# EXERCISE–01

**CHECK YOUR GRASP**

MCQs with one correct answer

1. The waves produced by a motorboat sailing in water are:–
(A) Transverse (B) Longitudinal (C) Longitudinal and transverse (D) Stationary

2. 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

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. 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

5. Two wave are represented by equation $y_1$ = a sin ωt and $y_2$ = a cos ωt 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 $\frac{\pi}{2}$

6. 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

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

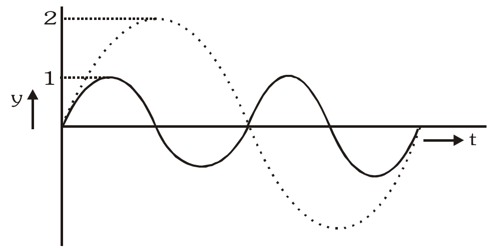
8. The displacement y of a particle executing periodic motion is given by : $y = 4\cos^2\left(\frac{1}{2}t\right)\sin(1000t)$ .
This expression may be considered to be a result of the superposition of ......... independent, simple harmonic motions.
(A) two (B) three (C) four (D) five

9. A transverse wave is described by the equation $y = y_0\sin2\pi\left(ft - \frac{x}{\lambda}\right)$. 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. The equation of displacement of two waves are given as $y_1 = 10\sin(3\pi t + \pi/3)$ and $y_2 = 5\left(\sin 3\pi t + \sqrt{3}\cos3\pi t\right)$, then what is the ratio of their amplitude:–
(A) 1 : 2 (B) 2 : 1 (C) 1 : 1 (D) None of these

11. A plane progressive wave is represented by the equation y= 0.25 cos (2πt – 2πx). 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 (πt – πx) (B) y = 0.5 cos (2πt + 2πx) (C) y = 0.25 cos (πt + 2πx) (D) y = 0.5 cos (πt + πx)

**12.** 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

**13.** 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

**14.** 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) $a_1^2 + a_2^2$

**15.** 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

**16.** 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

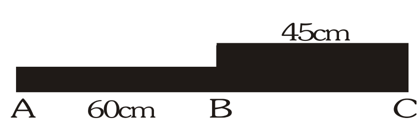
**17.** The linear density of a vibrating string is $1.3 \times 10^{-4}$ kg/m. A transverse wave is propagating on the string and is described by the equation $y=0.021 \sin(x+30t)$ where x and y are measured in meter and t in second the tension in the string is :–

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

**18.** A 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 $10^3$ kg/m$^3$, Young's modulus Y = 1.3 $10^{11}$ N/m and temperature coefficient of expansion $\alpha$ = 1.7 $10^{-5}$ / C):–

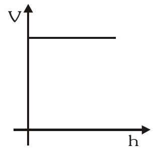
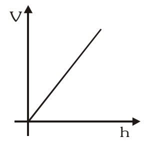
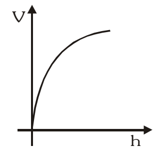
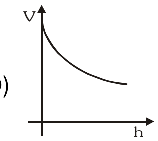
(A) 210 m/s (B) 110 m/s (C) 90 m/s (D) 70 m/s

**19.** 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:–

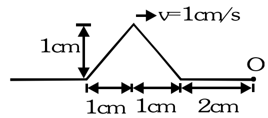


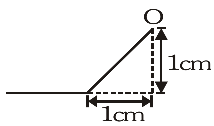

(A) 357.3 Hz (B) 375.3 Hz (C) 337.5 Hz (D) 325.5 Hz

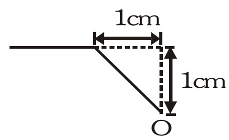
20. A uniform rope having some mass hinges vertically from a rigid support. A transverse wave pulse is produced at the lower end. The speed (v) of the wave pulse varies with height (h) from the lower end as:–

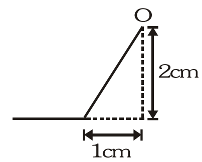
(A) 
(B) 
(C) 
(D) 

21. 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) 


22. 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.

23. 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.

24. 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

25. 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) $y = a \sin (kx + \omega t)$

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. 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) $n = n_1 \quad n_2 \quad n_3$ (C) $n = n_1 + n_2 + n_3$ (D) $n = \frac{n_1 + n_2 + n_3}{3}$

28. 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) $300\left(\frac{2\rho-1}{2\rho}\right)$

**29.** 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

**30.** 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

**31.** 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

**32.** 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

**33.** 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

**34.** 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) $2f$

**35.** 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) $\frac{1}{3}$

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

**37.** 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

**38.** 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

**39.** 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

**40.** 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) $2r_2 - r_1 = 2.5\ L$

**41.** 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

**42.** 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

43. 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

44. 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

45. 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

46. 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

47. 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) $\frac{2L^2}{vy}$

48. 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

49. 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

50. 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

51. 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

52. 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

53. 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

CHECK YOUR GRASP **ANSWER KEY** EXERCISE –1

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

# EXERCISE–02

**BRAIN TEASERS [MCQs]**

MCQs with one or more than one correct answer

1. 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 $f\dfrac{(c+v)}{c}$

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

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

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

2. A wave disturbance in a medium is described by $y(x, t) = 0.02\cos\left(50\pi t + \dfrac{\pi}{2}\right)\cos(10\pi x)$, 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

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

4. 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

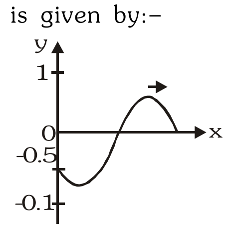
5. A hollow metallic tube of length L and closed at one end produce resonance with a tuning fork of frequency n. The entire tube is then heated carefully so that at equilibrium temperature its length changes by $\ell$. If the change in velocity V of sound is v, the resonance will now produced by tuning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

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

6. 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:–

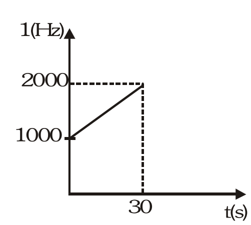
(A) 4 m/s in + x direction
(B) 4 m/s in – x direction
(C) 2 m/s in + x direction
(D) 2 m/s in – x direction

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




(A) $\sin\left(kx - \omega t + \dfrac{\pi}{6}\right)$
(B) $\sin\left(kx - \omega t - \dfrac{\pi}{6}\right)$
(C) $\sin\left(\omega t - kx + \dfrac{\pi}{6}\right)$
(D) $\sin\left(\omega t - kx - \dfrac{\pi}{6}\right)$

8. 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

**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.** 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 $\lambda$ 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 $\sqrt{4L/3g}$

**11.** 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

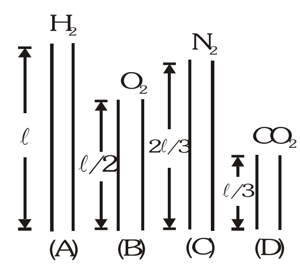
(D) None of these

**12.** 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

**13.** 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 $\gamma_{CO_2}$=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) $f_D/f_A = \sqrt{76/11}$

**14.** 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

**15.** 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 $\frac{\pi}{2}$

**16.** P, Q and R are three particles of a medium which lie on the x-axis. A sine wave of wavelength $\lambda$ 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 $\lambda$ (C) P and R is $\frac{\lambda}{2}$ (D) P and R is $\lambda$

17. A plane progressive wave of frequency 25 Hz, amplitude $2.5 \times 10^{-5}$ 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 $\phi$. The maximum difference in the displacements of particle at A and B is $\Delta$.

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

18. The stationary waves set up on a string have the equation $y = (2\text{ mm}) \sin[(6.28\text{ m}^{-1})x]\cos(\omega t)$. 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

19. 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

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) $\frac{I_{max}}{I_{min}} = \frac{1.64}{0.36}$

| BRAIN TEASERS | | | | | | | ANSWER KEY | | | | | | | | | | | EXERCISE –2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| A | ABC | ABCD | AB | D | A | A | D | C | C | BC | AC | C | C | D | BCD | AD | AD | BC | BD | AC |

# EXERCISE–03

## MISCELLANEOUS TYPE QUESTIONS

**Match the Columns**

1. 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 |

2.

| | 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 |

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) | 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 |

5.

| | 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 |

**Assertion-Reason**

These questions contains, Statement 1 (assertion) and Statement 2 (reason).

1. **Statement–1** : Sound travels faster in moist air.

**and**

**Statement–2** : The density of moist air is less then density of dry air.

(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

2. **Statement–1** : Standing waves do not transport energy in the medium.
**and**
**Statement–2** : In standing waves, every particle vibrates with its own energy and it does not share its energy with any other particle.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

3. **Statement–1** : Explosions on other planets are not heard on earth.
**and**
**Statement–2** : To hear distinct beats, difference in frequencies of two sources should be less than 10.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

4. **Statement–1** : Vacuum is densest for sound and rarest for light.
**and**
**Statement–2** : A medium is said to be denser, when velocity of waves through this medium is smaller.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

5. **Statement–1** : Ultrasonics is the acoustic analogue of ultraviolet radiation.
**and**
**Statement–2** : Ultraviolet rays do not produce visual sensations while ultrasonic waves are not heards by the human ear.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

6. **Statement–1** : Infrasonic waves are generally produced by large vibrating bodies.
**and**
**Statement–2** : Infrasonic waves have frequency range lies below 20 Hz.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

7. **Statement–1** : Partially transverse waves are possible on a liquid surface.
**and**
**Statement–2** : Surface tension provide some rigidity on a liquid surface.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

8. **Statement–1** : 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.

**and**

**Statement–2** : The resultant of $y_1$ & $y_2$ is $y=y_1+y_2 = 2A \sin kx \cos \omega t+2A \sin (kx+\omega t)$

(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

9. **Statement–1** : Mechanical transverse waves cannot be generated in gaseous medium.

**and**

**Statement–2** : Mechanical transverse waves can be produced only in such medium which have shearing property.

(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

10. **Statement–1** : Description of sound as pressure wave is preferred over displacement wave.

**and**

**Statement–2** : Sound sensors (ear or mike) detect pressure changes.

(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

11. **Statement–1** : During thunderstorm, light is seen much earlier than the sound is heard

**and**

**Statement–2** : Light travels faster than sound.

(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

12. **Statement–1** : The flash of lightening is seen before the sound of thunder is heard.

**and**

**Statement–2** : The sound of thunder is produced after the flash of lightening.

(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

13. **Statement–1** : Earthquakes cause vast devastation. Sometimes short and tall structures remain unaffected while the medium height structures fall.

**and**

**Statement–2** : The natural frequency of the medium structures coincides with the frequency of the seismic wave.

(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

14. **Statement–1** : Shock waves produced by supersonic aircraft may be visible.
**and**
**Statement–2** : The sudden decrease in air pressure in the shock waves caused water molecules in the air to condense, forming a fog.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

15. **Statement–1** : In the case of a stationary wave, a person hear a loud sound at the nodes as compared to the antinodes.
**and**
**Statement–2** : In a stationary wave all the particles of the medium vibrate in phase.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

16. **Statement–1** : Waves generated in a metal piece can be transverse or longitudinal.
**and**
**Statement–2** : Waves generated depend upon the method of creating waves in the metal.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

17. **Statement–1** : A balloon filled with $CO_2$ gas acts as a converging lens for a sound wave.
**and**
**Statement–2** : Sound waves travel faster in air than in $CO_2$.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

18. **Statement–1** : Node of pressure wave is formed at the open end of an organ pipe.
**and**
**Statement–2** : Due to huge volume of the atmosphere outside the tube, deformation in its volume is negligible.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

19. **Statement–1** : If transverse waves are produced in a very long string fixed at one end. Near the free end only progressive wave is observed, in practice.
**and**
**Statement–2** : Energy of reflected wave does not reach the free end.
(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

20. **Statement–1** : 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.

**and**

**Statement–2** : The principle of superposition is valid only when $f_1 - f_2 < 10$ Hz

(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

21. **Statement–1** : The fundamental frequency of an organ pipe increases as the temperature increases.

**and**

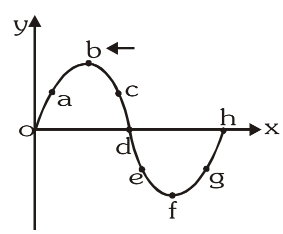
**Statement–2** : As the temperature increases, the velocity of sound increases more rapidly than length of the pipe.

(A) Statement–1 is true, Statement–2 is true ; Statement–2 is 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

COMPREHENSION TYPE QUESTIONS

**Comprehension#1**

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:–

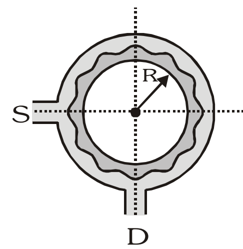
(A) b (B) c (C) d (D) h

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

### Comprehension#2

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 $\lambda$ of the wave produced is given by :–

(A) $\pi R$ (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 $\lambda$ of the wave produced is given by:–

(A) $\pi R$ (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 $\lambda$ to produce a maxima at D is given by :–

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

**5.** The maximum value of $\lambda$ to produce a minima at D is given by :–

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

MISCELLANEOUS TYPE QUESTION **ANSWER KEY** EXERCISE –3

- ***Match the Column***
  1. (A) q, (B) p, (C) p
  2. (A) p, q (B) s (C) p,r (D) s
  3. (A) q, (B) p (C) r
  4. (A) r, (B) p (C) q (D) t
  5. (A) q, (B) r (C) s (D) p

- ***Assertion – Reason***

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

- ***Comprehension Based***

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

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

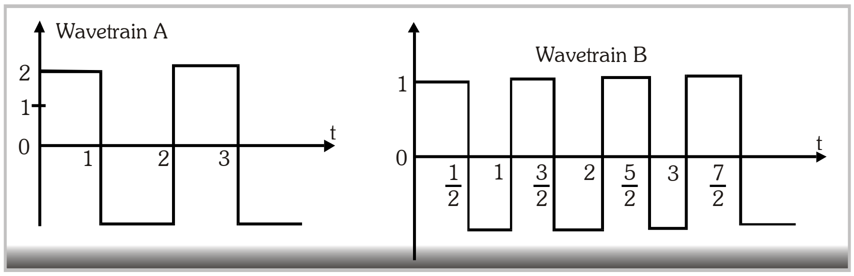
# EXERCISE–04 [A]

## CONCEPTUAL SUBJECTIVE EXERCISE

1. 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 $ms^{-2}$)

2. 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

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



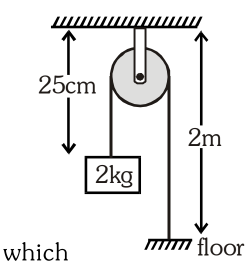

4. Two audio speakers are kept some distance apart and are driven by the same amplifier system. A person is sitting at a place 6.0 m from one of the speakers and 6.4 m from the other. If the sound signal is continuously varied from 500 Hz to 5000 Hz, what are the frequencies for which there is a destructive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

5. 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.

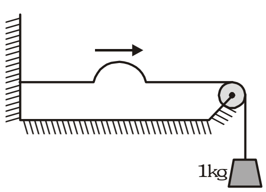
6. A uniform rope of length 12 m and mass 6 kg hangs vertically from a rigid support. A block of mass 2 kg is attached to the free end of the rope. A transverse pulse of wavelength 0.06 m is produced at the lower end of the rope. What is the wavelength of the pulse when it reaches the top of the rope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

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: $Y_{stell} = 2 \quad 10^{11}$ N/$m^2$, $\alpha_{stell} = 1.21 \quad 10^{-5}$/ C]

8. 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 $ms^{-2}$).




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. 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 ?

**11.** 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 $ms^{-1}$.

**12.** 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

**13.** 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) $y = \cos x \sin t + \cos 2x \sin 2t$

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

**15.** 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 ?

**16.** 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.

**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.** 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.

**19.** 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.

**20.** 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 ?

**21.** 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 ?

**22.** 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)

**23.** 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 $ms^{-1}$.

**24.** 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]

**25.** 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]

**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 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.

**28.** 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)

**29.** A train of length $\ell$ 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.

CONCEPTUAL SUBJECTIVE EXERCISE — **ANSWER KEY** — EXERCISE-4(A)

**1.** 8.707 s

**2.** 2.83 mm

**3.** 1

**4.** 1200 Hz, 2000 Hz, 2800 Hz, 3600Hz, 4400 Hz

**5.** y = 0.05 sin (1609 t – 4.84 x)
(where x and y in m)

**6.** 0.12 m

**7.** 11 Hz

**8.** 0.02 s

**9.** 0.05 s

**10.** (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

**11.** (i) 3.4   $10^{-4}$ m (ii) 1.49   $10^{-3}$ m

**12.** (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

$y_2 = 2 \sin\left(\frac{\pi x}{15} + 96\pi t\right)$

**13.** (i) Stationary wave
(ii) Unacceptable function for any travelling wave
(iii) Travelling harmonic wave
(iv) Superposition of two stationary waves.

**14.** 2000 $ms^{-1}$

**15.** 5.06   $10^3$ $ms^{-1}$

**16.** 0.25 m

**17.** 283.33 Hz

**18.** 27.04 N

**19.** (i) 25 beats(ii) $\frac{1}{10}$s

**20.** 422 Hz

**21.** 7.87 Hz

**22.** 680 Hz

**23.** 220 Hz

**24.** 403.3 Hz to 484 Hz

**25.** 1.5 m/s

**26.** 45.93 kHz

**27.** 0.073 m/s

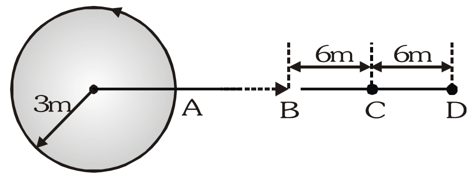
**28.** (i) 599.33 Hz (ii) 0.935 km, 621.43 Hz

**29.** f

# EXERCISE–04 [B]

## BRAIN STORMING SUBJECTIVE EXERCISE

**1.** 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.

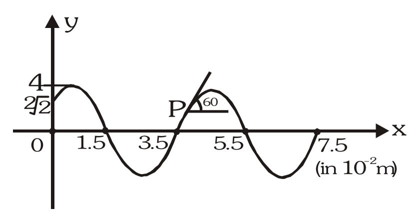



The source is at the point A when the detector is at the point B. If the source emits a continuous sound wave of frequency 340 Hz, find the maximum and the minimum frequencies recorded by the detector.
(Speed of sound = 340 m/s)

**2.** Two radio stations broadcast their programmes at the same amplitude A and at slightly different frequencies $\omega_1$ and $\omega_2$ 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

**3.** 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.

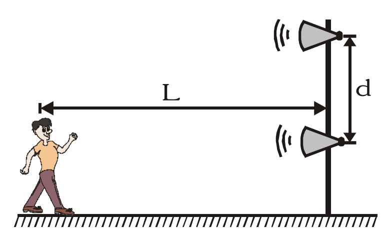
**4.** The figure shows a snap photograph of a vibrating string at t=0. The particle P is observed moving up with velocity $20\sqrt{3}$ cm/s. The tangent at P makes an angle $60^0$ with x–axis (i) Find the direction in which the wave is moving (ii) the equation of the wave (iii) the total energy carried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



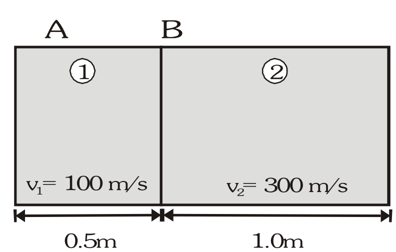

**5.** The harmonic wave $y_i = (2.0 \quad 10^{-3}) \cos\pi\ (2.0\ x - 50t)$ travels along a string toward a boundary at x=0 with a second string. The wave speed on the second string is 50 m/s. Write expressions for reflected and transmitted waves. Assume SI units.

**6.** 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.

**7.** 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.

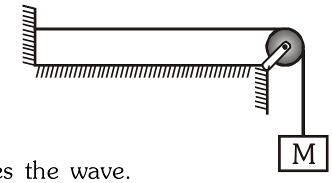



**8.** A cylinder ABC consists of two chambers 1 and 2 which contains two different gases. The wall C is rigid but the walls A and B are thin diaphragms. A vibrating tuning fork approaches the wall A with velocity u= 30 m/s and air columns in chamber 1 and 2 vibrates with minimum frequency such that 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.

**9.** 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(100πt) 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.

**10.** 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.

**11.** 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?

**12.** 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.

**13.** 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?

BRAIN STORMING SUBJECTIVE EXERCISE **ANSWER KEY** EXERCISE–4(B)

**1.** 438.7Hz, 257.3Hz

**2.** (i) 6.28 $10^{-3}$ S, (ii)1.57 $10^{-3}$ S

**3.** $\frac{2f v_b (v + v_m)}{(v^2 - v_b^2)}$

**4.** (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

**5.** (i) 6.67 $10^{-4}$ $\pi(2.0x + 50t)$

(ii) 2.67 $10^{-3}$ $\cos\pi(1.0x - 50t)$

**6.** 33 cm and 13.2 cm

**7.** (i) 2 (ii) 9.28 m and 1.99 m

**8.** (i) 1650 Hz (ii) 1500 Hz

**9.** (i) 10 (ii) 3cm (iii) 36 J

(iv) $y_1 = 3\sin\left(\frac{\pi x}{10} - 100\pi t\right)$, $y_2 = 3\sin\left(\frac{\pi x}{10} + 100\pi t\right)$

**10.** (i) $z_1$ and $z_2$ : x = (2n + 1) $\frac{\pi}{2k}$ ⇒ (2n+1) λ/4

where n = 0, ± 1, ± 2 ..... etc.

(ii) $z_1$ and $z_3$ : x – y = (2n + 1) $\frac{\pi}{k}$

where n = 0, ± 1, ± 2 ......etc.

**11.** (i) $\frac{2\pi}{a}, \frac{b}{2\pi}$

(ii) $y_r$ = – 0.8 A cos (ax – bt)

(iii) 1.8 Ab, 0

(iv) y = – 1.6 A sin ax sinbt + 0.2 A cos (ax + bt)

Antinodes are at $x = \left[n + \frac{(-1)^n}{2}\right]\frac{\pi}{a}$. Travelling wave is propagating in negative x–direction

**12.** y = $10^{-6}$ sin (0.1π) sin (25000 πt), $y_1$=$10^{-6}$ sin (25000 πt–5πx), $y_2$ = $10^{-6}$ sin (25000 πt + 5πx)

**13.** 0.2 cm

# EXERCISE–05(A)

**PREVIOUS YEAR QUESTIONS**

**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 $y = a\sin(\omega t - kx)$ on a string meets with another wave producing a node at $x = 0$. Then the equation of the unknown wave is- [AIEEE-2002]

(1) $y = a\sin(\omega t + kx)$ (2) $y = -a\sin(\omega t + kx)$ (3) $y = a\sin(\omega t - kx)$ (4) $y = -a\sin(\omega t - kx)$

**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 $y(x, t) = 0.005\cos(\alpha x - \beta t)$. If the wavelength and the time period of the wave in 0.08m and 2.0 s respectively then $\alpha$ and $\beta$ 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 $(\nu-1)$, $\nu$, $(\nu+1)$. 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-1:** 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 $y = A\sin(\omega t-kx)$ is superimposed on another wave represented by $y = A\sin(\omega t + kx)$. 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

## ANSWER-KEY

| Que. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ans. | 3 | 2 | 2 | 2 | 1 | 3 | 3 | 4 | 3 | 4 | 2 | 1 | 1 | 4 | 1 | 4 | 2 | 1 | 2 | 2 |

# EXERCISE–05(B) PREVIOUS YEAR QUESTIONS

MCQ'S WITH ONE CORRECT ANSWER

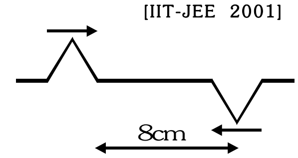
1. A string of length 0.4 m and mass $10^{-2}$ kg is tightly clamped at its ends. The tension in the string is 1.6 N. Identicals wave pulses are produced at one end at equal intervals of time $\Delta t$. The minimum value of $\Delta t$, which allows constructive interference between successive pulses, 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) $E_2 = 16E_1$

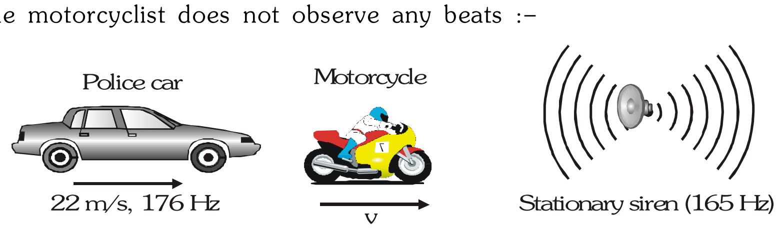
5. Two pulses in a stretched string, whose centres are initially 8 cm apart, are moving towards each other as shown in the figure. The speed of each pulse is 2 cm/s. After 2 s the total energy of the pulses will be :– [IIT-JEE 2001]
(A) Zero
(B) Purely kinetic
(C) Purely potential
(D) Partialy kinetic 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 :–
(A) 200 Hz (B) 3000 Hz (C) 120 Hz (D) 600 Hz [IIT-JEE 2004]

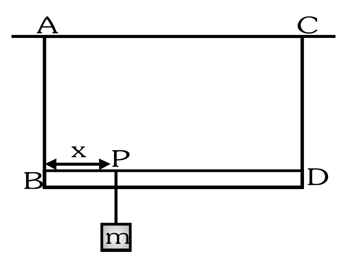
11. A closed organ pipe of length L and an open organ pipe contain gases of densities $\rho_1$ and $\rho_2$ respectively. The compressibility of gases are equal in both the pipes. Both the pipes are vibrating in their first overtone with same frequency. The length of the open organ pipe is :– [IIT-JEE 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) $n = 5,\ f_2 = \frac{3}{4}f_1$

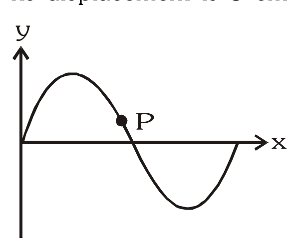
14. A tuning fork of 512 Hz is used to produce resonance in a resonance tube experiment. The level of water at first resonance is 30.7 cm and at second resonance is 63.2 cm. The error in calculating velocity of sound is :–
(A) 204.1 cm/s (B) 110 cm/s (C) 58 cm/s (D) 280 cm/s[IIT-JEE 2005]

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

17. A vibrating string of certain length $\ell$ 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

<u>MCQS (one or more than one answer may be correct)</u>

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 $\lambda$ 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 $\lambda$ and $f$ are given by :– **[IIT-JEE 1998]**

(A) $\lambda = 2\pi \quad 10^{-2}$ 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 (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 **[IIT-JEE 1999]**

5. In a wave motion $y=a\sin(kx-\omega t)$, 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 $\pi$ 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, $y(x, t) = (0.01m) \sin [(62.8 \text{ m}^{-1})x]\cos [(628 \text{ s}^{-1})t]$. 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.

## Comprehension Based Question

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

Two plane harmonic sound waves are expressed by the equations.

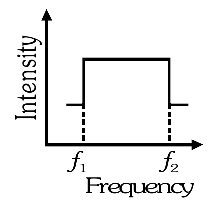
$y_1$ (x, t) = Acos(0.5$\pi$x – 100$\pi$t),  $y_2$ (x, t) = Acos(0.46$\pi$x – 92$\pi$t) (All parameters are in MKS) :

**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

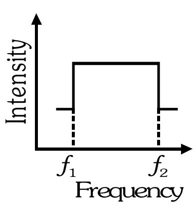
### Comprehension#2 [IIT-JEE 2007]

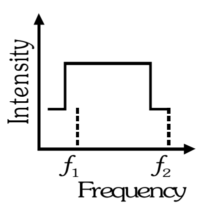


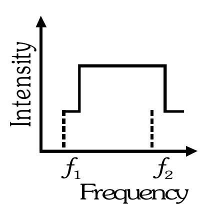

Two trains A and B are moving with speed 20 m/s and 30 m/s respectively in the same direction on the same straight track, with B ahead of A. The engines are at the front ends. The engine of train A blows a long whistle. Assume that the sound of the whistle is composed of components varying in frequency 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.

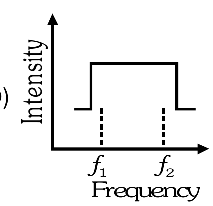
**1.** The speed of sound of the whistle is :–
(A) 340 m/s for passengers in A and 310 m/s for passengers in B
(B) 360 m/s for passengers in A and 310 m/s for passengers in B
(C) 310 m/s for passengers in A and 360 m/s for passengers in B
(D) 340 m/s for passengers in both the trains

**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 $\Delta P_0$ 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.
(i) What will be the frequency detected by a receiver kept inside the river downstream ? **[IIT-JEE 2001]**
(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 = ℓ. 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 the string. **[IIT-JEE 2009]**

PREVIOUS YEARS QUESTIONS — **ANSWER KEY** — EXERCISE –5

- <u>MCQ's One correct answers</u>

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | D | D | C | B | B | A | B | B | D | C | C | C | D | A | A | A |

- <u>MCQ's with one or more than one correct answer</u>

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

- <u>Comprehension based question</u>

<u>Comprehension #1</u> 1. A 2. A 3. D <u>Comprehension #2</u> 1. B 2. A 3. A

- <u>*Subjective Questions*</u>

1. (i) $\frac{15}{16}$ m (ii) $\frac{\Delta P_0}{\sqrt{2}}$ (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) $A_r = \left(\frac{v_2 - v_1}{v_2 + v_1}\right) A_i = 1.5 cm$ , $A_t = \left(\frac{2v_2}{v_2 + v_1}\right) A_i = 2$ 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) $\frac{3}{4}$ 6. 336 $ms^{-1}$ 7. $\frac{A^2\pi^2 T}{4\ell}$ 8. 30 $ms^{-1}$ 9. y = (10 cm) sin $\left(30t \pm \frac{3}{2}x + \phi\right)$ 10. 5