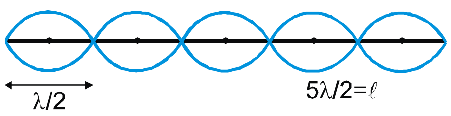
SOLVED EXAMPLES

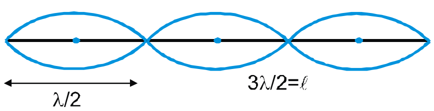
Ex.1 A sonometer wire resonates with a given tuning fork forming a standing wave with five antinodes between the two bridges when a mass of 9 kg is suspended from the wire . When this mass is replaced by a mass 'M' kg, the wire resonates with the same tuning fork forming three antinodes for the same positions of the bridges. Find the value of M.

(A) 25 **(B)** 20 **(C)** 15 **(D)** 10

Sol.



$$f = \frac{\sqrt{\frac{9g}{\mu}}}{\frac{2\ell}{5}}$$



$$f = \frac{\sqrt{\frac{Mg}{\mu}}}{\frac{2\ell}{3}} \Rightarrow f = \frac{\sqrt{\frac{9g}{\mu}}}{\frac{2\ell}{5}} = \frac{\sqrt{\frac{Mg}{\mu}}}{\frac{2\ell}{3}} \Rightarrow \sqrt{M} = 5$$

Ex.2 A particle of mass 50 g participates in two simple harmonic oscillations, simultaneously as given by $x_1 = 10(\text{cm})\cos[80\pi(s^{-1})\,t]$ and $x_2 = 5(\text{cm})\sin[(80\pi(s^{-1})\,t + \pi/6]$. The amplitude of particle's oscillations is given by 'A'. Find the value of A^2 (in cm^2).

(A) 175 **(B)** 165 **(C)** 275 **(D)** 375

Sol. $A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi} = \sqrt{10^2 + 5^2 + 2\times5\times10\times\frac{1}{2}} = \sqrt{175} \Rightarrow A^2 = 175$

Ex.3 A steel wire of length 1 m and mass 0.1 kg and having a uniform cross-sectional area of 10^{-6} m^2 is rigidly fixed at both ends. The temperature of the wire is lowered by 20°C. If the wire is vibrating in fundamental mode, find the frequency (in Hz).($Y_{steel} = 2\times10^{11}$ N/m^2, $\alpha_{steel} = 1.21\times10^{-5}$/°C)

(A) 11 **(B)** 20 **(C)** 15 **(D)** 10

Sol. $\Delta\ell = \alpha\ell\Delta\theta \Rightarrow Y = \frac{T/A}{\Delta\ell/\ell} \Rightarrow T = YA\frac{\Delta\ell}{\ell} \Rightarrow T = \alpha YA\Delta\theta = 48.4N$; $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{48.4}{\left(\frac{0.1}{1}\right)}} = 22m/s$

$\because$ for fundamental note $\ell = \frac{\lambda}{2} \Rightarrow \lambda = 2m \Rightarrow f = \frac{v}{\lambda} = \frac{22}{2} = 11Hz$

Ex.4 Two tuning forks A and B lying on opposite sides of observer 'O' and of natural frequency 85 Hz move with velocity 10 m/s relative to stationary observer O. Fork A moves away from the observer while the fork B moves towards him. A wind with a speed 10 m/s is blowing in the direction of motion of fork A. Find the beat frequency measured by the observer in Hz. [Take speed of sound in air as 340 m/s]

(A) 5 **(B)** 6 **(C)** 7 **(D)** 8

Sol. $f_{\text{observer for source 'A'}} = f_0\left[\frac{v_{sound} - v_{medium}}{v_{sound} - v_{medium} + v_{source}}\right] = \frac{33}{34}f_0$; $f_{\text{observer for source 'B'}} = f_0\left[\frac{v_{sound} + v_{medium}}{v_{sound} + v_{medium} - v_{source}}\right] = \frac{35}{34}f_0$

$\therefore$ Beat frequency $= f_1 - f_2 = \left(\frac{35-33}{34}\right)f_0 = 5$

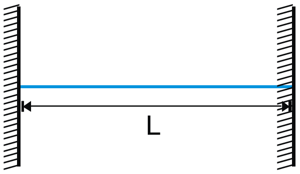
Ex.5 A progressive wave on a string having linear mass density ρ is represented by $y = A\sin\left(\frac{2\pi}{\lambda}x - \omega t\right)$ where y is in mm. Find the total energy (in μJ) passing through origin from t = 0 to $t = \frac{\pi}{2\omega}$.

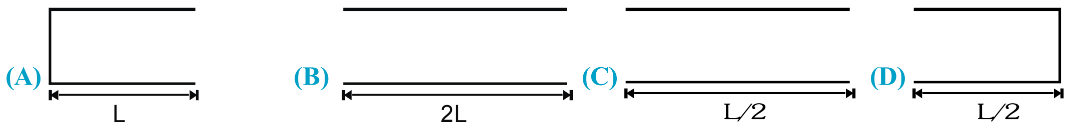
[Take : $\rho = 3\times10^{-2}$ kg/m; A = 1mm; ω = 100 rad/sec; λ = 16 cm]

(A) 6 **(B)** 7 **(C)** 8 **(D)** 9

Sol. Total energy $\frac{1}{2}\rho A^2\omega^2 \times \frac{\lambda}{4}$

Ex.6 Figure shows a stretched string of length L and pipes of length L, 2L, L/2 and L/2 in options (A), (B), (C) and (D) respectively. The string's tension is adjusted until the speed of waves on the string equals the speed of sound waves in air. The fundamental mode of oscillation is then set up on the string. In which pipe will the sound produced by the string cause resonance?





Sol. (B)

Ex.7 A transverse wave, travelling along the positive x-axis, given by $y = A\sin(kx - \omega t)$ is superposed with another wave travelling along the negative x-axis given by $y = -A\sin(kx + \omega t)$. The point x = 0 is

(A) a node (B) an antinode
(C) neither a node nor an antinode (D) a node or antinode depending on t.

Sol. At x = 0, $y_1 = A\sin(-\omega t)$ and $y_2 = -A\sin\omega t$; $y_1 + y_2 = -2A\sin\omega t$ (antinode)

Ex.8 If $y_1 = 5$ (mm) $\sin\pi t$ is equation of oscillation of source S_1 and $y_2 = 5$ (mm) $\sin(\pi t + \pi/6)$ be that of S_2 and it takes 1 sec and ½ sec for the transverse waves to reach point A from sources S_1 and S_2 respectively then the resulting amplitude at point A, is

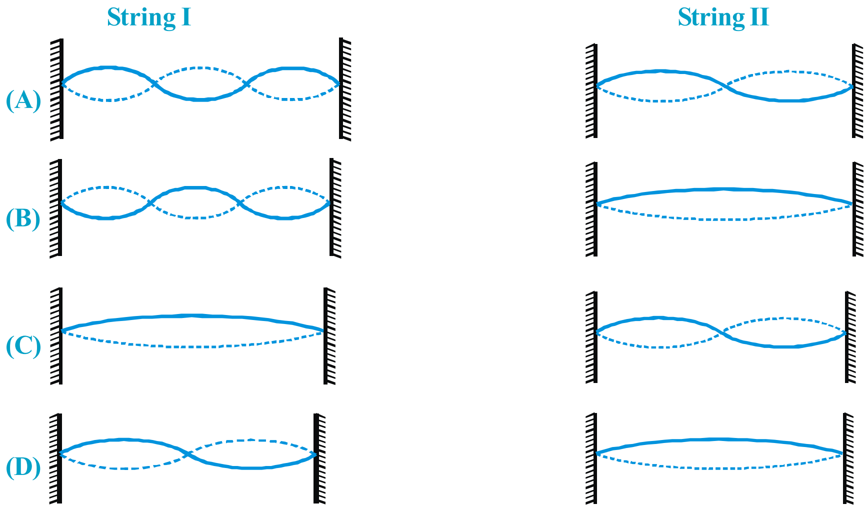
(A) $5\sqrt{2+\sqrt{3}}$ mm (B) $5\sqrt{3}$ mm (C) 5 mm (D) $5\sqrt{2}$ mm

Sol. Wave originating at t = 0 from S_1 reaches point A at t = 1.

Wave originating at $t = \frac{1}{2}$ from S_2 reaches point A at t = 1.

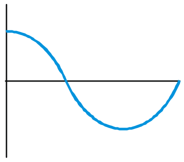
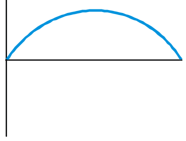
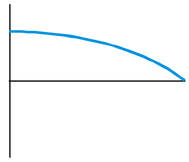
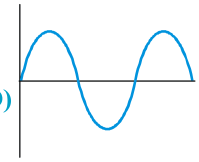
So phase difference in these waves $= \frac{\pi}{2} + \frac{\pi}{6}$; $A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi} = 5$

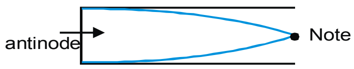
Ex.9 String I and II have identical lengths and linear mass densities, but string I is under greater tension than string II. The accompanying figure shows four different situations, A to D, in which standing wave patterns exist on the two strings. In which situation it is possible that strings I and II are oscillating at the same resonant frequency?



Sol. Since tension in I > tension in II $\Rightarrow V_I > V_{II}$ Thus, for same frequency, $\lambda_I > \lambda_{II}$

Ex.10 Which of the figures, shows the pressure difference from regular atmospheric pressure for an organ pipe of length L closed at one end, corresponds to the 1st overtone for the pipe?

(A)  **(B)**  **(C)**  **(D)** 

Sol. For pressure standing wave 

fundamental frequency

first overtone

Ex.11 A standing wave is created on a string of length 120 m and it is vibrating in 6th harmonic. Maximum possible amplitude of any particle is 10 cm and maximum possible velocity will be 10 cm/s. Choose the correct statement.

(A) Angular wave number of two waves will be $\frac{\pi}{20}$.

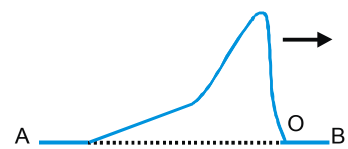
(B) Time period of any particle's SHM will be 4π sec.

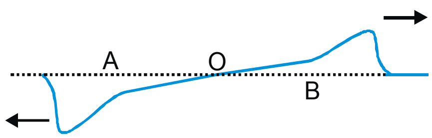
(C) Any particle will have same kinetic energy as potential energy.

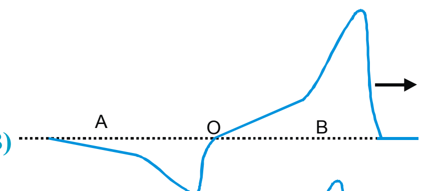
(D) Amplitude of interfering waves are 10 cm each.

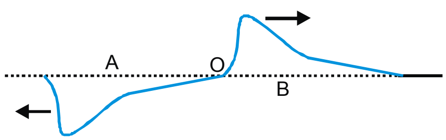
Sol. $6\left(\frac{\lambda}{2}\right) = 120 \Rightarrow \lambda = 40 \Rightarrow k = \frac{\pi}{20} \Rightarrow A\omega = v_{max} \Rightarrow \omega = 1 \Rightarrow T = 2\pi \Rightarrow$

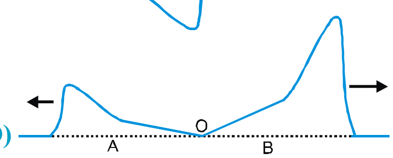
Ex.12 Two strings, A and B, of lengths 4L and L respectively and same mass M each, are tied together to form a knot 'O' and stretched under the same tension. A transverse wave pulse is sent along the composite string from the side A, as shown to the right. Which of the following diagrams correctly shows the reflected and transmitted wave pulses near the knot 'O'?



(A) 

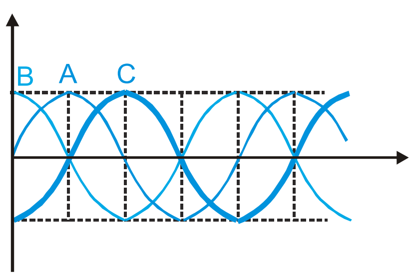
(B) 

(C) 

(D) 

Sol. The wave suffers a phase difference of π when reflected by denser medium.

Ex.13 Three progressive waves A, B and C are shown in figure.



With respect to wave A

(A) The wave *C* lags behind in phase by $\pi/2$ and *B* leads by $\pi/2$.

(B) The wave *C* leads in phase by π and *B* lags behind by π.

(C) The wave *C* leads in phase by $\pi/2$ and *B* lags behind by $\pi/2$.

(D) The wave *C* lags behind in phase by π and *B* leads by π.

Ex.14 A man generates a symmetrical pulse in a string by moving his hand up and down. At $t = 0$ the point in his hand moves downward. The pulse travels with speed of 3 m/s on the string & his hands passes 6 times in each second from the mean position. Then the point on the string at a distance 3m will reach its upper extreme first time at time t =

(A) 1.25 sec. **(B)** 1 sec **(C)** $\frac{13}{12}$ sec **(D)** none

Sol. Frequency of wave $=\frac{6}{2}=3 \Rightarrow T=\frac{1}{3}s\ ;\ \lambda=vT=(3)\left(\frac{1}{3}\right)=1m$

Total time taken $=\frac{3}{3}+\frac{3T}{4}=1.25$ sec

Ex.15 Two mechanical waves, $y_1=2\sin 2\pi(50t-2x)$ & $y_2=4\sin 2\pi(ax+100t)$ propagate in a medium with same speed.

(A) The ratio of their intensities is 1: 16
(B) The ratio of their intensities is 1: 4
(C) The value of 'a' is 4 units
(D) The value of 'a' is 2 units

Sol. $I=\frac{1}{2}\rho v\omega^2A^2$ and velocity $=\frac{\omega}{k}$

Ex.16 Following are equations of four waves :

(i) $y_1=a\sin\omega\left(t-\frac{x}{v}\right)$ **(ii)** $y_2=a\cos\omega\left(t+\frac{x}{v}\right)$ **(iii)** $z_1=a\sin\omega\left(t-\frac{x}{v}\right)$ **(iv)** $z_2=a\cos\omega\left(t+\frac{x}{v}\right)$

Which of the following statements is/are **correct**?

(A) On superposition of waves (i) and (iii), a travelling wave having amplitude $a\sqrt{2}$ will be formed.
(B) Superposition of waves (ii) and (iii) is not possible.
(C) On superposition of waves (i) and (ii), a transverse stationary wave having maximum amplitude $a\sqrt{2}$ will be formed.
(D) On superposition of waves (iii) and (iv), a transverse stationary wave will be formed.

Sol. Superposition of waves (i) & (iii) will give travelling wave having amplitude of $a\sqrt{2}$

{waves are along x-axis but particle displacements are along y & z-axis respectively}

$$z_1+z_2=a\left[\sin\omega\left(t-\frac{x}{v}\right)+\sin\left\{\omega\left(t+\frac{x}{v}\right)+\frac{\pi}{2}\right\}\right]$$

Ex.17 Three simple harmonic waves, identical in frequency n and amplitude A moving in the same direction are superimposed in air in such a way, that the first, second and the third wave have the phase angles $\phi, \phi+\frac{\pi}{2}$ and $(\phi+\pi)$ respectively at a given point P in the superposition.

Then as the waves progress, the superposition will result in

(A) a periodic, non-simple harmonic wave of amplitude 3A
(B) a stationary simple harmonic wave of amplitude 3A
(C) a simple harmonic progressive wave of amplitude A
(D) the velocity of the superposed resultant wave will be the same as the velocity of each wave

Sol. Since the first wave and the third wave moving in the same direction have the phase angles ϕ and $(\phi+\pi)$, they superpose with opposite phase at every point of the vibrating medium and thus cancel out each other, in displacement, velocity and acceleration. They, in effect, destroy each other out. Hence we are left with only the second wave which progresses as a simple harmonic wave of amplitude A. The velocity of this wave is the same as if it were moving alone.

Ex.18 A progressive wave having amplitude 5 m and wavelength 3 m. If the maximum average velocity of particle in half time period is 5 m/s and wave is moving in the positive x-direction then find which may be the **correct** equation(s) of the wave? [where x in meter]

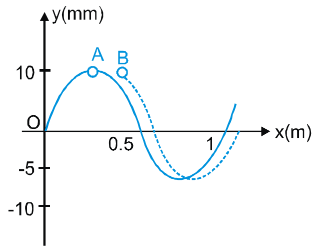
(A) $5\sin\left(\frac{2\pi}{5}t-\frac{2\pi}{3}x\right)$
(B) $4\sin\left(\frac{\pi t}{2}-\frac{2\pi}{3}x\right)+3\cos\left(\frac{\pi t}{2}-\frac{2\pi}{3}x\right)$
(C) $5\sin\left(\frac{\pi t}{2}-\frac{2\pi}{3}x\right)$
(D) $3\cos\left(\frac{2\pi}{5}t-\frac{2\pi}{3}x\right)-4\sin\left(\frac{2\pi}{5}t-\frac{2\pi}{3}x\right)$

Sol. $\because \lambda = 3m \ \therefore k = \frac{2\pi}{\lambda} = \frac{2\pi}{3}$

Maximum displacement in half time period = 2a = 10 m

So maximum average velocity = $\frac{10}{T/2} = 5 \Rightarrow T = 4\ s \Rightarrow \omega = \frac{2\pi}{T} = \frac{2\pi}{4} = \frac{\pi}{2}$

Ex.19 Two identical waves A and B are produced from the origin at different instants t_A and t_B along the positive x-axis, as shown in the figure. If the speed of wave is 5m/s then



(A) the wavelength of the waves is 1m
(B) the amplitude of the waves is 10 mm
(C) the wave A leads B by 0.0167 s
(D) the wave B leads A by 1.67 s

Sol. Wavelength of the waves = 1m; Amplitude of the waves = 10 mm

Ex.20 A standing wave of time period T is set up in a string clamped between two rigid supports. At t = 0 antinode is at its maximum displacement 2A.

(A) The energy density of a node is equal to energy density of an antinode for the first time at t = T/4.
(B) The energy density of node and antinode becomes equal after T/2 second.
(C) The displacement of the particle at antinode at $t = \frac{T}{8}$ is $\sqrt{2}A$
(D) The displacement of the particle at node is zero

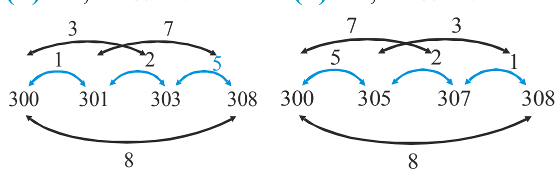
Sol. Equation of SHM of particle who is at antinode is $y = 2A\sin\left(\frac{2\pi}{T}\right)t$ at time $t = \frac{T}{8}$

$y = 2A\sin\frac{\pi}{4} = \sqrt{2}A$; Displacement of particle at note is always zero.

Ex.21 You are given four tuning forks, the lowest frequency of the forks is 300 Hz. By striking two tuning forks at a time any of 1, 2, 3, 5, 7 & 8 Hz beat frequencies are heard. The possible frequencies of the other three forks are-

(A) 301,302 & 307 **(B)** 300,304 & 307 **(C)** 301, 303 & 308 **(D)** 305, 307 & 308

Sol.



Ex.23 Two notes A and B, sounded together, produce 2 beats per sec. Notes B and C sounded together produce 3 beats per sec. The notes A and C separately produce the same number of beats with a standard tuning fork of 456 Hz. The possible frequency of the note B is

(A) 453.5 Hz **(B)** 455.5 Hz **(C)** 456.5 Hz **(D)** 458.5 Hz

Sol. Let frequency of note B be n then according to question

$n_A = n-2$ or $n+2$

$n_C = n-3$ or $n+3$

As A & C produce same number of beats with T.F. of frequency 456 Hz so

$(n-2) - 456 = 456 - (n-3) \Rightarrow n = 458.5$ Hz

$(n+3) - 456 = 456 - (n-2) \Rightarrow n = 455.5$ Hz

$(n+2) - 456 = 456 - (n-3) \Rightarrow n = 456.5$ Hz

$(n+3) - 456 = 456 - (n+2) \Rightarrow n = 453.5$ Hz

Ex.24 to 26

A detector at x =0 receives waves from three sources each of amplitude A and frequencies f +2, f and f–2.

24. The equations of waves are ; $y_1=A\sin[2\pi(f+2)t]$, $y_2=A\sin 2\pi ft$ and $y_3=A\sin[2\pi(f-2)t]$. The time at which intensity is minimum, is

(A) t=0, 1/4, 1/2, 3/4,... sec (B) t=1/6, 1/3, 2/3, 5/6, ...sec

(C) t=0, 1/2, 3/2, 5/2, ...sec (D) t=1/2, 1/4, 1/6, 1/8, ...sec

25. The time at which intensity is maximum, is

(A) t=0, 1/4, 1/2, 3/4, ...sec (B) t=1/6, 1/3, 2/3, 5/6...sec

(C) t=0, 1/2, 3/2, 5/2 ...sec (D) t=1/2, 1/4, 1/6, 1/8...sec

26. If $I_0 \propto A^2$, then the value of maximum intensity, is

(A) $2I_0$ (B) $3I_0$ (C) $4I_0$ (D) $9I_0$

Sol.

24. **Ans. (B)**

$$y = y_1 + y_2 + y_3 = A\sin 2\pi ft + A\sin[2\pi(f-2)t] + A\sin[2\pi(f+2)t] = A\sin 2\pi ft + 2A\sin 2\pi ft\cos 4\pi t$$

$$= A[1+2\cos 4\pi t]\sin 3\pi ft = A_0 \sin 2\pi ft$$

[where A_0 = Amplitude of the resultant oscillation = A [1+2cos4πt]

Intensity $\propto A_0^2 \quad \therefore \propto (1+2\cos 4\pi t)^2$

For maxima or minima of the intensity.

$$\frac{dI}{dt} = 0 \Rightarrow 2(1+2\cos 4\pi t)(2)(-\sin 4\pi t)4\pi = 0 \Rightarrow 1+2\cos 4\pi t = 0 \text{ or } \sin 4\pi t = 0$$

$$\therefore \cos 4\pi t = -\frac{1}{2} \Rightarrow 4\pi t = 2\pi n \pm \frac{2\pi}{3}$$

$$\therefore t = \frac{n}{2} + \frac{1}{6} \Rightarrow t = \frac{1}{6}, \frac{1}{3}, \frac{2}{5}, \frac{5}{6} \text{ ... (point of minimum intensity)}$$

25. $\sin 4\pi t = 0 \Rightarrow t = \frac{n}{4} \quad \therefore t = 0, \frac{1}{4}, \frac{1}{2}, \frac{3}{4}$ ... (point of maximum intensity)

26. At t = 0, $I_{max} \propto (1+2)^2A^2 = 9A^2 \therefore I_{max} = 9I_0$

Ex..27 to 29

A metallic rod of length 1m has one end free and other end rigidly clamped. Longitudinal stationary waves are set up in the rod in such a way that there are total six antinodes present along the rod. The amplitude of an antinode is 4×10^{-6} m. Young's modulus and density of the rod are 6.4×10^{10} N/m² and 4×10^3 Kg/m³ respectively. Consider the free end to be at origin and at t=0 particles at free end are at positive extreme.

27. The equation describing displacements of particles about their mean positions is

(A) $s = 4\times10^{-6}\cos\left(\frac{11\pi}{2}x\right)\cos(22\pi\times10^3 t)$ (B) $s = 4\times10^{-6}\cos\left(\frac{11\pi}{2}x\right)\sin(22\pi\times10^3 t)$

(C) $s = 4\times10^{-6}\cos(5\pi x)\cos(20\pi\times10^3 t)$ (D) $s = 4\times10^{-6}\cos(5\pi x)\sin(20\pi\times10^3 t)$

28. The equation describing stress developed in the rod is

(A) $140.8\pi\times10^4\cos\left(\frac{11}{2}\pi x+\pi\right)\cos(22\pi\times10^3 t)$ (B) $140.8\pi\times10^4\sin\left(\frac{11}{2}\pi x+\pi\right)\cos(22\pi\times10^3 t)$

(C) $128\pi\times10^4\cos(5\pi x+\pi)\cos(20\pi\times10^3 t)$ (D) $128\pi\times10^4\sin(5\pi x+\pi)\cos(20\pi\times10^3 t)$

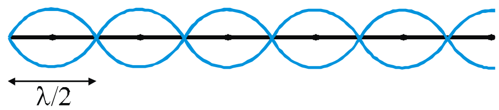
29. The magnitude of strain at midpoint of the rod at t= 1 sec is

(A) $11\sqrt{3}\pi \times 10^{-6}$ **(B)** $11\sqrt{2}\pi \times 10^{-6}$ **(C)** $10\sqrt{3}\pi \times 10^{-6}$ **(D)** $10\sqrt{2}\pi \times 10^{-6}$

Sol.

27. **Solution (27 to 29)**

Speed of wave $v = \sqrt{\frac{y}{\rho}} = 4 \times 10^3$



$\lambda = \frac{5\lambda}{2} + \frac{\lambda}{4} \Rightarrow \lambda = \frac{4\ell}{11}$

Frequency $\nu = \frac{v}{\lambda} = \frac{4 \times 10^3}{\frac{4}{11} \times 1} = 11 \times 10^3\,\text{Hz}$; Wave Number $K = \frac{2\pi}{\lambda} = \frac{11\pi}{2}$

(i) Equation of standing wave in the rod $S = A \cos kx \sin(\omega t + \phi)$ where $A = 4 \times 10^{-6}$ m

$\because$ at x =0, t =0 $\Rightarrow S = A \Rightarrow A = A \Rightarrow \cos k(0) \sin\phi \Rightarrow \sin\phi = 1 \Rightarrow \phi = \frac{\pi}{2}$

$$S = 4 \times 10^{-6} \cos\left(\frac{11\pi}{2}x\right) \cos\left(22\pi \times 10^3 t\right)$$

(ii) Strain $= \frac{ds}{dx} = -22\pi \times 10^{-6} \sin\left(\frac{11\pi}{2}x\right) \cos\left(22\pi \times 10^3 t\right)$ $\because$ stress = Y × strain

$$\Rightarrow \text{stress} = 140.8 \times 10^4 \cos\left(22\pi \times 10^3 t\right) \sin\left(\frac{11\pi}{2}x + \pi\right)$$

(iii) Strain at t = 1s and $x = \frac{\ell}{2} = \frac{1}{2}$ m ; $\left|\frac{ds}{dx}\right|_{x=\frac{\ell}{2}}^{t=1} = 22\pi \times 10^{-6} \times \sin\left(\frac{11\pi}{4}\right) = 11\sqrt{2}\pi \times 10^{-6}$

Ex.29 Column I represents the standing waves in air columns and string. Column II represents frequency of the note. Match the column-I with column-II. [v = velocity of the sound in the medium]

	Column -I		Column-II
(A)	Second harmonic for the tube open at both ends	**(P)**	$\frac{v}{4\ell}$
(B)	Fundamental frequency for the tube closed at one end	**(Q)**	$\frac{v}{2\ell}$
(C)	First overtone for the tube closed at one end	**(R)**	$\frac{3v}{4\ell}$
(D)	Fundamental frequency for the string fixed at both ends	**(S)**	$\frac{v}{\ell}$
		(T)	$\frac{5v}{4\ell}$

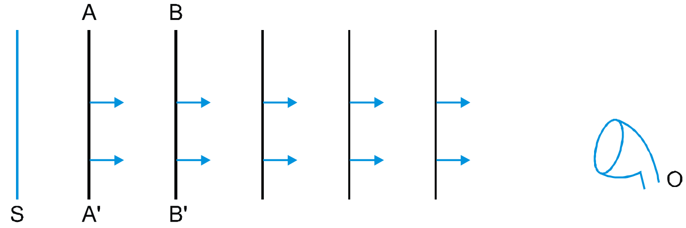
Sol. For **(A)** : For open organ pipe 2nd harmonic $= 2\left(\frac{v}{2\ell}\right)$

For **(B)** : For closed organ pipe fundamental frequency $= \frac{v}{4\ell}$

For **(C)** : For closed organ pipe, first overtone frequency $= \frac{3v}{4\ell}$

For **(D)** : For string fixed at both ends, fundamental frequency $= \frac{v}{2\ell}$

Ex.30 Consider a large plane diaphragm 'S' emitting sound and a detector 'O'. The diagram shows plane wavefronts for the sound wave travelling in air towards right when source, observer and medium are at rest. AA' and BB' are fixed imaginary planes. Column-I describes about the motion of source, observer or medium and column-II describes various effects. Match them correctly.

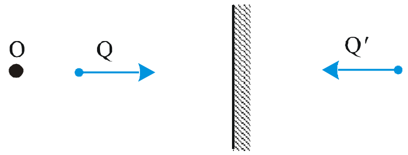


Column I		**Column II**	
(A)	Source starts moving towards right	**(P)**	Distance between any two wavefronts will increase.
(B)	Air starts moving towards right	**(Q)**	Distance between any two wavefronts will decrease.
(C)	Observer and source both move towards left with same speed.	**(R)**	The time needed by sound to move from plane AA' to BB' will increase.
(D)	Source and medium (air) both move towards right with same speed.	**(S)**	The time needed by sound to move from plane AA' to BB' will decrease.
		(T)	Frequency received by observer increases.

Sol. Velocity of sound in a medium is always given in the reference frame of medium.

Ex.31 A tuning fork P of unknown frequency gives 7 beats in 2 seconds with another tuning fork Q. When Q is moved towards a wall with a speed of 5 m/s, it gives 5 beats per second for an observer located left to it. On filing, P gives 6 beats per second with Q. The frequency (in Hz) of P is given by $(80 \times \alpha) + \beta$. $(\alpha, \beta \in I, 0 \le \alpha, \beta \le 9)$ then find the value of $\alpha + \beta$. Assume speed of sound = 332 m/s.

Sol. Let f_1 and f_2 be the frequencies of tuning forks P and Q,



Then $|f_1 - f_2| = 7/2$

Apparent frequency for O corresponding to signal directly coming from $Q = f_2\left(\frac{v}{v+v_q}\right)$

Apparent frequency of the echo $= f_2\left(\frac{v}{v-v_q}\right)$ $\therefore \Delta f_2 = f_2\left[\frac{2v_q v}{v^2 - v_q^2}\right]$

Since, $\Delta f_2 = 5$ (given) $\therefore f_2 = 163.5$ Hz. Now, $f_1 = 163.5 \pm 3.5 = 167$ or 160 Hz, when P is filed, its frequency will increase, since it is given that filed P gives greater number of beats with Q. It implies that f_1 must be 167 Hz.

Ex.32 Two vibrating tuning forks produce progressive waves given by $y_1 = 4\sin(500\pi t)$ and $y_2 = 2\sin(506\pi t)$. These tuning forks are held near the ear of a person. The person will hear α beats/s with intensity ratio between maxima and minima equal to β. Find the value of $\beta - \alpha$.

Sol. $y_1 = 4\sin(500\ \pi t)$ $\quad y_2 = 2\sin(506\ \pi t)$

Number of beats $= \dfrac{n_1 - n_2}{2} = \dfrac{506 - 500}{2} = 3$ beat/sec.

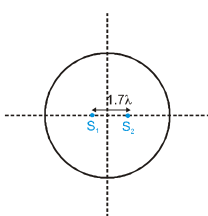
As $I_1 \propto (16)$ and $I_2 \propto 4 \Rightarrow \dfrac{I_{max}}{I_{min}} = \dfrac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2} \Rightarrow \left(\dfrac{4+2}{4-2}\right)^2 = \left(\dfrac{6}{2}\right)^2 = 9$

Ex.33 A 1000 m long rod of density 10.0×10^4 kg/m^3 and having young's modulus $Y = 10^{11}$ Pa, is clamped at one end. It is hammered at the other free end as shown in the figure. The longitudinal pulse goes to right end, gets reflected and again returns to the left end. How much time (in sec) the pulse take to go back to initial point?

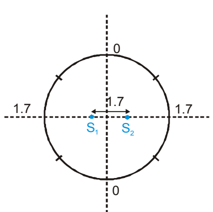
Sol. Velocity of longitudinal $u = \sqrt{\dfrac{Y}{\rho}} = \sqrt{\dfrac{10^{11}}{10 \times 10^4}} = 10^3\ \text{ms}^{-1}$

Required time $\dfrac{2\ell}{v} = \dfrac{2 \times 1000}{10^3} = 2$ s

Ex.34 Find the number of maxima attend on circular perimeter as shown in the figure. Assume radius of circle>>>λ.



Sol.



1 in each quadrant, 1 top point, 1 bottom point

Exercise # 1

[Single Correct Choice Type Questions]

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

(A) 2500 s **(B)** 75 s **(C)** 4 s **(D)** 0·25 s

2. The waves produced by a motorboat sailing in water are:–

(A) Transverse **(B)** Longitudinal

(C) Longitudinal and transverse **(D)** Stationary

3. A wave of frequency 500 Hz travels between X and Y, a distance of 600 m in 2 sec. How many wavelength are there in distance XY:–

(A) 1000 **(B)** 300 **(C)** 180 **(D)** 2000

4. Two wave are represented by equation $y_1 = a \sin \omega t$ and $y_2 = a \cos \omega t$ the first wave:–

(A) leads the second by π **(B)** lags the second by π

(C) leads the second by $\frac{\pi}{2}$ **(D)** lags the second by $\frac{\pi}{2}$

5. The distance between two consecutive crests in a wave train produced in string is 5 m. If two complete waves pass through any point per second, the velocity of wave is:–

(A) 2.5 m/s **(B)** 5 m/s **(C)** 10 m/s **(D)** 15 m/s

6. The displacement y of a particle executing periodic motion is given by : $y = 4\cos^2\left(\frac{1}{2}t\right)\sin(1000t)$.

This expression may be considered to be a result of the superposition of .... independent, simple harmonic motions.

(A) two **(B)** three **(C)** four **(D)** five

7. The displacement of particles in a string stretched in the x–direction is represented by y. Among the following expressions for y, those describing wave motion are:–

(A) $\cos kx \sin\omega t$ **(B)** $k^2x^2 - \omega^2t^2$ **(C)** $\cos^2(kx + \omega t)$ **(D)** $\cos(k^2x^2 - \omega^2t^2)$

8. Two waves traveling in a medium in the x–direction are represented by $y_1 = A\sin(\alpha t - \beta x)$ and $y_2 = A\cos\left(\beta x + \alpha t - \frac{\pi}{4}\right)$, where y_1 and y_2 are the displacements of the particles of the medium, t is time, and α and β are constants. The two waves have different:–

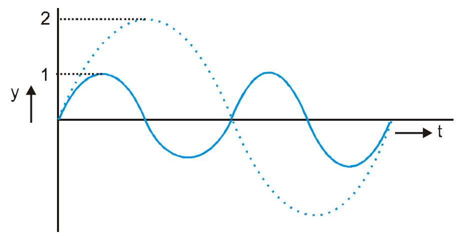
(A) speeds **(B)** directions of propagation

(C) wavelengths **(D)** frequencies

9. A transverse wave is described by the equation $y = y_0 \sin 2\pi(ft - \frac{x}{\lambda})$. The maximum particle velocity is equal to four times the wave velocity if:–

(A) $\lambda = \frac{\pi y_0}{4}$ **(B)** $\lambda = \frac{\pi y_0}{2}$ **(C)** $\lambda = \pi y_0$ **(D)** $\lambda = 2\pi y_0$

10. Dependence of disturbances due to two waves on time is shown in the figure. The ratio of their intensities I_1 / I_2 will be:–



(A) 1 : 1 **(B)** 1 : 2 **(C)** 4 : 1 **(D)** 16 : 1

11. The equation of displacement of two waves are given as $y_1 = 10 \sin(3\pi t + \pi/3)$ and $y_2 = 5\left(\sin 3\pi t + \sqrt{3}\cos 3\pi t\right)$, then what is the ratio of their amplitude:–

(A) 1 : 2 **(B)** 2 : 1 **(C)** 1 : 1 **(D)** None of these

12. A plane progressive wave is represented by the equation $y = 0.25 \cos(2\pi t - 2\pi x)$. The equation of a wave is with double the amplitude and half frequency but travelling in the opposite direction will be:–

(A) $y = 0.5 \cos(\pi t - \pi x)$ **(B)** $y = 0.5 \cos(2\pi t + 2\pi x)$

(C) $y = 0.25 \cos(\pi t + 2\pi x)$ **(D)** $y = 0.5 \cos(\pi t + \pi x)$

13. The resultant amplitude, when two waves of same frequency but with amplitudes a_1 and a_2 superimpose at phase difference of $\pi/2$ will be:–

(A) $a_1 + a_2$ **(B)** $a_1 - a_2$ **(C)** $\sqrt{a_1^2 + a_2^2}$ **(D)** $a_1^2 + a_2^2$

14. A source of sound is in the shape of a long narrow cylinder radiating sound waves normal to the axis of the cylinder. Two points P and Q are at perpendicular distances of 9 m and 25 m from the axis. The ratio of the amplitudes of the waves at P and Q is:–

(A) 5 : 3 **(B)** $\sqrt{5} : \sqrt{3}$ **(C)** 3 : 5 **(D)** 25 : 9

15. The extension in a string, obeying Hooke's law, is x. The speed of sound in the stretched string is v. If the extension in the string is increased to 1.5x, the speed of sound will be:–

(A) 1.22 v **(B)** 0.61 v **(C)** 1.50 v **(D)** 0.75 v

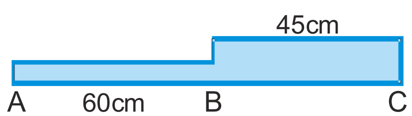
16. The ratio of intensities of two waves is 9 : 1. When they superimpose, the ratio of maximum to minimum intensity will become:–

(A) 4 : 1 **(B)** 3 : 1 **(C)** 2 : 1 **(D)** 1 : 1

17. The linear density of a vibrating string is 1.3×10^{-4} kg/m. A transverse wave is propagating on the string and is described by the equation $y=0.021 \sin(x+30t)$ where x and y are measured in meter and t in second the tension in the string is :–

(A) 0.12 N **(B)** 0.48 N **(C)** 1.20 N **(D)** 4.80 N

18. A steel wire of length 60 cm and area of cross–section 10^{-6} m^2 is joined with an aluminium wire of length 45 cm and area of cross–section 3×10^{-6}m^2. The composite string is stretched by tension of 80 N. Density of steel is 7800 kg m^{-3} and that of aluminium is 2600 kg m^{-3}. The minimum frequency of tuning fork which can produce standing wave in it with node at the joint is:–

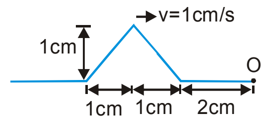


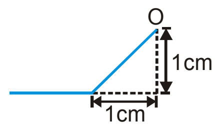
(A) 357.3 Hz **(B)** 375.3 Hz **(C)** 337.5 Hz **(D)** 325.5 Hz

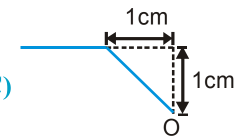
19. A copper wire is fixed between two rigid supports. It is stretched with negligible tension at 30°C. The speed of transverse waves in the wire at 10°C will be– (density $d = 9 \times 10^3$ kg/m^3, Young's modulus $Y = 1.3 \times 10^{11}$ N/m^2 and temperature coefficient of expansion $\alpha = 1.7 \times 10^{-5}$ /°C):–

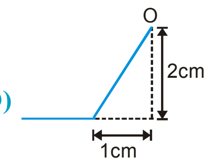
(A) 210 m/s **(B)** 110 m/s **(C)** 90 m/s **(D)** 70 m/s

20. A wave pulse on a string has the dimension shown in figure. The waves speed is v = 1 cm/s. If point O is a free end. The shape of wave at time t=3s is:–

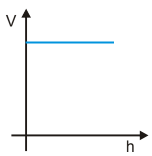


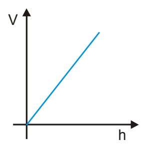
(A) **(B)** 

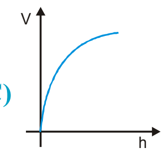
(C) 

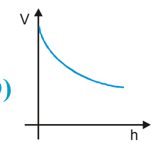
(D) 

21. A uniform rope having some mass hinges vertically from a rigid support. A transverse wave pulse is produced at the lower end. The speed (v) of the wave pulse varies with height (h) from the lower end as:–

(A) 

(B) 

(C) 

(D) 

22. The equation $y = a \sin 2\pi/\lambda\ (vt - x)$ is expression for:–
(A) Stationary wave of single frequency along x–axis.
(B) A simple harmonic motion.
(C) A progressive wave of single frequency along x–axis.
(D) The resultant of two SHM's of slightly different frequencies.

23. A plane wave $y = a \sin (bx + ct)$ is incident on a surface. Equation of the reflected wave is $y' = a' \sin(ct - bx)$. Which of the following statements is not correct ?
(A) The wave is incident on the surface normally.
(B) Reflecting surface is y–z plane.
(C) Medium, in which incident wave is travelling, is denser than the other medium.
(D) a' cannot be greater than a.

24. A wave is represented by the equation $y = a \sin(kx - \omega t)$ is superimposed with another wave to form a stationary wave such that the point x = 0 is a node. Then the equation of other wave is:–
(A) $y = a \cos (kx - \omega t)$ **(B)** $y = a\cos (kx + \omega t)$ **(C)** $y = -a\sin (kx + \omega t)$ **(D)** $y = a \sin (kx + \omega t)$

25. Stationary waves are produced in 10m long stretched string. If the string vibrates in 5 segments and wave velocity 20m/s then the frequency is:–
(A) 10 Hz **(B)** 5 Hz **(C)** 4 Hz **(D)** 2Hz

26. A standing wave having 3 nodes and 2 antinodes is formed between 1.21 Å distance then the wavelength is:–
(A) 1.21 Å **(B)** 2.42 Å **(C)** 0.605 Å **(D)** 4.84 Å

27. An object of specific gravity ρ is hung from a thin steel wire. The fundamental frequency for transverse standing waves in the wire is 300 Hz. The object is immersed in water, so that one half of its volume is submerged. The new fundamental frequency (in Hz) is:–

(A) $300\left(\frac{2\rho-1}{2\rho}\right)^{1/2}$ **(B)** $300\left(\frac{2\rho}{2\rho-1}\right)^{1/2}$ **(C)** $300\left(\frac{2\rho}{2\rho-1}\right)$ **(D)** $300\left(\frac{2\rho-1}{2\rho}\right)$

28. A string is cut into three parts, having fundamental frequencies n_1, n_2 and n_3 respectively. Then original fundamental frequency 'n' related by the expression as (other quantities are identical):–

(A) $\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}$ **(B)** $n = n_1 \times n_2 \times n_3$ **(C)** $n = n_1 + n_2 + n_3$ **(D)** $n = \frac{n_1 + n_2 + n_3}{3}$

29. A thunder tap is heard 5.5 s after the lightening flash. The distance of the flash is (velocity of sound in air is 330 m/s):–
(A) 3560 m **(B)** 300 m **(C)** 1780 m **(D)** 1815 m

30. Microwaves from a transmitter are directed normally towards a plane reflector. A detector moves along the normal to the reflector. Between positions of 14 successive maxima, the detector travels a distance 0.14m. If the velocity of light is 3×10^8 m/s, find the frequency of the transmitter:–
(A) 1.5×10^{10} Hz **(B)** 10^{10} Hz **(C)** 3×10^{10} Hz **(D)** 6×10^{10} Hz

31. A tube, closed at one end and containing air, produces, when excited, the fundamental note of frequency 512 Hz. If the tube is opened at both ends the fundamental frequency that can be excited is (in Hz.):–
(A) 1024 **(B)** 512 **(C)** 256 **(D)** 128

32. At the room temperature the velocity of sound in O_2 gas is v. Then in mixture of H_2 and O_2 gas the speed of sound at same temperature:–
(A) will be less than v. **(B)** will be more than v **(C)** will be equal to v **(D)** nothing can be said

33. An underwater sonar source operating at a frequency of 60 kHz directs its beam towards the surface. If velocity of sound in air is 330 m/s, wavelength and frequency of the waves in air are:–
(A) 5.5 mm, 60 kHz **(B)** 3.30 m, 60kHz **(C)** 5.5 mm, 30 kHz **(D)** 5.5 mm, 80 kHz

34. An organ pipe P_1 closed at one end vibrating in its first harmonic and another pipe P_2 open at ends vibrating in its third harmonic are in resonance with a given tuning fork. The ratio of the length of P_1 and P_2 is:–
(A) $\frac{8}{3}$ **(B)** $\frac{3}{8}$ **(C)** $\frac{1}{6}$ **(D)** $\frac{1}{3}$

35. A cylindrical tube, open at both ends, has a fundamental frequency f in air. The tube is dipped vertically in water so that half of its in water. The fundamental frequency of the air column is now :–
(A) $\frac{f}{2}$ **(B)** $\frac{3f}{4}$ **(C)** f **(D)** $2f$

36. The velocity of sound in air is 333 m/s. If the frequency of the fundamental tone is 333 Hz, the length of the open pipe to generate second harmonic is:–
(A) 0.5m **(B)** 1.0m **(C)** 2.0m **(D)** 4.0 m

37. 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 than the fundamental frequency of the open pipe. The fundamental frequency of the open pipe is:–
(A) 200 Hz **(B)** 300 Hz **(C)** 240 Hz **(D)** 480 Hz

38. A cylindrical tube (L = 120 cm.) is in resonance with a tuning fork of frequency 330 Hz. If it is filling by water then to get resonance again, minimum length of water column is (v_{air} = 330 m/s):–
(A) 45 cm **(B)** 60 cm **(C)** 25 cm **(D)** 20 cm

39. The maximum length of a closed pipe that would produce a just audible sound is (v_{sound} = 336 m/s):–
(A) 4.2 cm **(B)** 4.2 m **(C)** 4.2 mm **(D)** 1.0 cm

40. Two vibrating tuning forks produce progressive waves given by $y_1 = 4 \sin 500\pi t$ and $y_2 = 2 \sin 506\pi t$. Number of beats produced per minute is:–
(A) 3 **(B)** 360 **(C)** 180 **(D)** 60

41. A closed organ pipe of radius r_1 and an open organ pipe of radius r_2 and having same length 'L' resonate when excited with a given tuning fork. Closed organ pipe resonates in its fundamental mode where as open organ pipe resonates in its first overtone, then:–
(A) $r_2 - r_1 = L$ **(B)** $r_2 = r_1 = L/2$ **(C)** $r_2 - 2r_1 = 2.5$ L **(D)** $2r_2 - r_1 = 2.5$ L

42. Length of a sonometer wire is either 95 cm or 100 cm. In both the cases a tuning fork produces 4 beats then the frequency of tuning fork is:–

(A) 152 **(B)** 156 **(C)** 160 **(D)** 164

43. Frequency of tuning fork A is 256 Hz. It produces 4 beats/second with tuning fork B. When wax is applied at tuning fork B then 6 beats/second are heard. Frequency of B is:–

(A) 250 Hz **(B)** 260 Hz **(C)** 252 Hz **(D)** (A) & (C) both may possible

44. 16 tuning forks are arranged in increasing order of frequency. Any two consecutive tuning forks when sounded together produce 8 beats per second. If the frequency of last tuning fork is twice that of first, the frequency of first tuning fork is:–

(A) 60 **(B)** 80 **(C)** 100 **(D)** 120

45. Two open pipes of length 25 cm and 25.5 cm produced 0.1 beat/second. The velocity of sound will be:–

(A) 255 cm/s **(B)** 250 cm/s **(C)** 350 cm/s **(D)** none of these

46. Two open pipes of length L are vibrated simultaneously. If length of one of the pipes is reduced by y, then the number of beats heard per second will be if the velocity of sound is v and y << L:–

(A) $\frac{vy}{2L^2}$ **(B)** $\frac{vy}{L^2}$ **(C)** $\frac{vy}{2L}$ **(D)** $\frac{2L^2}{vy}$

47. Two tuning forks having frequency 256 Hz **(A)** and 262 Hz **(B)** tuning fork. A produces some beats per second with unknown tuning fork, same unknown tuning fork produce double beats per second from B tuning fork then the frequency of unknown tuning fork is:–

(A) 262 **(B)** 260 **(C)** 250 **(D)** 300

48. A sound absorber attenuates the sound level by 20 dB. The intensity decreases by a factor of:–

(A) 1000 **(B)** 10000 **(C)** 10 **(D)** 100

49. The power of sound from the speaker of a radio is 20MW by turning the knob of the volume control the power of the sound is increased to 400 MW. The power increase in describe as compared to the original power is :–

(A) 13 dB **(B)** 10 dB **(C)** 20 dB **(D)** 800 dB

50. A person observes a change of 2.5% in frequency of sound of horn of a car. If the car is approaching forward the person & sound velocity is 320 m/s, then velocity of car in m/s will be approximately:–

(A) 8 **(B)** 800 **(C)** 7 **(D)** 6

51. A whistle giving out 450 Hz approaches a stationary observer at a speed of 33 m/s. The frequency heard by the observer (in Hz) is : (speed of sound 333 m/s)

(A) 409 **(B)** 429 **(C)** 517 **(D)** 500

52. A whistle revolves in a circle with angular speed $\omega = 20$ rad/s using a string of length 50 cm. If the frequency of sound from the whistle is 385 Hz, then what is the minimum frequency heard by an observer which is far away from the centre:– ($v_{sound} = 340$ m/s)

(A) 385 Hz **(B)** 374 Hz **(C)** 394 Hz **(D)** 333 Hz

53. Two trains A and B are moving in the same direction with velocities 30 m/s and 10 m/s respectively, B is behind from A, blows a horn of frequency 450 Hz. Then the apparent frequency heard by B is (The velocity of sound is 330 m/s):–

(A) 425 Hz **(B)** 300 Hz **(C)** 450 Hz **(D)** 350 Hz

Exercise # 2 Part # I [Multiple Correct Choice Type Questions]

1. A wave disturbance in a medium is described by $y(x, t) = 0.02 \cos\left(50\pi t + \frac{\pi}{2}\right)\cos(10\pi x)$, where x and y are in metre and t is in second:–

(A) A node occurs at x = 0.15 m **(B)** An antinode occurs at x=0.3 m

(C) The speed of wave is 5 ms^{-1} **(D)** The wavelength is 0.2 m

2. A sound wave of frequency f travels horizontally to the right. It is reflected from a large vertical plane surface moving to left with a speed v. The speed of sound in medium is c:–

(A) The number of wave striking the surface per second is $f\frac{(c+v)}{c}$

(B) The wavelength of reflected wave is $\frac{c(c-v)}{f(c+v)}$

(C) The frequency of the reflected wave is $f\frac{(c+v)}{(c-v)}$

(D) The number of beats heard by a stationary listener to the left of the reflecting surface is $\frac{vf}{c-v}$

3. A string of length L is stretched along the x–axis and is rigidly clamped at its two ends. It undergoes transverse vibration. If n is an integer, which of the following relations may represent the shape of the string at any time:–

(A) $y = A \sin\left(\frac{n\pi x}{L}\right) \cos\omega t$ **(B)** $y = A \sin\left(\frac{n\pi x}{L}\right) \sin \omega t$

(C) $y = A \cos\left(\frac{n\pi x}{L}\right) \cos \omega t$ **(D)** $y = A \cos\left(\frac{n\pi x}{L}\right) \sin\omega t$

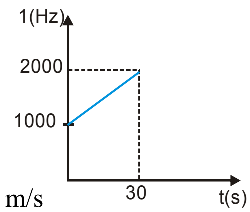
4. A hollow metallic tube of length L and closed at one end produce resonance with a tuning fork of frequency n. The entire tube is then heated carefully so that at equilibrium temperature its length changes by ℓ. If the change in velocity V of sound is v, the resonance will now produced by tuning fork of frequency:–

(A) $(V+v) / (4(L+\ell))$ **(B)** $(V+v) / (4(L-\ell))$ **(C)** $(V-v) / (4(L+\ell))$ **(D)** $(V-v)/ (4(L-\ell))$

5. Two tuning fork when sounded together produces 5 beats per second. The first tuning fork is in resonance with 16.0 cm wire of a sonometer and second is in the resonance with 16.2 cm wire of the same sonometer then the frequencies of the tuning forks are:–

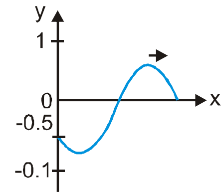
(A) 100 Hz, 105 Hz **(B)** 200 Hz, 205 Hz **(C)** 300 Hz, 305 Hz **(D)** 400 Hz, 405 Hz

6. A detector is released from rest over height h a source of sound of frequency $f_0 = 10^3$ Hz. The frequency observed by the detector at time t is plotted in the graph. The speed of sound in air is ($g = 10$ m/s^2)



(A) 330 m/s **(B)** 350 m/s **(C)** 300 m/s **(D)** 310 m/s

7. The equation of a wave travelling along the positive x–axis, as shown in figure at t=0 is given by:–



(A) $\sin\left(kx - \omega t + \frac{\pi}{6}\right)$ **(B)** $\sin\left(kx - \omega t - \frac{\pi}{6}\right)$

(C) $\sin\left(\omega t - kx + \frac{\pi}{6}\right)$ **(D)** $\sin\left(\omega t - kx - \frac{\pi}{6}\right)$

8. A wave is propagating along x–axis. The displacement of particles of the medium in z–direction at t=0 is given by: $z=\exp[-(x+2)^2]$, where 'x' is in meter. At t=1s, the same wave disturbance is given by $z=\exp[-(2-x)^2]$. Then the wave propagation velocity is:–

(A) 4 m/s in + x direction **(B)** 4 m/s in – x direction
(C) 2 m/s in + x direction **(D)** 2 m/s in – x direction

9. A sinusoidal progressive wave is generated in a string. It's equation is given by y=(2mm) sin $(2\pi x - 100\pi t + \pi/3)$. The time when particle at x = 4 m first passes through mean position, will be:–

(A) $\frac{1}{150}$ s **(B)** $\frac{1}{12}$ s **(C)** $\frac{1}{300}$ s **(D)** $\frac{1}{100}$ s

10. Figure, shows a stationary wave between two fixed points P and Q.

Which point (s) of 1, 2 and 3 are in phase with the point X ?

(A) 1, 2 and 3 **(B)** 1 and 2 only **(C)** 2 and 3 only **(D)** 3 only

11. One end of a string of length L is tied to the ceiling of lift accelerating upwards with an accelerating 2g. The other end of the string is free. The linear mass density of the string varies linearly from 0 of λ from bottom to top:–

(A) The velocity of the wave in the string will be 0

(B) The acceleration of the wave on the string will be 3g/4 every where.

(C) The time taken by a pulse to reach from bottom to top will be $\sqrt{8L/3g}$

(D) The time taken by a pulse to reach from bottom to top will be $\sqrt{4L/3g}$

12. A clamped string is oscillating in n^{th} harmonic, then:–

(A) Total energy of oscillations will be n^2 times that of fundamental frequency

(B) Total energy of oscillations will be $(n-1)^2$ times that of fundamental frequency

(C) Average kinetic energy of the string over a complete oscillations is half of that the total energy of the string

(D) None of these

13. In an organ pipe whose one end is at x = 0, the pressure is expressed by

$P = P_0 \cos\frac{3\pi x}{2}\sin 300\pi t$ where x is in meter and t in sec. The organ pipe can be :–

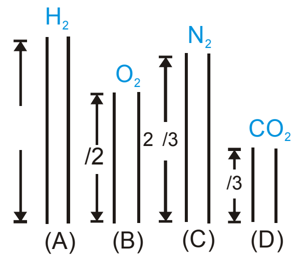
(A) Closed at one end, open at another with length =0.5 m

(B) Open at both ends, length = 1m

(C) Closed at both ends, length = 2m

(D) Closed at one end, open at another with length = 2/3 m

14. Four open organ pipes of different length and different gases at same temperature as shown in figure. Let f_A, f_B, f_C and f_D be their fundamental frequencies then:– [Take γ_{CO_2}=7/5]



(A) $f_A/f_B = \sqrt{2}$ **(B)** $f_B/f_C = \sqrt{72/28}$

(C) $f_C/f_D = \sqrt{11/28}$ **(D)** $f_D/f_A = \sqrt{76/11}$

15. P, Q and R are three particles of a medium which lie on the x-axis. A sine wave of wavelength λ is travelling through the medium in the x-direction. P and Q always have the same speed, while P and R always have the same velocity. The minimum distance between:–

(A) P and Q is $\frac{\lambda}{2}$ **(B)** P and Q is λ **(C)** P and R is $\frac{\lambda}{2}$ **(D)** P and R is λ

16. For a sine wave passing through a medium, let y be the displacement of a particle, v be its velocity and a be its acceleration:–

(A) y, v and a are always in the same phase **(B)** y and a are always in opposite phase

(C) Phase difference between y and v is $\frac{\pi}{2}$ **(D)** Phase difference between v and a is $\frac{\pi}{2}$

17. A plane progressive wave of frequency 25 Hz, amplitude 2.5 x 10^{-5} m and initial phase zero moves along the negative x-direction with a velocity of 300 m/s. A and B are two points 6m apart on the line of propagation of the wave. At any instant the phase difference between A and B is ϕ. The maximum difference in the displacements of particle at A and B is Δ.

(A) $\phi = \pi$ **(B)** $\phi = 0$ **(C)** $\Delta = 0$ **(D)** $\Delta = 5 \times 10^{-5}$ m

18. When an open organ pipe resonates in its fundamental mode then at the centre of the pipe:–

(A) The gas molecules undergo vibrations of maximum amplitude

(B) The gas molecules are at rest

(C) The pressure of the gas is constant

(D) The pressure of the gas undergoes maximum variation

19. The stationary waves set up on a string have the equation y = (2 mm) sin[(6.28 m^{-1})x]cos (ωt). This stationary wave is created by two identical waves, of amplitude A each, moving in opposite directions along the string:–

(A) A = 2 mm **(B)** A = 1 mm

(C) The smallest length of the string is 50 cm **(D)** The smallest length of the string is 2 m

20. Sounds from two identical sources S_1 and S_2 reach a point P. When the sounds reach directly, and in the same phase, the intensity at P is I_0. The power of S_1 is now reduced by 64% and the phase difference between S_1 and S_2 is varied continuously. The maximum and minimum intensities recorded at P are now I_{max} and I_{min}:–

(A) $I_{max} = 0.64 I_0$ **(B)** $I_{min} = 0.36\ I_0$ **(C)** $\frac{I_{max}}{I_{min}} = 16$ **(D)** $\frac{I_{max}}{I_{min}} = \frac{1.64}{0.36}$

Part # II [Assertion & Reason Type Questions]

These questions contains, Statement I (assertion) and Statement II (reason).

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for Statement–I

(C) Statement–I is true, Statement–II is false

(D) Statement–I is false, Statement–II is true

1. **Statement–I** : Standing waves do not transport energy in the medium.
Statement–II : In standing waves, every particle vibrates with its own energy and it does not share its energy with any other particle.

2. **Statement–I** : Sound travels faster in moist air.
Statement–II : The density of moist air is less then density of dry air.

3. **Statement–I** : Explosions on other planets are not heard on earth.
Statement–II : To hear distinct beats, difference in frequencies of two sources should be less than 10.

4. **Statement–I** : Ultrasonics is the acoustic analogue of ultraviolet radiation.
Statement–II : Ultraviolet rays do not produce visual sensations while ultrasonic waves are not heards by the human ear.

5. **Statement–I** : Vacuum is densest for sound and rarest for light.
Statement–II : A medium is said to be denser, when velocity of waves through this medium is smaller.

6. **Statement–I** : The superposition of the waves $y_1 = A \sin (kx - \omega t)$ and $y_2 = 3A \sin(kx + \omega t)$ is a pure standing wave plus a travelling wave moving in the negative direction along X–axis.
Statement–II : The resultant of y_1 & y_2 is $y=y_1+y_2 = 2A \sin kx \cos \omega t+2A \sin (kx+\omega t)$

7. **Statement–I** : Partially transverse waves are possible on a liquid surface.
Statement–II : Surface tension provide some rigidity on a liquid surface.

8. **Statement–I** : Infrasonic waves are generally produced by large vibrating bodies.
Statement–II : Infrasonic waves have frequency range lies below 20 Hz.

9. **Statement–I** : Mechanical transverse waves cannot be generated in gaseous medium.
Statement–II : Mechanical transverse waves can be produced only in such medium which have shearing property.

10. **Statement–I** : The flash of lightening is seen before the sound of thunder is heard.
Statement–II : The sound of thunder is produced after the flash of lightening.

11. **Statement–I** : Description of sound as pressure wave is preferred over displacement wave.
Statement–II : Sound sensors (ear or mike) detect pressure changes.

12. **Statement–I** : During thunderstorm, light is seen much earlier than the sound is heard
Statement–II : Light travels faster than sound.

13. **Statement–I** : Shock waves produced by supersonic aircraft may be visible.
Statement–II : The sudden decrease in air pressure in the shock waves caused water molecules in the air to condense, forming a fog.

14. **Statement–I** : Earthquakes cause vast devastation. Sometimes short and tall structures remain unaffected while the medium height structures fall.
Statement–II : The natural frequency of the medium structures coincides with the frequency of the seismic wave.

15. **Statement–I** : Waves generated in a metal piece can be transverse or longitudinal.
Statement–II : Waves generated depend upon the method of creating waves in the metal.

16. **Statement–I** : In the case of a stationary wave, a person hear a loud sound at the nodes as compared to the antinodes.
Statement–II : In a stationary wave all the particles of the medium vibrate in phase.

17. **Statement–I** : A balloon filled with CO_2 gas acts as a converging lens for a sound wave.
Statement–II : Sound waves travel faster in air than in CO_2.

18. **Statement–I** : If transverse waves are produced in a very long string fixed at one end. Near the free end only pro gressive wave is observed, in practice.
Statement–II : Energy of reflected wave does not reach the free end.

19. **Statement–I** : Node of pressure wave is formed at the open end of an organ pipe.
Statement–II : Due to huge volume of the atmosphere outside the tube, deformation in its volume is negligible.

20. **Statement–I** : The fundamental frequency of an organ pipe increases as the temperature increases.
Statement–II : As the temperature increases, the velocity of sound increases more rapidly than length of the pipe.

21. **Statement–I** : When two vibrating tuning forks have $f_1 = 300$ Hz and $f_2 = 350$ Hz and held close to each other; beats cannot be heard.
Statement–II : The principle of superposition is valid only when $f_1 - f_2 < 10$ Hz

Exercise # 3 Part # I [Matrix Match Type Questions]

1.

	Column I		Column II
(A)	$y = 4\sin(5x-4t)+3\cos(4t-5x+\pi/6)$	(P)	Particles at every position are performing SHM
(B)	$y = 10\cos\left(t-\frac{x}{330}\right)\sin(100)\left(t-\frac{x}{330}\right)$	(Q)	Equation of travelling wave
(C)	$y=10\sin(2\pi x-120t)+10\cos(120t+2\pi x)$	(R)	Equation of standing wave
(D)	$y=10\sin(2\pi x-120t)+8\cos(118t-59/30\pi x)$	(S)	Equation of Beats

2. From a single source, two wave trains are sent in two different strings. Strings–2 is 4 times heavy than string–1. The two wave equations are : (area of cross–section and tension of both strings is same) $y_1 = A\sin(\omega_1 t - k_1 x)$ and $y_2 = 2A\sin(\omega_2 t - k_2 x)$. Suppose u= energy density, P=power transmitted and I=intensity of the wave.

	Column I		Column II
(A)	u_1/u_2 is equal to	(P)	1/8
(B)	P_1/P_2 is equal to	(Q)	1/16
(C)	I_1/I_2 is equal to	(R)	1/4

3.

	Column I		Column II
(A)	Interference	(P)	Intensity varies periodically with time
(B)	Beats	(Q)	Intensity varies periodically with position
(C)	Echo	(R)	Reflection of waves
		(S)	Refraction of waves

4.

	Column I		Column II
(A)	Infrasonic	(P)	Speed is greater than speed of sound
(B)	Ultrasonic	(Q)	Frequency < 20 Hz
(C)	Audible (sonic)	(R)	Frequency > 20 kHz
(D)	Supersonic	(S)	20 Hz < frequency < 20 kHz

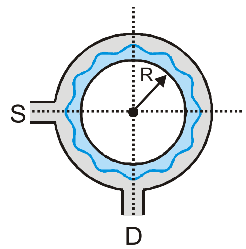
5.

	Column I		Column II
(A)	Pitch	(P)	Number of overtones
(B)	Quality	(Q)	Intensity
(C)	Loudness	(R)	Frequency
(D)	Musical interval	(S)	Difference of the frequencies of two notes
		(T)	Ratio of the frequencies of two notes

Part # II [Comprehension Type Questions]

Comprehension # 1

A narrow tube is bent in the form of a circle of radius R, as shown in the figure. Two small holes S and D are made in the tube at the positions right angle to each other. A source placed at S generated a wave of intensity I_0 which is equally divided into two parts : One part travels along the longer path, while the other travels along the shorter path. Both the parts waves meet at the point D where a detector is placed.



1. If a maxima is formed at the detector then, the magnitude of wavelength λ of the wave produced is given by :–

(A) πR **(B)** $\frac{\pi R}{2}$ **(C)** $\frac{\pi R}{4}$ **(D)** $\frac{\pi R}{3}$

2. If the minima is formed at the detector then, the magnitude of wavelength λ of the wave produced is given by:–

(A) πR **(B)** $\frac{3\pi R}{2}$ **(C)** $\frac{2\pi R}{3}$ **(D)** $\frac{2\pi R}{5}$

3. The maximum intensity produced at D is given by :–

(A) $4I_0$ **(B)** $2\,I_0$ **(C)** I_0 **(D)** $3I_0$

4. The maximum value of λ to produce a maxima at D is given by :–

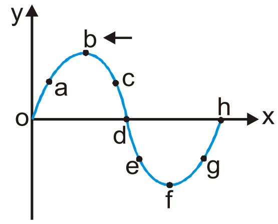
(A) πR **(B)** $2\pi R$ **(C)** $\frac{\pi R}{2}$ **(D)** $\frac{3\pi R}{2}$

5. The maximum value of λ to produce a minima at D is given by :–

(A) πR **(B)** $2\pi R$ **(C)** $\frac{\pi R}{2}$ **(D)** $\frac{3\pi R}{2}$

Comprehension # 2

The figure represents the instantaneous picture of a transverse harmonic wave travelling along the negative x-axis. Choose the correct alternative(s) related to the movement of the 9 points shown in the figure. (Instanteous velocity)



1. The points moving upward is/are :–

(A) a **(B)** c **(C)** f **(D)** g

2. The points moving downwards is/are :–

(A) o **(B)** b **(C)** d **(D)** h

3. The stationary points is/are:–

(A) o **(B)** b **(C)** f **(D)** h

4. The points moving with maximum velocity is/are:–

(A) b **(B)** c **(C)** d **(D)** h

5. A perfectly elastic uniform string is suspended vertically with its upper end fixed to the ceiling and the lower end loaded with the weight. If a transverse wave is imparted to the lower end of the string, the pulse will

(A) not travel along the length of the string

(B) travel upwards with increasing speed

(C) travel upwards with decreasing speed

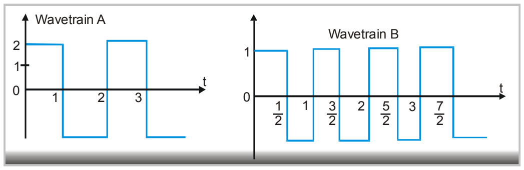
(D) travelled upwards with constant acceleration

Exercise # 4 [Subjective Type Questions]

1. Determine resultant amplitude after super position of given four waves with help of phasor diagram.
$y_1 = 15 \sin \omega t$ mm, $y_2 = 9 \sin (\omega t - \pi/2)$ mm, $y_3 = 7 \sin (\omega t + \pi/2)$ mm & $y_4 = -13 \sin \omega t$ mm

2. A stone dropped from the top of a tower of height 300 m high splashes into the water of a pond near the base of the tower. When is the splash heard at the top, given that the speed of sound in air is 340 m s^{-1} ? (g=9.8 ms^{-2})

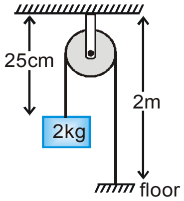
3. Calculate the ratio of intensity of wave train A to wave train B.



4. One end of a long string of linear mass density 8.0×10^{-3} kg m^{-1} is connected to an electrically driven tuning fork of frequency 256 Hz. The other end passes over a pulley and is tied to a pan containing a mass of 90 kg. The pulley end absorbs all the incoming energy so that reflected waves at this end have negligible amplitude. At t = 0, the left end (fork end) of the string x = 0 has zero transverse displacement (y = 0) and is moving along positive y–direction. The amplitude of the wave is 5.0 cm. Write down the transverse displacement y as function of x and t that describes the wave on the string.

5. Two audio speakers are kept some distance apart and are driven by the same amplifier system. A person is sitting at a place 6.0 m from one of the speakers and 6.4 m from the other. If the sound signal is continuously varied from 500 Hz to 5000 Hz, what are the frequencies for which there is a destructive interference at the place of the listener? Speed of sound in air = 320 m/s.

6. In the given figure the string has mass 4.5 g. Find the time taken by a transverse pulse produced at the floor to reach the pulley. (g = 10 ms^{-2}).



7. A steel wire of length 1m, mass 0.1 kg and uniform cross–sectional area 10^{-6} m^2 is rigidly fixed at both ends. The temperature of the wire is lowered by 20°C. If transverse waves are set up by plucking the string in the middle calculate the frequency of the fundamental mode of vibration.
[Given: $Y_{stell} = 2 \times 10^{11}$ N/m^2, $\alpha_{stell} = 1.21 \times 10^{-5}$/°C]

8. A uniform rope of length 12 m and mass 6 kg hangs vertically from a rigid support. A block of mass 2 kg is attached to the free end of the rope. A transverse pulse of wavelength 0.06 m is produced at the lower end of the rope. What is the wavelength of the pulse when it reaches the top of the rope ?

9.

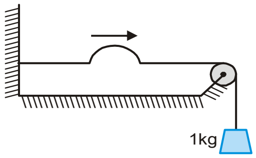


Figure shows a string of linear mass density 1.0 g/cm on which a wave pulse is travelling. Find the time taken by the pulse in travelling through a distance of 50 cm on the string. (g=10 m/s^2).

10. The vibrations of a string of length 60 cm fixed at both ends are represented by the equation :

$y = 4\sin\left(\frac{\pi x}{15}\right)\cos(96\pi t)$ where x and y are in cm and t in seconds.

(i) What is the maximum displacement of a point at x = 5 cm ?
(ii) Where are the nodes located along the string ?
(iii) What is the velocity of the particle at x = 7.5 cm at t = 0.25 s ?
(iv) Write down the equations of the component waves whose superposition gives the above wave

11. A string vibrate according to the equation $y = 5\sin\left(\frac{\pi x}{3}\right)\cos(40\pi t)$ where x and y are in cm's and t is in second.

(i) What is the equation of incident and reflected wave ? **(ii)** What is the distance between the adjacent nodes?

(iii) What is the velocity of the particle of the string at the position x = 1.5 cm when $t = \frac{9}{8}$ sec ?

12. A bat emits ultrasonic sound of frequency 1000 kHz in air. If the sound meets a water surface, what is the wavelength of **(i)** the reflected sound, **(ii)** the transmitted sound ? Speed of sound in air is 340 ms^{-1} and in water 1486 ms^{-1}.

13. If the bulk modulus of water is 4000 MPa, what is the speed of sound in water?

14. Given below are some functions of x and t to represent the displacement (transverse or longitudinal) of an elastic wave. State which of these represent (A) a travelling wave, (B) a stationary wave or (C) none at all :

(i) $y = \cos(3x)\sin(10t)$ **(ii)** $y = 2\sqrt{x - vt}$

(iii) $y = 3\sin(5x - 0.5t) + 4\cos(5x - 0.5t)$ **(iv)** $y = \cos x \sin t + \cos 2x \sin 2t$

15. Two successive resonant frequencies in an open organ pipe are 1944 and 2592 Hz. If the speed of sound in air 324 ms^{-1}, then find the length of tube.

16. A steel rod 100 cm long is clamped at its middle. The fundamental frequency of longitudinal vibrations of the rod are given to be 2.53 kHz. What is the speed of sound in steel ?

17. A flute which we treat as a pipe open at both ends is 60 cm long. How far from the mouth piece should a hole be uncovered for the fundamental frequency to be 330 Hz ? Take the speed of sound in air as 340 m/sec. And also calculate fundamental frequency when all the holes are covered ?

18. Two tunning fork having frequency. 300 Hz & 305 Hz produce beat phenomena. Then (i) How many beats produce in 5 sec. (ii) Determine minimum time interval in which maximum intensity become min.

19. A string 25 cm long and having a mass of 2.5 g is under tension. A pipe closed at one end is 40 cm long. When the string is set vibrating in its first overtone and the air in the pipe in its fundamental frequency. 8 beats/s are heard. It is observed that decreasing the tension in the string decreases the beat frequency. If the speed of sound in air is 320 m/s find the tension in the string.

20. A source of sound of frequency 256 Hz is moving rapidly towards a wall with a velocity of 5 m/s. How many beats per second will be heard by the observer on source it self if sound travels at a speed of 330 m/s ?

21. Two sitar strings A and B playing the note 'Dha' are slightly out of tune and produce beats of frequency 5 Hz. The tension of the string B is slightly increased and the beat frequency is found to decrease to 3 Hz. What is the original frequency of B if the frequency of A is 427 Hz ?

22. A car has two horns having a difference in frequency of 180 Hz. The car is approaching a stationary observer with a speed of 60 ms^{-1}. Calculate the difference in frequencies of the notes as heard by the observer, if velocity of sound in air is 330 ms^{-1}.

23. A person going away from a factory on his scooter at a speed of 36 km/hr listens to the siren of the factory. If the actual frequency of the siren is 700Hz and a wind is blowing along the direction of the scooter at 36 km/hr, find the observed frequency heard by the person. (Given speed of sound = 340 m/s)

24. Two tuning forks with natural frequencies of 340 Hz each move relative to a stationary observer. One fork moves away from the observer, While the other moves towards him at the same speed. The observer hears beats of frequency 3 Hz. Find the speed of the tuning fork. [Speed of sound = 330m/s]

25. A whistle emitting a sound of frequency 440 Hz is tied to a string of 1.5 m length and rotated with an angular velocity of 20 rad/s in the horizontal plane. Calculate the range of frequencies heard by an observer stationed at a large distance from the whistle. [Speed of sound = 330m/s]

26. A SONAR system fixed in a submarine operates at a frequency 40.0 kHz. An enemy submarine moves towards the SONAR with a speed of 360 km h^{-1}. What is the frequency of sound reflected by the submarine ? Take the speed of sound in water to be 1450 ms^{-1}.

27. A train approaching a hill at a speed of 40 km/h sounds a whistle of frequency 580 Hz when it is at a distance of 1 km from a hill. A wind with a speed of 40 km/h is blowing in the direction of motion of the train. Find

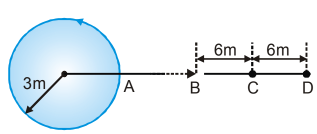
(i) The frequency of the whistle as heard by an observer on the hill.

(ii) The distance from the hill at which the echo from the hill is heard by the driver and its frequency.

(Velocity of sound in air = 1200 km/h)

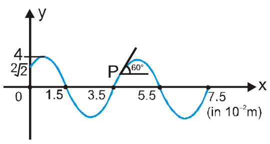
28. A sonometer wire under tension of 64 N vibrating in its fundamental mode is in resonance with a vibrating tuning fork. The vibrating portion of the sonometer wire has a length of 10 cm and mass of 1g. The vibrating tuning fork is now moved away from the vibrating wire with a constant speed and an observer standing near the sonometer hears one beat per second. Calculate the speed with which the tuning fork is moved, if the speed of sound in air is 300 m/s.

29. A source of sound is moving along a circular orbit of radius 3m with an angular velocity of 10 rad/s. A sound detector located far away from the source is executing linear simple harmonic motion along the line BD (see figure) with an amplitude BC = CD = 6 m. The frequency of oscillation of the detector is $\frac{5}{\pi}$ per second. The source is at the point A when the detector is at the point B. If the source emits a continuous sound wave of frequency 340 Hz, find the maximum and the minimum frequencies recorded by the detector. (Speed of sound = 340 m/s)



30. A train of length ℓ is moving with a constant sped v along a circular track of radius R, the engine of the train emits a whistle of frequency f. Find the frequency heard by a guard at the rear end of the train.

31. The figure shows a snap photograph of a vibrating string at t = 0. The particle P is observed moving up with velocity $20\sqrt{3}$ cm/s. The tangent at P makes an angle 60^0 with x–axis **(i)** Find the direction in which the wave is moving **(ii)** the equation of the wave **(iii)** the total energy carried by the wave per cycle of the string. [Assuming that μ, the mass per unit length of the string = 50 gm/m]



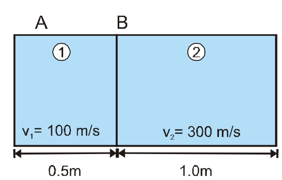
32. Two radio stations broadcast their programmes at the same amplitude A and at slightly different frequencies ω_1 and ω_2 respectively, where $\omega_1 - \omega_2 = 10^3$ Hz. A detector receives the signals from the two stations simultaneously. It can only detect signals of intensity $\geq 2A^2$.
(i) Find the time interval between successive maximum of the intensity of the signal received by the detector.
(ii) Find the time for which the detector remains idle in each cycle of the intensity of the signal

33. A band playing music at a frequency f is moving towards a wall at a speed v_b. A motorist is following the band with a speed v_m. If v is the speed of sound. Obtain an expression for the beat frequency heard by the motorist.

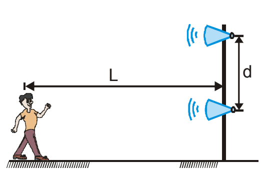
34. An open organ pipe filled with air has a fundamental frequency 500 Hz. The first harmonic of another organ pipe closed at one end and filled with carbon dioxide has the same frequency as that of the first harmonic of the open organ pipe. Calculate the length of each pipe. Assume that the velocity of sound in air and in carbondioxide to be 330 and 264 m/s respectively.

35. The harmonic wave $y_i = (2.0 \times 10^{-3}) \cos\pi (2.0x - 50t)$ travels along a string toward a boundary at x=0 with a second string. The wave speed on the second string is 50 m/s. Write expressions for reflected and transmitted waves. Assume SI units.

36. A cylinder ABC consists of two chambers 1 and 2 which contains two different gases. The wall C is rigid but the walls A and B are thin diaphragms. A vibrating tuning fork approaches the wall A with velocity u= 30 m/s and air columns in chamber 1 and 2 vibrates with minimum frequency such that there is node (displacement) at B and antinode (displacement) at A. Find :
(i) the fundamental frequency of air column
(ii) find the frequency of tuning fork.
Assume velocity of sound in the first and second chamber be 1100 m/s and 300 m/s respectively. Velocity of sound in air 330 m/s.

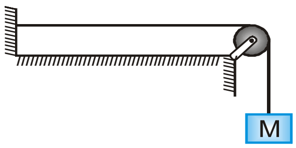


37. Two speakers are driven by the same oscillator with frequency of 200 Hz. They are located 4 m apart on a vertical pole. A man walks straight towards the lower speaker in a direction perpendicular to the pole, as shown in figure. **(i)** How many times will he hear a minimum in sound intensity, and **(ii)** how far is he from the pole at these moments? Take the speed of sound to be 330 m/s, and ignore any sound reflections coming off the ground.



38. The following equation represent transverse wave; $z_1 = A\cos(kx - \omega t)$, $z_2 = A\cos(kx + \omega t)$, $z_3 = A\cos(ky - \omega t)$
Identify the combination (s) of the waves which will produce. **(i)** standing wave (s) **(ii)** a wave travelling in the direction making an angle of 45° with the positive x and positive y–axis. In each case, find the position at which the resultant intensity is always zero.

39. A string of length 1 m fixed at one end and on the other end a block of mass M = 4 kg is suspended. The string is set into vibration and represented by equation $y = 6\sin\left(\frac{\pi x}{10}\right)\cos(100\pi t)$ where x and y are in cm and t is in seconds.



(i) Find the number of loops formed in the string .

(ii) Find the maximum displacement of a point at x=5/3 cm

(iii) Calculate the maximum kinetic energy of the string

(iv) Write down the equations of the component waves whose superposition gives the wave.

40. A metallic rod of length 1m is rigidly clamped at its mid point. Longitudinal stationary waves are setup in the rod in such a way that there are two nodes on either side of the midpoint. The amplitude of an antinode is 2×10^{-6}m. Write the equation of motion at a point 2 cm from the midpoint and those of the constituent waves in the rod. (Young's modulus of the material of the rod = 2×10^{11} Nm^{-2}; density = 8000 kg–m^{-3}). Both ends are free.

41. The displacement of the medium in a sound wave is given by the equation y_1 = Acos(ax + bt) where A, a and b are positive constants. The wave is reflected by an obstacle situated a x = 0. The intensity of the reflected wave is 0.64 times that of the incident wave.

(i) What are the wavelength and frequency of incident wave ?

(ii) Write the equation for the reflected wave.

(iii) In the resultant wave formed after reflection, find the maximum and minimum values of the particle speeds in the medium.

(iv) Express the resultant wave as a superposition of a standing wave and a travelling wave.

What are the positions of the antinodes of the standing wave ?

What is the direction of propagation of travelling wave?

42. A parabolic pulse given by equation y (in cm) = 0.3 – 0.1 $(x - 5t)^2$ $(y \geq 0)$ travelling in a uniform string. The pulse passes through a boundary beyond which its velocity becomes 2.5 m/s. What will be the amplitude of pulse in this medium after transmission?

Exercise # 5 Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

1. Tube A has both ends open while tube B has one end closed, otherwise they are identical. The ratio of fundamental frequency of tubes A and B is- **[AIEEE - 2002]**
(1) 1 : 2 (2) 1 : 4 (3) 2 : 1 (4) 4 : 1

2. A tuning fork arrangement (pair) produces 4beats/s with one fork of frequency 288 cps. A little wax is placed on the unknown fork and it then produces 2 beats/s. The frequency of the unknown fork is- **[AIEEE - 2002]**
(1) 286 cps (2) 292 cps (3) 294 cps (4) 288 cps

3. A wave y = asin(ωt – kx) on a string meets with another wave producing a node at x = 0. Then the equation of the unknown wave is- **[AIEEE-2002]**
(1) y = asin(ωt + kx) (2) y = – asin(ωt + kx) (3) y = asin(ωt – kx) (4) y = – asin(ωt – kx)

4. Length of a string tied to two rigid supports is 40 cm. Maximum length (wavelength in cm) of a stationary wave produced on it, is- **[AIEEE-2002]**
(1) 20 (2) 80 (3) 40 (4) 120

5. The displacement y of a wave travelling in the x-direction is given by $y = 10^{-4}\sin\left(600t - 2x + \frac{\pi}{3}\right)$ metre, where, x is expressed in metres and t in seconds. The speed of the wave-motion, in ms^{-1} is- **[AIEEE-2003]**
(1) 300 (2) 600 (3) 1200 (4) 200

6. A tuning fork of known frequency 256 Hz makes 5 beats per second with the vibrating string of a piano. The beat frequency decreases to 2 beats per second when the tension in the piano string is slightly increased. The frequency of the piano string before increasing the tension was- **[AIEEE-2003]**
(1) (256+2) Hz (2) (256–2) Hz (3) (256–5) Hz (4) (256+5) Hz

7. When two tuning forks (fork 1 and fork 2) are sounded simultaneously, 4 beats per second are heard. Now, some tape is attached on the prong of the fork 2. When the tuning forks are sounded again, 6 beats per second are heard. If the frequency of fork 1 is 200 Hz, then what was the original frequency of fork 2? **[AIEEE - 2005]**
(1) 200 Hz (2) 202 Hz (3) 196 Hz (4) 204 Hz

8. An observer moves towards a stationary source of sound, with a velocity one-fifth of the velocity of sound. what is the percentage increase in the apparent frequency ? **[AIEEE - 2005]**
(1) zero (2) 0.5% (3) 5% (4) 20%

9. 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 hear frequencies upto a maximum of 10,000 Hz, the maximum value of v upto which he can hear the whistle is- **[AIEEE - 2006]**
(1) $15\sqrt{2}$ ms^{-1} (2) $15/\sqrt{2}$ ms^{-1} (3) 15 ms^{-1} (4) 30 ms^{-1}

10. A sound absorber attenuates the sound level by 20 dB. The intensity decreases by a factor of- **[AIEEE - 2007]**
(1) 1000 (2) 10000 (3) 10 (4) 100

11. While measuring the speed of sound by performing a resonance column experiment, a student gets the first resonance condition at column length of 18 cm during winter. Repeation the same experiment during sumer, student measures the column length to be x cm for the second resonance. Then **[AIEEE - 2008]**
(1) 18 > x (2) x > 54 (3) 54 > x > 36 (4) 36 > x > 18

12. A wave travelling along the x-axis is described by the equation y (x, t) = 0.005 cos (αx – βt). If the wavelength and the time period of the wave in 0.08m and 2.0 s respectively then α and β in appropriate units are **[AIEEE - 2008]**
(1) $\alpha = 25.00\pi, \beta = \pi$ (2) $\alpha = \frac{0.08}{\pi}, \beta = \frac{2.0}{\pi}$ (3) $\alpha = \frac{0.04}{\pi}, \beta = \frac{1.0}{\pi}$ (4) $\alpha = 12.50\pi, \beta = \frac{\pi}{2.0}$

13. Three sound waves of equal amplitudes have frequencies (ν–1), ν, (ν+1). They superpose to give beats. The number of beats produced per second will be :- **[AIEEE - 2009]**

(1) 2 **(2)** 1 **(3)** 4 **(4)** 3

14. A motor cycle starts from rest and accelerates along a straight path at 2 m/s^2. At the starting point of the motor cycle there is a stationary electric siren. How far has the motor cycle gone when the driver hears the frequency of the siren at 94% of its value when the motor cycle was at rest ? (Speed of sound = 330 ms^{-1}) :-**[AIEEE - 2009]**

(1) 147 m **(2)** 196 m **(3)** 49 m **(4)** 98 m

15. The equation of a wave on a string of linear mass density 0.04 kg m^{-1} is given by y = 0.02(m) sin $\left[2\pi\left(\frac{t}{0.04(s)}-\frac{x}{0.50(m)}\right)\right]$. The tension in the string is : **[AIEEE - 2010]**

(1) 6.25 N **(2)** 4.0 N **(3)** 12.5 N **(4)** 0.5 N

16. The transverse displacement y(x, t) of a wave on a string is given by $y(x,t)=e^{-\left(ax^2+bt^2+2\sqrt{ab}xt\right)}$. This represents a :- **[AIEEE - 2011]**

(1) standing wave of frequency $\sqrt{b}$ **(2)** standing wave of frequency $\frac{1}{\sqrt{b}}$

(3) wave moving in +x directionwith speed $\sqrt{\frac{a}{b}}$ **(4)** wave moving in –x direction with speed $\sqrt{\frac{b}{a}}$

17. **Statement-1:** Two longitudinal waves given by equations : $y_1(x, t) = 2a \sin(\omega t - kx)$ and $y_2(x, t) = a \sin(2\omega t - 2kx)$ will have equal intensity.

Statement-2: Intensity of waves of given frequency in same medium is proportional to square of amplitude only. **[AIEEE - 2011]**

(1) Statement-1 is false, statement-2 is true
(2) Statement-1 is ture, statement-2 is false
(3) Statement-1 is ture, statement-2 true; statement-2 is the correct explanation of statement-1
(4) Statement-1 is true, statement-2 is true; statement -2 is not correct explanation of statement-1.

18. A travelling wave represented by y = A sin(ωt–kx) is superimposed on another wave represented by y = A sin (ωt + kx). The resultant is :- **[AIEEE-2011]**

(1) A standing wave having nodes at $x=\left(n+\frac{1}{2}\right)\frac{\lambda}{2}, n=0,1,2$
(2) A wave travelling along + x direction
(3) A wave travelling along –x direction
(4) A standing wave having nodes at $x=\frac{n\lambda}{2}$; n = 0, 1, 2

19. A cylindrical tube, open at both ends, has a fundamental frequency, f, in air. The tube is dipped vertically in water so that half of it is in water. The fundamental frequency of the air-column is now :- **[AIEEE-2012]**

(1) 2f **(2)** f **(3)** f/2 **(4)** 3f/4

20. A sonometer wire of length 1.5m is made of steel. The tension in it produces an elastic strain of 1%. What is the fundamental frequency of steel if density and elasticity of steel are 7.7×10^3 kg/m^3 and 2.2×10^{11} N/m^2 respectively? **[AIEEE-2013]**

(1) 188.5 Hz **(2)** 178.2 Hz **(3)** 200.5 Hz **(4)** 770 Hz

21. A train is moving on a straight track with speed 20 ms^{-1}. It is blowing its whistle at the frequency of 1000 Hz. The percentage change in the frequency heard by a person standing near the track as the train passes him is (speed of sound = 320 ms^{-1}) close to : **[JEE (Main) -2015]**

(1) 18% **(2)** 24% **(3)** 6% **(4)** 12%

22. A uniform string of length 20 m is suspended from a rigid support. A short wave pulse is introduced at its lowest end. It starts moving up the string. The time taken to reach the support is : (take g = 10 ms^{-2} **[JEE (Main) -2016]**

(1) 2 s **(2)** $2\sqrt{2}$ s **(3)** $\sqrt{2}$ s **(4)** $2\pi\sqrt{2}$ s

Part # II [Previous Year Questions][IIT-JEE ADVANCED]

MCQ's with one correct answer

1. A string of length 0.4 m and mass 10^{-2} kg is tightly clamped at its ends. The tension in the string is 1.6 N. Identicals wave pulses are produced at one end at equal intervals of time Δt. The minimum value of Δt, which allows constructive interference between successive pulses, is :– **[IIT-JEE 1998]**

(A) 0.05 s **(B)** 0.10 s **(C)** 0.20 s **(D)** 0.40 s

2. A train moves towards a stationary observer with speed 34 m/s. The train sounds a whistle and its frequency registered by the observer is f_1. If the train's speed is reduced to 17 m/s, the frequency registered is f_2. If the speed of sound is 340 m/s then the ratio $\frac{f_1}{f_2}$ is :– **[IIT-JEE 2000]**

(A) $\frac{18}{19}$ **(B)** $\frac{1}{2}$ **(C)** 2 **(D)** $\frac{19}{18}$

3. Two vibrating strings of the same material but of lengths L and 2L have radii 2r and r respectively. They are stretched under the same tension. Both the strings vibrate in their fundamental modes, the one of length L with frequency f_1 and the other with frequency f_2. The ratio $\frac{f_1}{f_2}$ is given by :– **[IIT-JEE 2000]**

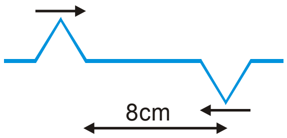
(A) 2 **(B)** 4 **(C)** 8 **(D)** 1

4. The ends of a stretched wire of length L are fixed at x=0 and x = L. In one experiment the displacement of the wire is $y_1 = A\sin\left(\frac{\pi x}{L}\right)\sin\omega t$ and energy is E_1 and in other experiment its displacement is $y_2 = A\sin\left(\frac{2\pi x}{L}\right)\sin 2\omega t$ and energy is E_2. Then :– **[IIT-JEE 2001]**

(A) $E_2 = E_1$ **(B)** $E_2 = 2E_1$ **(C)** $E_2 = 4E_1$ **(D)** $E_2 = 16E_1$

5. Two pulses in a stretched string, whose centres are initially 8 cm apart, are moving towards each other as shown in the figure. The speed of each pulse is 2 cm/s. After 2 s the total energy of the pulses will be :– **[IIT-JEE 2001]**

(A) Zero
(B) Purely kinetic
(C) Purely potential
(D) Partialy kinetic and partialy potential



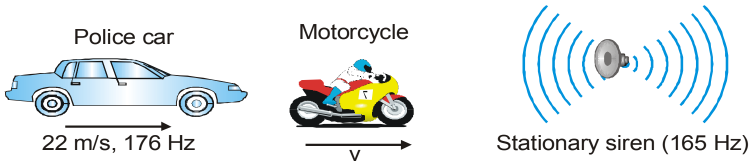
6. A siren placed at a railway platform is emitting sound of frequency 5 kHz. A passenger sitting in a moving train A records a frequency of 5.5 kHz, while the train approaches the siren. During his return journey in a different train B he records a frequency of 6.0 kHz while approaching the same siren. The ratio of the velocity of train B to that train A is :– **[IIT-JEE 2002]**

(A) $\frac{242}{252}$ **(B)** 2 **(C)** $\frac{5}{6}$ **(D)** $\frac{11}{6}$

7. A sonometer wire resonates with a given tuning fork forming standing waves with five antinodes between the two bridges when a mass of 9 kg is suspended from the wire. When this mass is replaced by mass M. The wire resonates with the same tuning fork forming three antinodes for the same positions of the bridges. The value of M is :– **[IIT-JEE 2002]**

(A) 25 kg **(B)** 5 kg **(C)** 12.5 kg **(D)** $\frac{1}{25}$ kg

8. A police car moving at 22 m/s chases a motocyclist. The police man sounds his horn at 176 Hz, while both of them move towards a stationary siren of frequency 165 Hz. Calculate the speed of the motorcycle. If it is given that the motorcyclist does not observe any beats :– **[IIT-JEE 2003]**



(A) 33 m/s **(B)** 22 m/s **(C)** zero **(D)** 11 m/s

9. In the experiment for the determination of the speed of sound in air using the resonance column method, the length of the air column that resonates in the fundamental mode, with a tuning fork is 0.1 m. When this length is changed to 0.35 m, the same tuning fork resonates with the first overtone. Calculate the end correction :– **[IIT-JEE 2003]**

(A) 0.012 m **(B)** 0.025 m **(C)** 0.05 m **(D)** 0.024 m

10. A source of sound of frequency 600 Hz is placed inside water. The speed of sound in water is 1500 m/s and in air it is 300 m/s. The frequency of sound recorded by an observer who is standing in air is :– **[IIT-JEE 2004]**

(A) 200 Hz **(B)** 3000 Hz **(C)** 120 Hz **(D)** 600 Hz

11. A closed organ pipe of length L and an open organ pipe contain gases of densities ρ_1 and ρ_2 respectively. The compressibility of gases are equal in both the pipes. Both the pipes are vibrating in their first overtone with same frequency. The length of the open organ pipe is :– **[IIT-JEE 2004]**

(A) $\frac{L}{3}$ **(B)** $\frac{4L}{3}$ **(C)** $\frac{4L}{3}\sqrt{\frac{\rho_1}{\rho_2}}$ **(D)** $\frac{4L}{3}\sqrt{\frac{\rho_2}{\rho_1}}$

12. A source emits sound of frequency 600 Hz inside water. The frequency heard in air will be equal to (velocity of sound in water = 1500 m/s, velocity of sound in air = 300 m/s) :– **[IIT-JEE 2004]**

(A) 3000 Hz **(B)** 120 Hz **(C)** 600 Hz **(D)** 6000 Hz

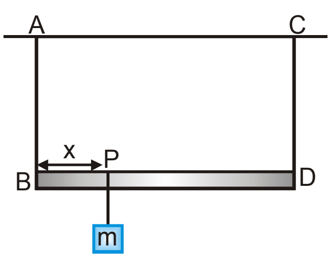
13. An open pipe is in resonance in 2nd harmonic with frequency f_1. Now one end of the tube is closed and frequency is increased to f_2 such that the resonance again occurs in nth harmonic. Choose the correct option :–**[IIT-JEE 2005]**

(A) $n = 3,\ f_2 = \frac{3}{4}f_1$ **(B)** $n = 3,\ f_2 = \frac{5}{4}f_1$ **(C)** $n = 5,\ f_2 = \frac{5}{4}f_1$ **(D)** $n = 5,\ f_2 = \frac{3}{4}f_1$

14. A tuning fork of 512 Hz is used to produce resonance in a resonance tube experiment. The level of water at first resonance is 30.7 cm and at second resonance is 63.2 cm. The error in calculating velocity of sound is :–

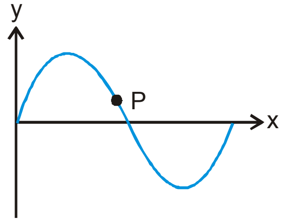
(A) 204.1 cm/s **(B)** 110 cm/s **(C)** 58 cm/s **(D)** 280 cm/s **[IIT-JEE 2005]**

15. A massless rod BD is suspended by two identical massless strings AB and CD of equal lengths. A block of mass m is suspended at point P such that BP is equal to x, if the fundamental frequency of the left wire is twice the fundamental frequency of right wire, then the value of x is :– **[IIT-JEE 2006]**



(A) $\frac{\ell}{5}$ **(B)** $\frac{\ell}{4}$ **(C)** $\frac{4\ell}{5}$ **(D)** $\frac{3\ell}{4}$

16. A transverse sinusoidal wave moves along a string in the positive x–direction at a speed of 10 cm/s. The wavelength of the wave is 0.5 m and its amplitude is 10 cm. At a particular time t, the snap–shot of the wave is shown in figure. The velocity of point P when its displacement is 5 cm is :– **[IIT-JEE 2008]**



(A) $\frac{\sqrt{3}\pi}{50}\tilde{j}$ m/s **(B)** $-\frac{\sqrt{3}\pi}{50}\tilde{j}$ m/s **(C)** $\frac{\sqrt{3}\pi}{50}\tilde{i}$ m/s **(D)** $-\frac{\sqrt{3}\pi}{50}\tilde{i}$ m/s

17. A vibrating string of certain length ℓ under a tension T resonates with a mode corresponding to the first overtone (third harmonic) of an air column of length 75 cm inside a tube closed at one end. The string also generates 4 beats per second when excited along with a tuning fork of frequency n. Now when the tension of the string is slightly increased the number of beats reduces to 2 per second. Assuming the velocity of sound in air to be 340 m/s, the frequency n of the tuning fork in Hz is. **[IIT-JEE 2008]**

(A) 344 **(B)** 336 **(C)** 117.3 **(D)** 109.3

MCQS (one or more than one answer may be correct)

1. The (x, y) coordinates of the corners of a square plate are (0, 0), (L, 0), (L, L) and (0, L). The edges of the plate are clamped and transverse standing waves are set–up in it. If u(x, y) denotes the displacement of the plate at the point (x, y) at some instant of time, the possible expression (s) for u is (are) (a = positive constant) :– **[IIT-JEE 1998]**

(A) $a\cos\left(\frac{\pi x}{2L}\right)\cos\left(\frac{\pi y}{2L}\right)$ **(B)** $a\sin\left(\frac{\pi x}{L}\right)\sin\left(\frac{\pi y}{L}\right)$ **(C)** $a\sin\left(\frac{\pi x}{L}\right)\sin\left(\frac{2\pi y}{L}\right)$ **(D)** $a\cos\left(\frac{2\pi x}{L}\right)\sin\left(\frac{\pi y}{L}\right)$

2. A transverse sinusoidal wave of amplitude a, wavelength λ and frequency f is travelling on a stretched string. The maximum speed of any point on the string is $\frac{v}{10}$, where v is the speed of propagation of the wave. If $a = 10^{-3}$ m and v = 10 m/s, then λ and f are given by :– **[IIT-JEE 1998]**

(A) $\lambda = 2\pi \times 10^{-2}$ m **(B)** $\lambda = 10^{-3}$ m **(C)** $f = \frac{10^3}{2\pi}$ Hz **(D)** $f = 10^4$ Hz

3. As a wave propagates :– **[IIT-JEE 1999]**

(A) The wave intensity remains constant for a plane wave

(B) The wave intensity decreases as the inverse of the distance from the source for a spherical wave

(C) The wave intensity decreases as the inverse square of the distance from the source for a spherical wave

(D) Total intensity of the spherical wave over the spherical surface centred at the source remains constant at all time

4. $y(x,t)=\frac{0.8}{[(4x+5t)^2+5]}$ represents a moving pulse where x and y are in metres and t in second. Then:

(A) pulse is moving in positive x–direction **[IIT-JEE 1999]**

(B) in 2 s it will travel a distance of 2.5 m

(C) its maximum displacement is 0.16 m

(D) it is a symmetric pulse

5. In a wave motion y=asin(kx – ωt), y can represent :– **[IIT-JEE 1999]**

(A) electric field **(B)** magnetic field **(C)** displacement **(D)** pressure

6. Standing wave can be produced :– **[IIT-JEE 1999]**

(A) on a string clamped at both ends

(B) on a string clamped at one end and free at the other

(C) when incident wave gets reflected from a wall

(D) when two identical waves with a phase difference of π are moving in the same direction

7. A horizontal stretched string, fixed at two ends, is vibrating in its fifth harmonic according to the equation, $y(x, t) = (0.01m) \sin [(62.8\ m^{-1})x]\cos [(628\ s^{-1})t]$. Assuming p = 3.14, the correct statement(s) is (are)

(A) The number of nodes is 5. **[IIT-JEE 2013]**

(B) The length of the string is 0.25 m.

(C) The maximum displacement of the midpoint of the string, from its equilibrium position is 0.01m.

(D) The fundamental frequency is 100 Hz.

8. One end of a taut string of length 3m along the x axis is fixed at x = 0. The speed of the waves in the string is 100 ms^{-1}. The other end of the string is vibrating in the y direction so that stationary waves are set up in the string. The possible waveform(s) of these stationary waves is (are) **[IIT-JEE 2014]**

(A) $y(t) = A\sin\frac{\pi x}{6}\cos\frac{50\pi t}{3}$ **(B)** $y(t) = A\sin\frac{\pi x}{3}\cos\frac{100\pi t}{3}$

(C) $y(t) = A\sin\frac{5\pi x}{6}\cos\frac{250\pi t}{3}$ **(D)** $y(t) = A\sin\frac{5\pi x}{2}\cos 250\pi t$

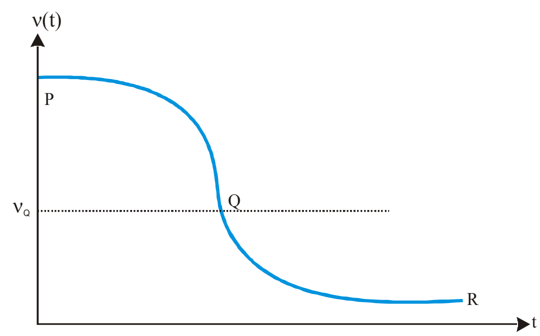
9. Two loudspeakers M and N are located 20 m apart and emit sound at frequencies 118 Hz and 121 Hz, respectively. A car is initially at a point P, 1800 m away from the midpoint Q of the line MN and moves towards Q constantly at 60 km/hr along the perpendicular bisector of MN. It crosses Q and eventually reaches a point R, 1800 m away from Q. Let ν(t) represent the beat frequency measured by a person sitting in the car at time t. Let ν_P, ν_Q and ν_R be the beat frequencies measured at locations P, Q and R, respectively.

The speed of sound in air is 330 m s*ƒ*{1. Which of the following statement(s) is(are) true regarding the sound heard by the person? **[IIT-JEE 2016]**

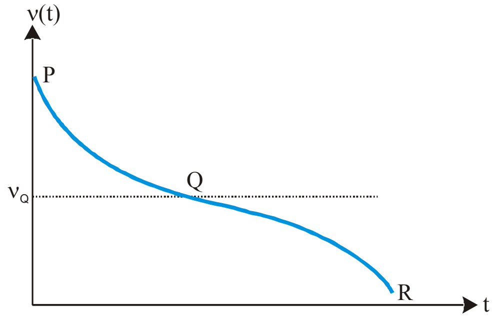
(A) $\nu_P + \nu_R = 2\nu_Q$

(B) The rate of change in beat frequency is maximum when the car passes through Q

(C) The plot below represents schematically the variation of beat frequency with time



(D) The plot below represents schematically the variation of beat frequency with time



Comprehension Based Question

Comprehension#1 **[IIT-JEE 2006]**

Two plane harmonic sound waves are expressed by the equations.

y_1 (x, t) = Acos(0.5πx – 100πt), y_2 (x, t) = Acos(0.46πx – 92πt) (All parameters are in MKS) :

1. How many times does an observer hear maximum intensity in one second :–

(A) 4 **(B)** 10 **(C)** 6 **(D)** 8

2. What is the speed of the sound :–

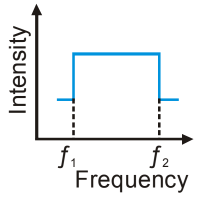
(A) 200 m/s **(B)** 180 m/s **(C)** 192 m/s **(D)** 96 m/s

3. At x = 0 how many times the amplitude of $y_1 + y_2$ is zero in one second :–

(A) 192 **(B)** 48 **(C)** 100 **(D)** 96

Comprehension#2

Two trains A and B are moving with speed 20 m/s and 30 m/s respectively in the same direction on the same straight track, with B ahead of A. The engines are at the front ends. The engine of train A blows a long whistle. Assume that the sound of the whistle is composed of components varying in frequency from f_1 = 800 Hz to f_2 = 1120 Hz, as shown in the figure. The spread in the frequency (highest frequency–lowest frequency) is thus 320 Hz. The speed of sound in still air is 340 m/s. **[IIT-JEE 2007]**



1. The speed of sound of the whistle is :–

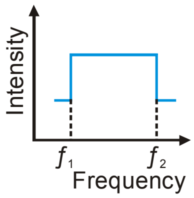
(A) 340 m/s for passengers in A and 310 m/s for passengers in B

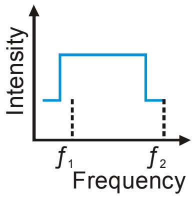
(B) 360 m/s for passengers in A and 310 m/s for passengers in B

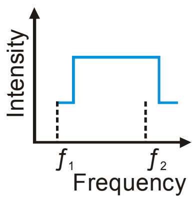
(C) 310 m/s for passengers in A and 360 m/s for passengers in B

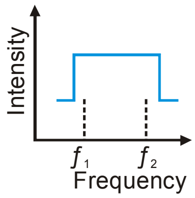
(D) 340 m/s for passengers in both the trains

2. The distribution of the sound intensity of the whistle as observed by the passengers in train A is best represented by

(A)


(B)


(C)


(D)


3. The spread of frequency as observed by the passengers in train B is :–

(A) 310 Hz **(B)** 330 Hz **(C)** 350 Hz **(D)** 290 Hz

Subjective Questions

1. The air column in a pipe closed at one end is made to vibrate in its second overtone by tuning fork of frequency 440 Hz. The speed of sound in air is 330 m/s. End corrections may be neglected. Let P_0 denote the mean pressure at any point in the pipe and ΔP_0 the maximum amplitude of pressure variation. **[IIT-JEE 1998]**

(i) Find the length L of the air column.

(ii) What is the amplitude of pressure variation at the middle of the column ?

(iii) What are the maximum and minimum pressures at the open end of the pipe ?

(iv) What are the maximum and minimum pressures at the closed end of the pipe ?

2. A long wire PQR is made by joining two wires PQ and QR of equal radii. PQ has length 4.8 m and mass 0.06 kg. QR has length 2.56 m and mass 0.2 kg. The wire PQR is under a tension of 80 N. A sinusoidal wave pulse of amplitude 3.5 cm is sent along the wire PQ from the end P. No power is dissipated during the propagation of the wave pulse. Calculate : **(i)** The time taken by the wave pulse to reach the other end R and **(ii)** The amplitude of the reflected and transmitted wave pulse after the incident wave pulse crosses the joint Q. **[IIT-JEE 1999]**

3. A 3.6 m long pipe resonates with a source of frequency 212.5 Hz when water level is at certain heights in the pipe. Find the heights of water level (from the bottom of the pipe) at which resonance occur. Neglect end correction. Now the pipe is filled to a height H ($\approx$ 3.6 m). A small hole is drilled very close to its bottom and water is allowed to leak. Obtain an expression for the rate of fall of water level in the pipe as a function of H. If the radii of the pipe and the hole are 2×10^{-2} m and 1×10^{-3} m respectively. Calculate the time interval between the occurrence of first two resonance. Speed of sound in air is 340 m/s and $g = 10\ m/s^2$. **[IIT-JEE 2010]**

4. A boat is travelling in a river with a speed 10 m/s along the stream flowing with a speed 2 m/s. From this boat a sound transmitter is lowered into the river through a rigid support. The wavelength of the sound emitted from the transmitter inside the water is 14.45 mm. Assume that attenuation of sound in water and air is negligible. **[IIT-JEE 2001]**

(i) What will be the frequency detected by a receiver kept inside the river downstream ?

(ii) The transmitter and the receiver are now pulled up into air. The air is blowing with a speed 5 m/s in the direction opposite the river stream. Determine the frequency of the sound detected by the receiver. (Temperature of the air and water = 20°C; Density of river water = 103 kg/m^3 ; Bulk modulus of the water = 2.088 × 109 Pa; Gas constant R = 8.31 J/mol–K; Mean molecular mass of air = 28.8 × 10–3 kg/mol; C_P/C_V for air = 1.4)

5. Two narrow cylindrical pipes A and B have the same length. Pipe A is open at both ends and is filled with a monatomic gas of molar mass MA. Pipe B is open at one end and closed at the other end, and is filled with a diatomic gas of molar mass MB. Both gases are at the same temperature. **[IIT-JEE 2002]**

(i) If the frequency to the second harmonic of the fundamental mode in pipe A is equal of the frequency of the third harmonic of the fundamental mode in pipe B, determine the value of M_A/M_B.

(ii) Now the open end of the pipe B is closed (so that the pipe is closed at both ends).
Find the ratio of the fundamental frequency in pipe A to that in pipe B.

6. In a resonance tube experiment to determine the speed of sound in air, a pipe of diameter 5 cm is used. The air column in pipe resonates with a tuning fork of frequency 480 Hz when the minimum length of the air column is 16 cm. Find the speed of sound in air at room temperature. **[IIT-JEE 2003]**

7. A string of mass per unit length μ is clamped at both ends such that one end of the string is at x = 0 and the other is at $x = \ell$. When string vibrates in fundamental mode, amplitude of the midpoint O of the string is a, tension in the string is T and amplitude of vibration is A. Find the total oscillation energy stored in the string. **[IIT-JEE 2003]**

8. An observer standing on a railway crossing receives frequency of 2.2 kHz and 1.8 kHz when the train approaches and recedes from the observer. Find the velocity of the train. (The speed of the sound in air is 300 m/s) **[IIT-JEE 2005]**

9. A harmonically moving transverse wave on a string has a maximum particle velocity and acceleration of 3 m/s and 90 m/s^2 respectively. Velocity of the wave is 20 m/s. Find the waveform. **[IIT-JEE 2005]**

10. A 20 cm long string having a mass of 1.0 g, is fixed at both the ends. The tension in the string is 0.5 N. The string is set into vibrations using an external vibrator of frequency 100 Hz. Find the separation (in cm) between the successive nodes on the string. **[IIT-JEE 2009]**

MOCK TEST : STRING WAVE

SECTION - I : STRAIGHT OBJECTIVE TYPE

1. A travelling wave $y = A \sin (kx - \omega t + \theta)$ passes from a heavier string to a lighter string. The reflected wave has amplitude 0.5 A. The junction of the strings is at x = 0. The equation of the reflected wave is:

(A) $y' = 0.5 A \sin (kx + \omega t + \theta)$
(B) $y' = -0.5 A \sin (kx + \omega t + \theta)$
(C) $y' = -0.5 A \sin (\omega t - kx - \theta)$
(D) $y' = -0.5 A \sin (kx + \omega t - \theta)$

2. Which of the following travelling wave will produce standing wave, with node at x = 0, when superimposed on $y = A \sin (\omega t - kx)$

(A) $A \sin (\omega t + kx)$
(B) $A \sin (\omega t + kx + \pi)$
(C) $A \cos (\omega t + kx)$
(D) $A \cos (\omega t + kx + \pi)$

3. A wire of length 'ℓ' having tension T and radius 'r' vibrates with fundamental frequency 'f'. Another wire of the same metal with length '2ℓ' having tension 2 T and radius 2 r will vibrate with fundamental frequency:

(A) f
(B) 2 f
(C) $\frac{f}{2\sqrt{2}}$
(D) $\frac{f}{2}\sqrt{2}$

4. A string of length 1.5 m with its two ends clamped is vibrating in fundamental mode. Amplitude at the centre of the string is 4 mm. Distances between the two points having amplitude 2 mm is:

(A) 1 m
(B) 75 cm
(C) 60 cm
(D) 50 cm

5. Two particles of medium disturbed by the wave propagation are at $x_1 = 0$ and $x_2 = 1$cm. The respective displacements (in cm) of the particles can be given by the equations :

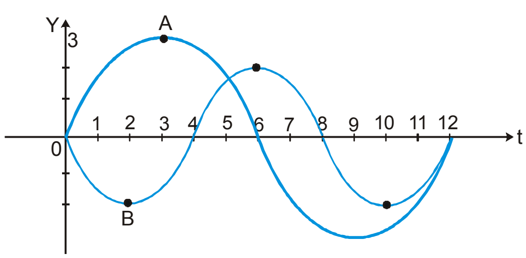
$y_1 = 2\sin 3\pi t$

$y_2 = 2\sin(3\pi t - \pi/8)$

The wave velocity is :

(A) 16 cm/sec
(B) 24 cm/sec
(C) 12 cm/sec
(D) 8 cm/sec.

6. The displacement Vs time graph for two waves A and B which travel along the same string are shown in the figure. Their intensity ratio I_A / I_B is

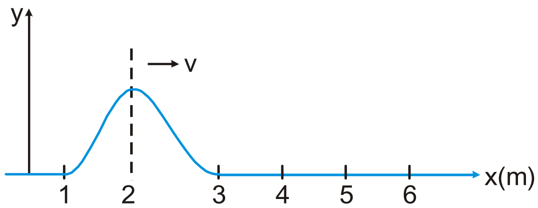


(A) $\frac{9}{4}$
(B) 1
(C) $\frac{81}{16}$
(D) $\frac{3}{2}$

7. At t = 0, a transverse wave pulse travelling in the positive x direction with a speed of 2 m/s in a wire is described by the function $y = \frac{6}{x^2}$, given that $x \neq 0$. Transverse velocity of a particle at x = 2m and t = 2 seconds is :

(A) 3 m/s
(B) – 3 m/s
(C) 8 m/s
(D) – 8 m/s

8. Wave pulse on a string shown in figure is moving to the right without changing shape. Consider two particles at positions x_1 = 1.5 m and x_2 = 2.5 m. Their transverse velocities at the moment shown in figure are along directions :



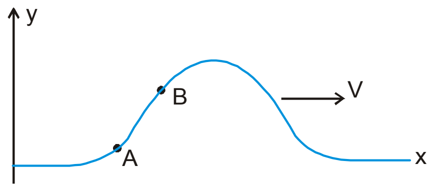
(A) positive y–axis and positive y–axis respectively

(B) negative y–axis and positive y–axis respectively

(C) positive y–axis and negative y–axis respectively

(D) negative y–axis and negative y–axis respectively

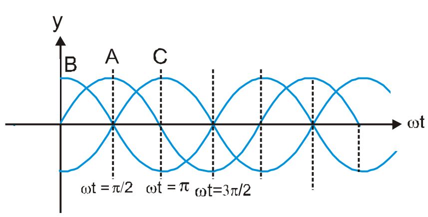
9. A wave pulse is generated in a string that lies along x-axis. At the points A and B, as shown in figure, if R_A and R_B are ratio of wave speed to the particle speed respectively then :



(A) $R_A > R_B$ **(B)** $R_B > R_A$
(C) $R_A = R_B$ **(D)** Information is not sufficient to decide.

10. Sinusoidal waves 5.00 cm in amplitude are to be transmitted along a string having a linear mass density equal to 4.00×10^{-2} kg/m. If the source can deliver a average power of 90 W and the string is under a tension of 100 N, then the highest frequency at which the source can operate is (take $\pi^2 = 10$) :
(A) 45.3 Hz **(B)** 50 Hz **(C)** 30 Hz **(D)** 62.3 Hz

11. The figure shows four progressive waves A, B, C & D. It can be concluded from the figure that with respect to wave A:



(A) the wave C is ahead by a phase angle of π/2 & the wave B lags behind by a phase angle π/2
(B) the wave C lags behind by a phase angle of π/2 & the wave B is ahead by a phase angle of π/2
(C) the wave C is ahead by a phase angle of π & the wave B lags behind by the phase angle of π
(D) the wave C lags behind by a phase angle of π & the wave B is ahead by a phase angle of π.

12. A 75 cm string fixed at both ends produces resonant frequencies 384 Hz and 288 Hz without there being any other resonant frequency between these two. Wave speed for the string is :
(A) 144 m/s **(B)** 216 m/s **(C)** 108 m/s **(D)** 72 m/s

13. A string of length 'ℓ' is fixed at both ends. It is vibrating in its 3^{rd} overtone with maximum amplitude 'a'. The amplitude at a distance $\frac{\ell}{3}$ from one end is :

(A) a **(B)** 0 **(C)** $\frac{\sqrt{3}\,a}{2}$ **(D)** $\frac{a}{2}$

14. What is the percentage change in the tension necessary in a sonometer of fixed length to produce a note one octave lower (half of original frequency) than before

(A) 25% **(B)** 50% **(C)** 67% **(D)** 75%

15. A chord attached about an end to a vibrating fork divides it into 6 loops, when its tension is 36 N. The tension at which it will vibrate in 4 loops is:

(A) 24 N **(B)** 36 N **(C)** 64 N **(D)** 81 N

16. Two vibrating strings of same length, same cross section area and stretched to same tension are made of materials with densities ρ & 2ρ. Each string is fixed at both ends. If v_1 represents the fundamental mode of vibration of the one made with density ρ and v_2 for another, then v_1/v_2 is:

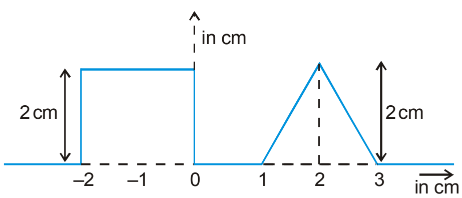
(A) $\frac{1}{2}$ **(B)** 2 **(C)** $\sqrt{2}$ **(D)** $\frac{1}{\sqrt{2}}$

17. Which of the following function correctly represents the wave equation for finite values of x and t :

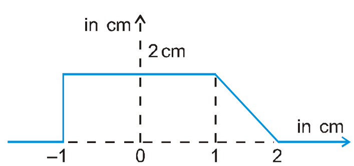
(A) $y = x^2 - t^2$ **(B)** $y = \cos x^2 \sin t$

(C) $y = \log(x^2 - t^2) - \log(x - t)$ **(D)** $y = e^{2x} \sin t$

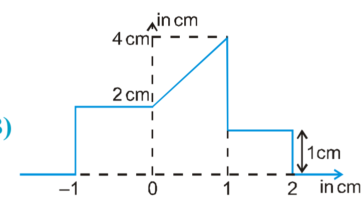
18. The figure shows at time t = 0 second, a rectangular and triangular pulse on a uniform wire are approaching each other. The pulse speed is 0.5 cm/s. The resultant pulse at t = 2 second is



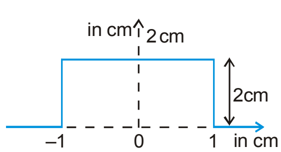
(A)



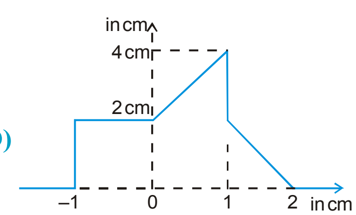
(B)



(C)



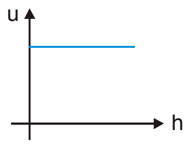
(D)

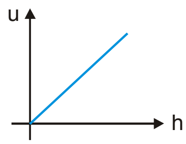


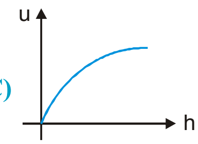
19. A loop of a string of mass per unit length μ and radius R is rotated about an axis passing through centre perpendicular to the plane with an angular velocity ω. A small disturbance is created in the loop having the same sense of rotation. The linear speed of the disturbance for a stationary observer is :

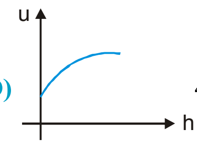
(A) ωR **(B)** $2\omega R$ **(C)** $3\omega R$ **(D)** zero

20. A uniform rope having mass m hangs vertically from a rigid support. A transverse wave pulse is produced at the lower end. The speed u of wave pulse varies with height h from the lower end as :

(A) 

(B) 

(C) 

(D) 

4

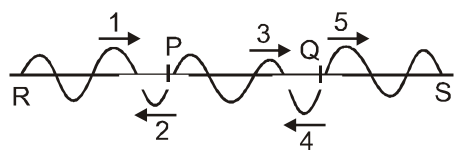
21. In a stationary wave that forms as a result of reflection of waves from an ostacle the ratio of the amplitude at an antinode to the amplitude at node is n. The fraction of energy reflected is :

(A) $\left(\frac{n-1}{n}\right)^2$ (B) $\left(\frac{n-1}{n+1}\right)^2$ (C) $\left(\frac{1}{n}\right)^2$ (D) $\left(\frac{n}{n+1}\right)^2$

22. The fundamental frequency of a sonometer wire of length ℓ is f_0. A bridge is now introduced at a distance of $\Delta\ell$ from the centre of the wire ($\Delta\ell << \ell$). The number of beats heard if both sides of the bridges are set into vibration in their fundamental modes are :

(A) $\frac{8f_0\Delta\ell}{\ell}$ (B) $\frac{f_0\Delta\ell}{\ell}$ (C) $\frac{2f_0\Delta\ell}{\ell}$ (D) $\frac{4f_0\Delta\ell}{\ell}$

23. There are three strings RP, PQ and QS as shown. Their mass and lengths are RP = (0.1Kg, 2m), PQ = (0.2 Kg, 3 m), QS = (0.15 Kg, 4 m) respectively. All the strings are under same tension. Wave-1 is incident at P. It is partly reflected (wave-2) and partly transmitted (wave-3). Now wave-3 is incident at Q. It is again partly transmitted (wave-5) and partly reflected (wave-4). Phase difference between wave-1 and wave :



(A) 2 is π
(B) 4 is zero
(C) both (A) and (B) are correct
(D) both (A) and (B) are wrong

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

24. A wire of density 9×10^3 kg/m^3 is stretched between two clamps 1 m apart and is stretched to an extension of 4.9×10^{-4} metre. Young's modulus of material is 9×10^{10} N/m^2. Then :

(A) The lowest frequency of standing wave is 35 Hz

(B) The frequency of 1st overtone is 70 Hz

(C) The frequency of 1st overtone is 105 Hz

(D) The stress in the wire is 4.41×10^7 N/m^2

25. In a standing wave on a string :

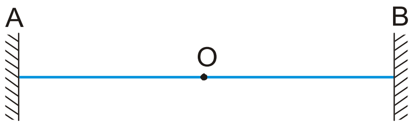
(A) In one time period all the particles are simultaneously at rest twice.

(B) All the particles must be at their positive extremes simultaneously once in one time period .

(C) All the particles may be at their positive extremes simultaneously once in a time period.

(D) All the particles are never at rest simultaneously.

26. A wire, under tension between two fixed points *A* and *B*, executes transverse vibrations so that the midpoint O of *AB* is a node. Then:



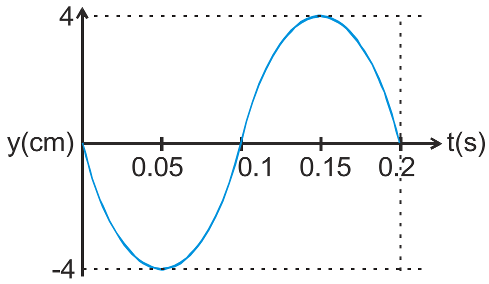
(A) All points of wire between *A* and *B* are in the same phase

(B) All points between *A* and *O* are in the same phase

(C) A point between *A* and *O* and a point between *O* and *B* may have a phase difference of $\pi/2$

(D) A point between *A* and *O* and a point between *O* and *B* may have a phase difference of π

27. For a certain transverse standing wave on a long string, an antinode is formed at x = 0 and next to it, a node is formed at x = 0.10 m. the displacement y(T) of the string particle at x = 0 is shown in figure.



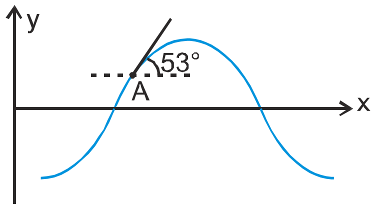
(A) Transverse displacement of the particle at x = 0.05m and t = 0.05 s is $-2\sqrt{2}$ cm.

(B) Transverse displacement of the particle at x = 0.04 m and t = 0.025 s is $-2\sqrt{2}$ cm.

(C) Speed of the travelling waves that interfere to produce this standing wave is 2 m/s.

(D) The transverse velocity of the string particle at $x = \frac{1}{15}$ m and t = 0.1 s is 20 π cm/s

28. y-x curve at an instant for a wave travelling along x axis on a string is shown. Slope at the point A on the curve, as shown, is 53°.



(A) Transverse velocity of the particle at point A is positive if the wave is travelling along positive x axis.

(B) Transverse velocity of the particle at point A is positive if the wave is travelling along negative x axis of the particle at point A

(C) Magnitude of transverse velocity of the particle at point A is greater than wave speed.

(D) Magnitude of transverse velocity of the particle at point A is lesser than wave speed.

29. For a certain stretched string, three consecutive resonance frequencies are observed as 105, 175, 245 Hz respectively. Then select the correct alternative(s) :

(A) The string is fixed at both ends

(B) The string is fixed at one end only

(C) The fundamental frequency is 35 Hz

(D) The fundamental frequency is 52.5 Hz

SECTION - III : ASSERTION AND REASON TYPE

30. **Statement-1 :** In a small segment of string carrying sinusoidal wave, total energy is conserved.

Statement-2 : Every small part moves in SHM and in SHM total energy is conserved.

(A) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

(B) If both Assertion and Reason are true, but Reason is not correct explanation of the Assertion.

(C) if Assertion is true, but the Reason is false.

(D) if Assertion is false, but the Reason is true.

31. **Statement-1 :** Two waves moving in a uniform string having uniform tension cannot have different velocities.

Statement-2 : Elastic and inertial properties of string are same for all waves in same string. Moreover speed of wave in a string depends on its elastic and inertial properties only.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

32. **Statement-1 :** A standing wave pattern is formed in a string. The power transfer through a point (other than node and antinode) is zero always.

Statement-2 : At antinode tension is perpendicular to the velocity.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

SECTION - IV : COMPREHENSION TYPE

Comprehension - 1

In a standing wave experiment, a 1.2 kg horizontal rope is fixed in place at its two ends (x = 0 and x = 2.0 m) and made to oscillate up and down in the fundamental mode, at frequency 5.0 Hz. At t = 0, the point at x = 1.0 m has zero displacement and is moving upward in the positive direction of y axis with a transverse velocity 3.14 m/s.

33. Tension in the rope is :

(A) 60 N **(B)** 100 N **(C)** 120 N **(D)** 240 N

34. Speed of the participating travelling wave on the rope is

(A) 6 m/s **(B)** 15 m/s **(C)** 20 m/s **(D)** 24 m/s

35. What is the correct expression of the standing wave equation ?

(A) $(0.1) \sin (\pi/2)x \sin (10\pi) t$ **(B)** $(0.1) \sin (\pi)x \sin (10\pi) t$

(C) $(0.05) \sin (\pi/2)x \cos (10\pi) t$ **(D)** $(0.04) \sin (\pi)x \sin (10\pi) t$

Comprehension - 2

A sinusoidal wave is propagating in negative x–direction in a string stretched along x-axis. A particle of string at x = 2m is found at its mean position and it is moving in positive y direction at t = 1 sec. The amplitude of the wave, the wavelength and the angular frequency of the wave are 0.1meter, π/4 meter and 4π rad/sec respectively.

36. The equation of the wave is

(A) $y = 0.1 \sin(4\pi(t-1) + 8(x-2))$ **(B)** $y = 0.1 \sin((t-1) - (x-2))$

(C) $y = 0.1 \sin(4\pi(t-1) - 8(x-2))$ **(D)** none of these

37. The speed of particle at x = 2 m and t = 1sec is

(A) 0.2π m/s **(B)** 0.6π m/s **(C)** 0.4π m/s **(D)** 0

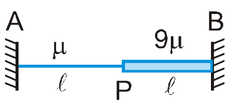
38. The instantaneous power transfer through x=2 m and t= 1.125 sec, is

(A) 10 J/s **(B)** $\frac{4\pi}{3}$ J/s **(C)** $\frac{2\pi}{3}$ J/s **(D)** 0

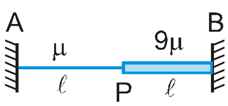
SECTION - V : MATRIX - MATCH TYPE

39. Match the column :

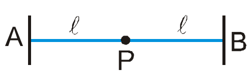
Column–I

(A) 

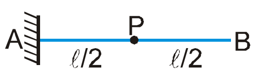
Two strings each of length ℓ and linear mass density μ and 9μ are joined together and system is oscillated such that joint P is node T is tension in the strings. A and B are fixed ends.

(B) 

Two strings each of length ℓ and linear mass density μ and 9μ are joined together and system is oscillated such that joint P is antinode. T is tension in each string. A and B are fixed ends.

(C) 

P is the mid–point of the string fixed at both ends. T is tension in the string and μ is its linear mass density.

(D) 

T is the tension in the string fixed at A and B is free end. P is mid–point. μ is its the linear mass density.

Column–II

(P) Speed of component travelling wave is portion AP will be $\sqrt{\frac{T}{\mu}}$

(Q) Speed of component travelling wave in the portion AP will be more than that in portion BP.

(R) Frequency of oscillation of the system AB can be $\frac{1}{2\ell}\sqrt{\frac{T}{\mu}}$

(S) Frequency of oscillation of the system AB can be $\frac{1}{4\ell}\sqrt{\frac{T}{\mu}}$

(T) Wavelength of the wave in the portion PB can be $\frac{2\ell}{3}$.

40. Match the statements in column-I with the statements in column-II.

	Column-I		Column-II
(A)	A tight string is fixed at both ends and sustaining standing wave	**(P)**	At the middle, antinode is formed in odd harmonic
(B)	A tight string is fixed at one end and free at the other end	**(Q)**	At the middle, node is formed in even harmonic
(C)	A tight string is fixed at both ends and vibrating in four loops	**(R)**	the frequency of vibration is 300% more than its fundamental frequency
(D)	A tight string is fixed at one end and free at the other end, vibrating in 2nd overtone	**(S)**	Phase difference between SHMs of any two particles will be either π or zero.
		(T)	The frequency of vibration is 400% more than fundamental frequency.

41. Match the following :

	Column-I		Column-II
(A)	In refraction	**(P)**	Speed of wave does not change
(B)	In reflection	**(Q)**	Wavelength is decreased
(C)	In refraction from rarer to denser medium	**(R)**	Frequency does not change
(D)	In reflection from a denser medium	**(S)**	Phase change of π takes place
		(T)	Phase does not change

SECTION - VI : INTEGER TYPE

42. A 40 cm long wire having a mass 3.2 gm and area of cross section 1 mm^2 is stretched between the support 40.05 cm apart. In its fundamental mode. It vibrate with a frequency 1000/64 Hz. the young's modulus of the wire is 10^x N/m^2 then x is.

43. A non–uniform string of mass 45 kg and length 1.5 m has a variable linear mass density given by $\mu = kx$, where x is the distance from one end of the string and k is a constant. Tension in the string is 15 N which is uniform. Find the time (in second) required for a pulse generated at one end of the string to travel to the other end.

44. The equation of a string wave is given by (all quantity expressed in S.I. units) $Y = 5\sin 10\pi(t - 0.01x)$ along the x-axis. The magnitude of phase difference between the points separated by a distance of 10 m along x- axis is $x\pi$ then x is

MOCK TEST : SOUND WAVE

SECTION - I : STRAIGHT OBJECTIVE TYPE

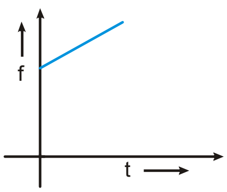
1. A closed organ pipe has length 'ℓ'. The air in it is vibrating in 3rd overtone with maximum amplitude 'a'. Find the amplitude at a distance of $\ell/7$ from closed end of the pipe.

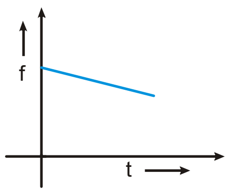
(A) a **(B)** a/2 **(C)** $\sqrt{3}$ a/2 **(D)** a/$\sqrt{2}$

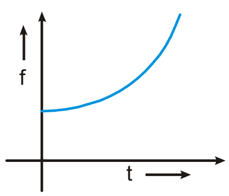
2. When a sound wave is reflected from a wall, the phase difference between the reflected and incident pressure wave is:

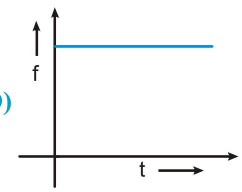
(A) 0 **(B)** π **(C)** $\pi/2$ **(D)** $\pi/4$

3. A source of frequency 'f' is stationary and an observer starts moving towards it at t = 0 with constant small acceleration. Then the variation of observed frequency f ' registered by the observer with time is best represented as :

(A) 

(B) 

(C) 

(D) 

4. A stationary observer receives sonic oscillations from two tuning forks, one of which approaches and the other recedes with same speed. As this takes place the observer hears the beat frequency of 2 Hz. Find the speed of each tuning fork, if their oscillation frequency is 680 Hz and the velocity of sound in air is 340 m/s.

(A) 1 m/s **(B)** 2 m/s **(C)** 0.5 m/s **(D)** 1.5 m/s

5. A source of sound of frequency 256 Hz is moving rapidly towards a wall with a velocity of 5 m/sec. If sound travels at a speed of 330 m/sec, then number of beats per second heard by an observer between the wall and the source is:

(A) 7.7 Hz **(B)** 9 Hz **(C)** 4 Hz **(D)** none of these

6. 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 3 dB is: ($\log_{10} 2 = 0.3$)

(A) $\frac{1}{2}$ **(B)** $\frac{1}{\sqrt{2}}$ **(C)** $\frac{1}{4}$ **(D)** $\frac{2}{3}$

7. Two coherent sources of different intensities send waves which interfere. The ratio of the maximum intensity to the minimum intensity is 25. The intensities are in the ratio:

(A) 25: 1 **(B)** 5: 1 **(C)** 9: 4 **(D)** 625: 1

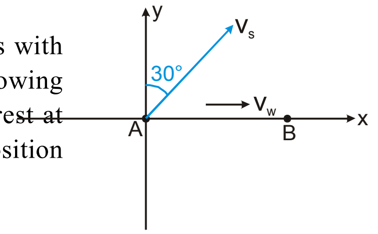
8. The frequency of a man's voice is 300 Hz and its wavelength is 1 meter. If the wavelength of a child's voice is 1.5 m, then the frequency of the child's voice is:

(A) 200 Hz **(B)** 150 Hz **(C)** 400 Hz **(D)** 350 Hz.

9. A sound wave of frequency 440 Hz is passing through air. An O_2 molecule (mass = 5.3×10^{-26} kg) is set in oscillation with an amplitude of 10^{-6} m. Its speed at the centre of its oscillation is:

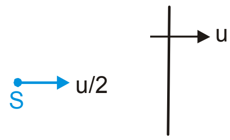
(A) 1.70×10^{-5} m/s **(B)** 17.0×10^{-5} m/s **(C)** 2.76×10^{-3} m/s **(D)** 2.77×10^{-5} m/s

10. In the figure shown a source of sound of frequency 510 Hz moves with constant velocity v_s = 20 m/s in the direction shown. The wind is blowing at a constant velocity v_w = 20 m/s towards an observer who is at rest at point B. Corresponding to the sound emitted by the source at initial position A, the frequency detected by the observer is equal to (speed of sound relative to air = 330 m/s)



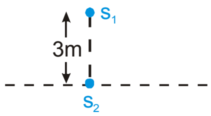
(A) 510 Hz **(B)** 500 Hz **(C)** 525 Hz **(D)** 550 Hz

11. A wall is moving with velocity u and a source of sound moves with velocity $\frac{u}{2}$ 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

12. S_1 & S_2 are two coherent sources of sound having no initial phase difference. The velocity of sound is 330 m/s. No minima will be formed on the line passing through S_2 and perpendicular to the line joining S_1 and S_2, if the frequency of both the sources is :



(A) 50 Hz **(B)** 60 Hz **(C)** 70 Hz **(D)** 80 Hz

13. Under similar conditions of temperature and pressure, In which of the following gases the velocity of sound will be largest.

(A) H_2 **(B)** N_2 **(C)** He **(D)** CO_2

14. When beats are produced by two progressive waves of nearly the same frequency, which one of the following is correct?

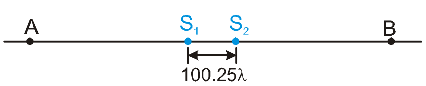
(A) The particles vibrate simple harmonically, with the frequency equal to the difference in the component frequencies.

(B) The amplitude of vibration at any point changes simple harmonically with a frequency equal to the difference in the frequencies of the two waves.

(C) The frequency of beats depends upon the position, where the observer is

(D) The frequency of beats changes as the time progresses

15. S_1 and S_2 are two coherent sources of sound separated by distance 100.25 λ, where λ is the wave length of sound. S_1 leads S_2 in phase by $\pi/2$. A and B are two points on the line joining S_1 and S_2 as shown in figure. The ratio of amplitudes of source S_1 and S_2 are in ratio 1:2. The ratio of intensity at A to that of B $\left(\frac{I_A}{I_B}\right)$ is



(A) ∞ **(B)** $\frac{1}{9}$ **(C)** 0 **(D)** 9

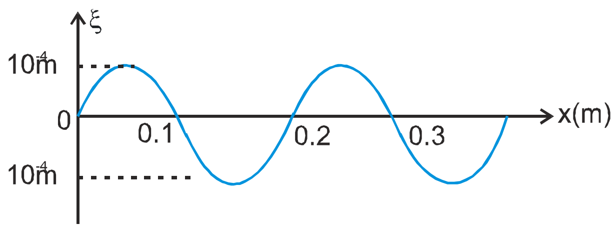
16. There is a set of four tuning forks, one with the lowest frequency vibrating at 550 Hz. By using any two tuning forks at a time, the following beat frequencies are heard: 1, 2, 3, 5, 7, 8. The possible frequencies of the other three forks are:

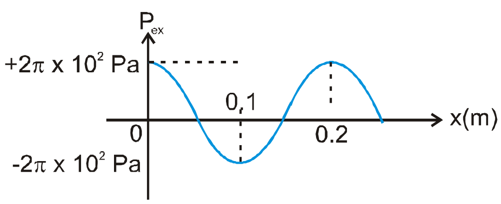
(A) 552, 553, 560 **(B)** 557, 558, 560 **(C)** 552, 553, 558 **(D)** 551, 553, 558

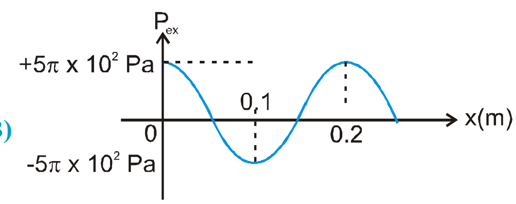
17. A 100 m long rod of density 10.0 x 10^4 kg/m^3 and having Young's modulus Y = 10^{11} Pa, is clamped at one end. It is hammered at the other free end. The longitudinal pulse goes to right end, gets reflected and again returns to the left end. How much time, the pulse take to go back to initial point.

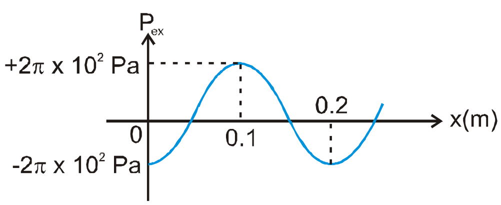
(A) 0.1 sec. **(B)** 0.2 sec. **(C)** 0.3 sec. **(D)** 2 sec.

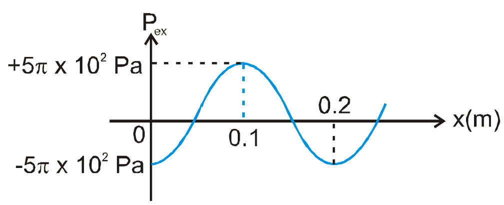
18. For a sound wave travelling towards +x direction, sinusoidal longitudinal displacement ξ at a certain time is given as a function of x. If Bulk modulus of air is B = 5 x 10^5 N/m^2, the variation of pressure excess will be



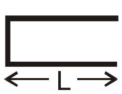
(A)


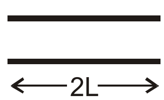
(B)


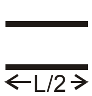
(C)


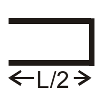
(D)


19. Figure shows a stretched string of length L and pipes of length L, 2L, L/2 and L/2 in options (A), (B), (C) and (D) respectively. The string's tension is adjusted until the speed of waves on the string equals the speed of sound waves in the air. The fundamental mode of oscillation is then set up on the string. In which pipe will the sound produced by the string cause resonance ?

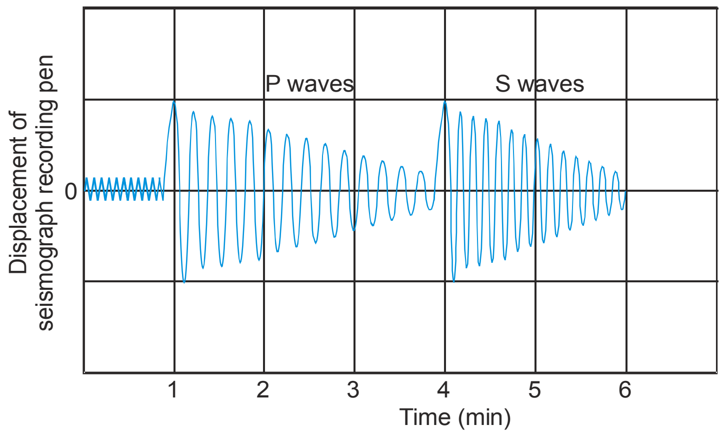
(A)


(B)


(C)


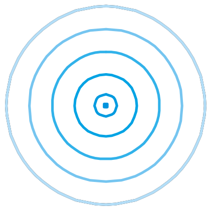
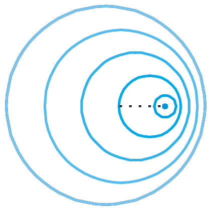
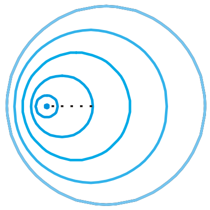
(D)


20. Earthquakes generate sound waves inside Earth. Unlike a gas, Earth can experience both transverse (S) and longitudinal (P) sound waves. Typically, the speed of S waves is about 4 km/s. A seismograph records P and S waves from an earthquake. The first P waves arrive 3.0 min before the first S wave (figure). Assuming the waves travel in a straight line, how far away does the earthquake occur ?
($Y_{earth} = 12.8 \times 10^{10}$ pa,
$\rho_{earth} = 2000$ kg/m^3)



(A) 1900 km **(B)** 1440 km **(C)** 1800 km **(D)** 1200 km

21. If the source is moving towards right, wave front of sound waves get modified to –

(A)  **(B)**  **(C)**  **(D)** None of these

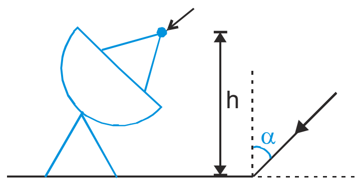
22. Equation of a stationary and a travelling waves are as follows $y_1 = a \sin kx \cos \omega t$ and $y_2 = a \sin (\omega t - kx)$. The phase difference between two points $x_1 = \frac{\pi}{3k}$ and $x_2 = \frac{3\pi}{2k}$ is ϕ_1 in the standing wave (y_1) and is ϕ_2 in travelling wave (y_2) then ratio $\frac{\phi_1}{\phi_2}$ is

(A) 1 **(B)** 5/6 **(C)** 3/4 **(D)** 6/7

23. In the resonance tube experiment, the first resonance is heard when length of air column is ℓ_1 and second resonance is heard when length of air column is ℓ_2. What should be the minimum length of the tube so that third resonance can also be heard.

(A) $2\ell_2 - \ell_1$ **(B)** $2\,\ell_1$ **(C)** $5\,\ell_1$ **(D)** $7\,\ell_1$

24. Radio waves coming at $\angle\,\alpha$ to vertical are received by a radar after reflection from a nearby water surface & directly. What can be height of antenna from water surface so that it records a maximum intensity (a maxima). (wavelength = λ) (Assume phase changes by π after reflection)



(A) $\frac{\lambda}{2\cos\alpha}$ **(B)** $\frac{\lambda}{2\sin\alpha}$ **(C)** $\frac{\lambda}{4\sin\alpha}$ **(D)** $\frac{\lambda}{4\cos\alpha}$

25. Microwaves from a transmitter are directed normally towards a plane reflector. A detector moves along the normal to the reflector. Between positions of 14 successive maxima, the detector travels a distance 0.14 m. If the velocity of light is 3×10^8 m/s, find the frequency of the transmitter -

(A) 1.5×10^{10} Hz **(B)** 10^{10} Hz **(C)** 3×10^{10} Hz **(D)** 6×10^{10} Hz

26. A man standing in front of a mountain at a certain distance beats a drum at regular intervals. The drumming rate is gradually increased and he finds that the echo is not heard distinctly when the rate becomes 40 per minute. He then moves nearer to the mountain by 90 meters and finds that the echo is again not heard when the drumming rate becomes 60 per minute

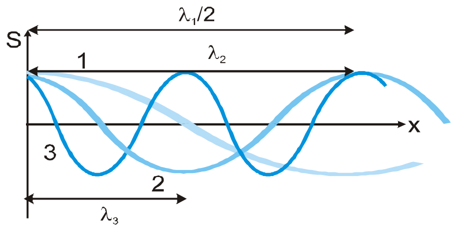
(a) The distance between the mountain and the initial position of the man is :

(A) 330 m **(B)** 300 m **(C)** 240 m **(D)** 270 m

(b) the velocity of sound is

(A) 330 m/s **(B)** 360 m/s **(C)** 300 m/s **(D)** 270 m/s

27. Figure shown is a graph, at a certain time t, of the displacement function S(x,t) of three sound waves 1,2 and 3 as marked on the curves that travel along x–axis through air. If P_1,P_2 and P_3 represent their pressure amplitudes respectively, then correct relation between them is :



(A) $P_1 > P_2 > P_3$ **(B)** $P_3 > P_2 > P_1$

(C) $P_1 = P_2 = P_3$ **(D)** $P_2 > P_3 > P_1$

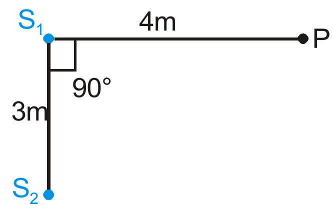
28. In Quincke's tube a detector detects minimum intensity. Now one of the tube is displaced by 5 cm. During displacement detector detects maximum intensity 10 times, then finally a minimum intensity (when displacement is complete). The wavelength of sound is:

(A) 10/9 cm **(B)** 1 cm **(C)** 1/2 cm **(D)** 5/9 cm

29. $x = x_1 + x_2$ (where $x_1 = 4 \cos \omega t$ and $x_2 = 3 \sin \omega t$) is the equation of motion of a particle along x-axis. The phase difference between x_1 and x is :

(A) 37° **(B)** 53° **(C)** 90° **(D)** none of these

30. S_1 and S_2 are two coherent sources of sound of frequency 110Hz each. They have no initial phase difference. The intensity at a point P due to S_1 is I_0 and due to S_2 is $4I_0$. If the velocity of sound is 330 m/s then the resultant intensity at P is



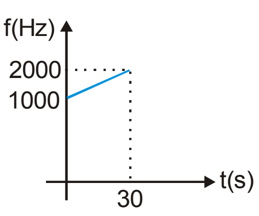
(A) I_0 **(B)** $9I_0$

(C) $3I_0$ **(D)** $8I_0$

31. A conveyor belt moves to the right with speed v = 300 m/min. A pieman puts pies on the belt at a rate of 20 per minute while walking with speed 30 m/min towards a receiver at the other end. The frequency with which they are received by the stationary receiver is:

(A) 26.67 / minute **(B)** 30 / minute **(C)** 22.22 / minute **(D)** 24 / minute

32. A detector is released from rest over a source of sound of frequency $f_0 = 10^3$ Hz. The frequency observed by the detector at time t is plotted in the graph. The speed of sound in air is : ($g = 10$ m/s^2)



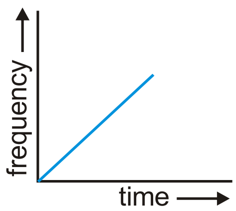
(A) 330 m/s **(B)** 350 m/s

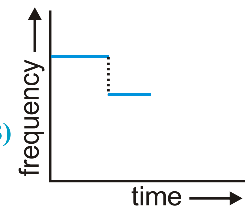
(C) 300 m/s **(D)** 310 m/s

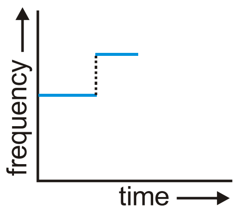
33. In the experiment for the determination of the speed of sound in air using the resonance column method, the length of the air column that resonates in the fundamental mode, with a tuning fork is 0.1 m. When this length is changed to 0.35 m, the same tuning fork resonates with the first overtone. Calculate the end correction :

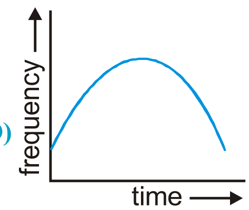
(A) 0.012 m **(B)** 0.025 m **(C)** 0.05 m **(D)** 0.024 m

34. A roller skater carrying a portable stereo skates at constant speed towards an observer at rest. Which of the following accurately represents how the frequency perceived by the observer changes with time ?

(A)


(B)


(C)


(D)


SECTION - II : MULTIPLE CORRECT ANSWER TYPE

35. In a resonance tube experiment, a closed organ pipe of length 120 cm resonates when tuned with a tuning fork of frequency 340 Hz. If water is poured in the pipe then (given v_{air} = 340 m/sec.) :

(A) minimum length of water column to have the resonance is 45 cm.

(B) the distance between two successive nodes is 50 cm.

(C) the maximum length of water column to create the resonance is 95 cm.

(D) none of these.

36. Two identical stretched wires are vibrated together. They produce 8 beats per second. When tension in one wire is changed then the beat frequency is increased. If T_1 and T_2 denote the tensions in the two wires at any instant and $T_1 > T_2$ (initially) then how the change may be performed.

(A) T_1 decreased **(B)** T_1 increased **(C)** T_2 decreased **(D)** T_2 increased

SECTION - III : ASSERTION AND REASON TYPE

37. **Statement 1 :** Doppler formula for sound wave is symmetric with respect to the speed of source and speed of observer

Statement 2 : Motion of source with respect to stationary observer is not equivalent to the motion of an observer with respect to a stationary source.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

38. **Statement 1 :** The base of Laplace correction was that exchange of heat between the region of compression and rarefaction in air is negligible.

Statement 2 : Air is bad conductor of heat and velocity of sound in air is quite large.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

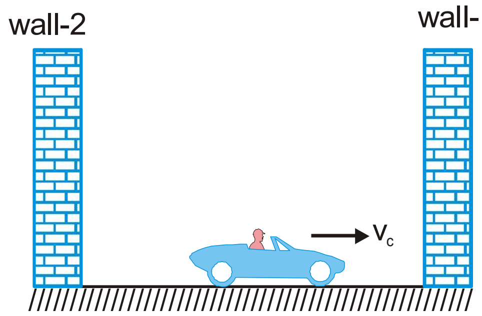
(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

SECTION - IV : COMPREHENSION TYPE

Comprehension # 1

A driver is riding a car with velocity v_C between two vertical walls on a horizontal surface as shown in figure. A source of sound of frequency 'f' is situated on the car. ($v_c << v$, where v is the speed of sound in air)



39. Beat frequency observed by the driver corresponding to sound waves reflected from wall-1 and wall-2 (reflected waves corresponding to waves directly coming from source) :

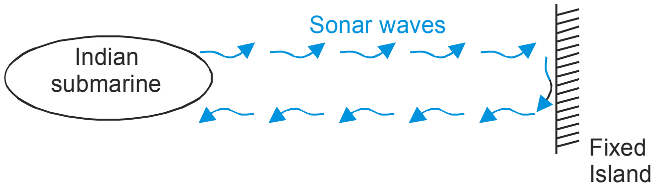
(A) $\frac{v_c}{v}f$ **(B)** $\frac{2v_c}{v}f$ **(C)** $\frac{v_c}{2v}f$ **(D)** $\frac{4v_c}{v}f$

40. Consider the sound wave observed by the driver directly from car has a wavelength λ_1 and the sound wave after reflection from wall-1 observed by the driver has wavelength λ_2 then $\frac{\lambda_1 - \lambda_2}{\lambda_1 + \lambda_2}$ is :

(A) $\frac{v_c}{v}$ **(B)** $\frac{2v_c}{v}$ **(C)** $\frac{v_c}{4v}$ **(D)** $\frac{4v_c}{v}$

Comprehension # 2

An Indian submarine is moving in "Arab Sagar" with a constant velocity. To detect enemy it sends out sonar waves which travel with velocity 1050 m/s in water. Initially the waves are getting reflected from a fixed island and the reflected waves are coming back to submarine. The frequency of reflected waves are detected by the submarine and found to be 10% greater than the sent waves.



Now an enemy ship comes in front, due to which the frequency of reflected waves detected by submarine becomes 21% greater than the sent waves.

41. The speed of Indian submarine is

(A) 10 m/sec **(B)** 50 m/sec **(C)** 100 m/sec **(D)** 20 m/sec.

42. The velocity of enemy ship should be :

(A) 50 m/sec. toward Indian submarine. **(B)** 50 m/sec. away from Indian submarine.

(C) 100 m/sec. toward Indian submarine. **(D)** 100 m/sec. away from Indian submarine.

43. If the wavelength received by enemy ship is λ' and wavelength of reflected waves received by submarine is λ'' then $\left(\frac{\lambda'}{\lambda''}\right)$ equals

(A) 1 **(B)** 1.1 **(C)** 1.2 **(D)** 2

44. Bulk modulus of sea water should be approximately (ρ_{water} = 1000 kg/m^3)

(A) 10^8 N/m^2 **(B)** 10^9 N/m^2 **(C)** 10^{10} N/m^2 **(D)** 10^{11} N/m^2

Comprehension # 3

In sound wave, y (x, t) equation and ΔP (x, t) equation have a phase difference of $\frac{\pi}{2}$.

Pressure amplitude in ΔP (x, t) equation is equal to BAK.

y (x, t) equation of a longitudinal wave is given as:

$y = 10^{-2} \sin 2\pi \left(1000\,t + \frac{50}{17}x\right)$ (AII SI units)

45. At t = 0, change in pressure is maximum at x = ...m.

(A) 0.34 **(B)** 0.255 **(C)** 0.085 **(D)** all of these

46. If density of the gas is 10^{-2} kg/m^3, find the pressure amplitude :

(A) 200.62 N/m^2 **(B)** 421.24 N/m^2 **(C)** 100.26 N/m^2 **(D)** 21.36 N/m^2

SECTION - V : MATRIX - MATCH TYPE

47. Match the columns I & II.

Column I	Column II
(A) Pitch	**(P)** Number of harmonics present in the sound
(B) Loudness	**(Q)** Intensity
(C) Quality	**(R)** Frequency
(D) wave front	**(S)** wave form
	(T) locus of points vribrating in a phase

48. Match the Column:

Column I	Column II
(A) $y = 4\sin(5x - 4t) + 3\cos(4t - 5x + \pi/6)$	**(P)** Particles at every position are performing SHM
(B) $y = 10\cos\left(t - \frac{x}{330}\right)\sin(100)\left(t - \frac{x}{330}\right)$	**(Q)** Equation of travelling wave
(C) $y = 10\sin(2\pi x - 120t) + 10\cos(120t + 2\pi x)$	**(R)** Equation of standing wave
(D) $y = 10\sin(2\pi x - 120\,t) + 8\cos(118t - 59/30\pi x)$	**(S)** Equation of Beats
	(T) Initial displacement of particle at origin is zero

SECTION - VI : INTEGER TYPE

49. A 3 m long organ pipe open at both ends is driven to third harmonic standing wave. If the amplitude of pressure oscillation is 0.1 % of the mean atmospheric pressure ($P_0 = 10^5$ N/m^2). if the amplitude of:

Particle oscillation is $\frac{x}{1089\pi}$ m then x is

50. In previous question density oscillation is $\frac{x}{1089}$ kgm^{-3} then x is

Speed of sound v = 330 m/s, density of air $\rho_0 = 1.0$ kg/m^3.

51. In a car race sound signals emitted by the two cars are detected by the detector on the straight track at the end point of the race. Frequency observed are 330 Hz & 360 Hz and the original frequency is 300 Hz of both cars. Race ends with the separation of 100 m between the cars. Assume both cars move with constant velocity and velocity of sound is 330 m/s. Find the time taken by winning car (in sec.)

52. A bat emits ultrasonic sound of frequency 1000 kHz in air. If the sound meets a water surface, it gets partially reflected back and partially refracted (transmitted) in water. Difference of wavelength transmitted to wavelength reflected is x cm. then x is (speed of sound in air = 330 m/sec, Bulk modulus of water = 2.25 x 10^9, $\rho_{water} = 1000$ kg/m^3)

ANSWER KEY

EXERCISE - 1

1. C	**2.** C	**3.** A	**4.** D	**5.** C	**6.** B	**7.** A	**8.** B	**9.** B	**10.** A	**11.** C	**12.** D	**13.** C
14. A	**15.** A	**16.** A	**17.** A	**18.** C	**19.** D	**20.** D	**21.** C	**22.** C	**23.** C	**24.** D	**25.** B	**26.** A
27. A	**28.** A	**29.** D	**30.** A	**31.** A	**32.** B	**33.** A	**34.** C	**35.** C	**36.** B	**37.** A	**38.** A	**39.** B
40. C	**41.** C	**42.** B	**43.** C	**44.** D	**45.** A	**46.** A	**47.** C	**48.** D	**49.** A	**50.** A	**51.** D	**52.** B
53. A												

EXERCISE - 2 : PART # I

1. A,B,C,D	**2.** A,B,C	**3.** A,B	**4.** A	**5.** D	**6.** C	**7.** D	**8.** A	**9.** C
10. C	**11.** B,C	**12.** A,C	**13.** D	**14.** C	**15.** A,D	**16.** B,C,D	**17.** A,D	**18.** B,D
19. B,C	**20.** A,C							

PART # II

1. A	**2.** A	**3.** B	**4.** A	**5.** A	**6.** A	**7.** A	**8.** A	**9.** A	**10.** C	**11.** A	**12.** A	**13.** A
14. A	**15.** A	**16.** C	**17.** A	**18.** A	**19.** A	**20.** A	**21.** C					

EXERCISE - 3 : PART # I

1. $A \to P, Q ; B \to S ; C \to$ P.R. ;$D \to S$ **2.** $A \to Q ; B \to P ; C \to P$ **3.** $A \to Q ; B \to P ; C \to R$

4. $A \to Q ; B \to R ; C \to S ; D \to P$ **5.** $A \to R ; B \to P; C \to Q ; D \to T$

PART # II

Comp. #1:	**1.** A,B,C,D	**2.** A,C,D	**3.** B	**4.** A	**5.** B
Comp. #2:	**1.** A,D	**2.** C	**3.** B,C	**4.** C,D	**5.** B,D

EXERCISE - 4

1. 2.83 mm **2.** 8.707 s **3.** 1 **4.** $y = 0.05 \sin(1609\,t - 4.84\,x)$ (where x and y in m)

5. 1200 Hz, 2000 Hz, 2800 Hz, 3600Hz, 4400 Hz **6.** 0.02 s **7.** 11 Hz **8.** 0.12 m **9.** 0.05 s

10. **(i)** $2\sqrt{3}$ cm **(ii)** x = 0, 15 cm, 30 cm .. etc. **(iii)** 0 (iv)$y_1 = 2 \sin\left(\frac{\pi x}{15} - 96\pi t\right)$ and $y_2 = 2 \sin\left(\frac{\pi x}{15} + 96\pi t\right)$

11. **(i)** $y_{incident} = 2.5 \sin\left(40\pi t + \frac{\pi}{3}x\right)$ and $y_{reflected} = -2.5 \sin\left(40\pi t - \frac{\pi}{3}x\right)$ **(ii)** 3 cm **(iii)** 0

12. **(i)** 3.4×10^{-4} m **(ii)** 1.49×10^{-3} m **13.** 2000 ms^{-1}

14. **(i)** Stationary wave **(ii)** Unacceptable function for any travelling wave **(iii)** Travelling harmonic wave **(iv)** Superposition of two stationary waves. **15.** 0.25 m **16.** 5.06×10^3 ms^{-1} **17.** 283.33 Hz

18. **(i)** 25 beats **(ii)** $\frac{1}{10}$s **19.** 27.04 N **20.** 7.87 Hz **21.** 422 Hz **22.** 220 Hz **23.** 680 Hz **24.** 1.5 m/s

25. 403.3 Hz to 484 Hz **26.** 45.93 kHz **27.** **(i)** 599.33 Hz **(ii)** 0.935 km, 621.43 Hz **28.** 0.073 m/s

29. 438.7Hz, 257.3Hz **30.** f

31. **(i)** Negative x, **(ii)** $y = 0.4 \sin\left(10\pi t + \frac{\pi}{2}x + \frac{\pi}{4}\right)$ (x, y are in cm) **(iii)** 1.6×10^{-5} J

32. **(i)** 6.28×10^{-3} S, **(ii)** 1.57×10^{-3} S **33.** $\frac{2f\,v_b(v + v_m)}{(v^2 - v_b^2)}$ **34.** 33 cm and 13.2 cm

35. **(i)** $6.67 \times 10^{-4}\ \pi(2.0x + 50t)$ **(ii)** $2.67 \times 10^{-3} \cos\pi(1.0x - 50t)$ **36.** **(i)** 1650 Hz **(ii)** 1500 Hz

37. **(i)** 2 **(ii)** 9.28 m and 1.99 m **38.** **(i)** z_1 and z_2 : $x = (2n+1)\dfrac{\pi}{2k} \Rightarrow (2n+1)\ l/4$ where $n = 0, \pm 1, \pm 2$ ..... etc.

(ii) z_1 and z_3 : $x - y = (2n+1)\dfrac{\pi}{k}$ where $n = 0, \pm 1, \pm 2$ ..etc.

39. **(i)** 10 **(ii)** 3cm **(iii)** 36 J **(iv)** $y_1 = 3\sin\left(\dfrac{\pi x}{10} - 100\pi t\right)$, $y_2 = 3\sin\left(\dfrac{\pi x}{10} + 100\pi t\right)$

40. $y = 10^{-6} \sin(0.1\pi) \sin(25000\ \pi t)$, $y_1 = 10^{-6} \sin(25000\ \pi t - 5\pi x)$, $y_2 = 10^{-6} \sin(25000\ \pi t + 5\pi x)$

41. **(i)** $\dfrac{2\pi}{a}, \dfrac{b}{2\pi}$ **(ii)** $y_r = -0.8 A \cos(ax - bt)$ **(iii)** 1.8 Ab, 0

(iv) $y = -1.6 A \sin ax \sin bt + 0.2 A \cos(ax + bt)$ Antinodes are at $x = \left[n + \dfrac{(-1)^n}{2}\right]\dfrac{\pi}{a}$. Travelling wave is propagating in negative x–direction **42.** 0.2 cm

EXERCISE - 5 : PART # I

1. 3 **2.** 2 **3.** 2 **4.** 2 **5.** 1 **6.** 3 **7.** 3 **8.** 4 **9.** 3 **10.** 4 **11.** 2 **12.** 1 **13.** 1
14. 4 **15.** 1 **16.** 4 **17.** 2 **18.** 1 **19.** 2 **20.** 2 **21.** 4 **22.** 2

PART # II

MCQ's with one correct answer

1. B **2.** D **3.** D **4.** C **5.** B **6.** B **7.** A **8.** B **9.** B **10.** D **11.** C **12.** C **13.** C
14. D **15.** A **16.** A **17.** A

MCQ's one or more than one correct

1. B,C **2.** A,C **3.** A,C,D **4.** B,C,D **5.** A,B, C **6.** A,B,C **7.** B, C **8.** A,C,D **9.** A,B,C

Comprehension Based questions

Comprehension #1 **1.** A **2.** A **3.** D **Comprehension #2** **1.** B **2.** A **3.** A

Subjective Questions

1. **(i)** $\dfrac{15}{16}$ m **(ii)** $\dfrac{\Delta P_0}{\sqrt{2}}$ **(iii)** $P_{max} = P_{min} = P_0$, **(iv)** $P_{max} = P_0 + \Delta P_0, P_{min} = P_0 - \Delta P_0$

2. **(i)** 140 ms **(ii)** $A_r = \left(\dfrac{v_2 - v_1}{v_2 + v_1}\right)A_i = 1.5\text{cm}$, $A_t = \left(\dfrac{2v_2}{v_2 + v_1}\right)A_i = 2\ \text{cm}$

3. $h = 3.2, 2.4, 1.6, 0.8, 0$, $v = 5 \times 10^{-3}\sqrt{5H}$, $\Delta t = 80\left(4 - 2\sqrt{3}\right)$

4. **(i)** 100696Hz **(ii)** 103038Hz **5.** **(i)** 2.116 **(ii)** $\dfrac{3}{4}$ **6.** 336 ms^{-1} **7.** $\dfrac{A^2\pi^2 T}{4\ell}$ **8.** 30 ms^{-1}

9. $y = (10\ \text{cm}) \sin\left(30t \pm \dfrac{3}{2}x + \phi\right)$ **10.** 5

MOCK TEST (STRING WAVE)

1. D **2.** B **3.** C **4.** A **5.** B **6.** B **7.** B **8.** B **9.** B
10. C **11.** B **12.** A **13.** C **14.** D **15.** D **16.** C **17.** C **18.** D
19. B **20.** C **21.** B **22.** A **23.** C **24.** A, B **25.** A, C **26.** B, D **27.** A, C, D
28. B, C **29.** B, C **30.** D **31.** D **32.** D **33.** D ,C, A **36.** A **37.** C **38.** D
39. $A \to P,Q,R,T$; $B \to P,Q,S$; $C \to P,R,S,T$; $D \to P,S$ **40.** $A \to P,Q,S$; $B \to S$; $C \to Q,R,S$; $D \to S,T$
41. $A \to R,T$; $B \to P,R$; $C \to Q, R, T$; $D \to P, R, S$ **42.** (1) **43.** (2) **44.** (1)

MOCK TEST (SOUND WAVE)

1. A **2.** A **3.** A **4.** C **5.** D **6.** B **7.** C **8.** A **9.** C **10.** C **11** A **12.** A **13.** A
14. B **15.** B **16.** D **17.** B **18.** D **19.** B **20** B **21.** B **22.** D **23.** A **24.** D **25.** A **26.** A D
27. B **28.** B **29.** A **30.** C **31.** C **32.** C **33.** B **34.** B **35.** A, B, C **36.** A,B,C,D **37.** D **38.** A
39. D **40.** A **41.** B **42.** A **43.** B **44.** B **45.** A **46.** D **7.** $A \to R$; $B \to Q$; $C \to P,S$; $D \to T$
48. $A \to P, Q$; $B \to Q, S, T$; $C \to R$; $D \to S,Q$ **49.** (1) **50.** (1) **51.** (4) **52.** (117)