## PRACTICE EXERCISES

## SINGLE CORRECT CHOICE TYPE QUESTIONS

This section contains Single Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct.

**1.** A transverse wave $y = 0.05\sin(20\pi x - 50\pi t)$ in metres, is propagating along +ve $X$-axis on a string. A light insect starts crawling on the string with the velocity of $5\ \text{cms}^{-1}$ at $t = 0$ along the +ve $X$-axis from a point where $x = 5$ cm. After 5 s the difference in the phase of its position is equal to

(A) $150\pi$ (B) $250\pi$
(C) $-245\pi$ (D) $-5\pi$

**2.** A string under a tension of 100 N, emitting its fundamental note, gives 5 bps with a tuning fork. When the tension is increased to 121 N, again 5 beats per second are heard. The frequency of the fork is

(A) 105 N (B) 95 N
(C) 210 N (D) 190 N

**3.** Two tuning forks $A$ and $B$ give 5 bps. A resonates with a column of air 15 cm long, closed at one end, and $B$ with a column 30.5 cm long, open at both ends. Neglecting end correction, the frequencies of $A$ and $B$ are respectively

(A) 300 Hz, 295 Hz (B) 295 Hz, 300 Hz
(C) 305 Hz, 300 Hz (D) 300 Hz, 305 Hz

**4.** A string fixed at both ends is vibrating in the lowest mode of vibration for which a point at quarter of its length from one end is a point of maximum displacement. The frequency of vibration in this mode is 100 Hz. What will be the frequency emitted when it vibrates in the next mode such that this point is again a point of maximum displacement?

(A) 400 Hz (B) 200 Hz
(C) 600 Hz (D) 300 Hz

**5.** The frequency of a sonometer wire is 100 Hz. When the weights producing the tensions are completely immersed in water the frequency becomes 80 Hz and on immersing the weights in a certain liquid the frequency becomes 60 Hz. The specific gravity of the liquid is

(A) 1.42 (B) 1.77
(C) 1.82 (D) 1.21

**6.** An organ pipe $P_1$, closed at one end and vibrating in its first overtone, and another pipe $P_2$ open at both ends and vibrating in its third overtone, are in resonance with a given tuning fork. The ratio of the length of $P_1$ to that of $P_2$ is

(A) $\frac{8}{3}$ (B) $\frac{3}{8}$
(C) $\frac{1}{2}$ (D) $\frac{1}{3}$

**7.** A tuning fork produces a wave of wavelength 110 cm in air at 0 °C. The wavelength at 25 °C would be

(A) 110 cm (B) 115 cm
(C) 120 cm (D) 130 cm

**8.** A 100 Hz sinusoidal wave is travelling in the positive $x$-direction along a string with a linear mass density of $3.5 \times 10^{-3}\ \text{kgm}^{-1}$ and a tension of 35 N. At time $t = 0$, the point $x = 0$ has zero displacement and the slope of the string is $\frac{\pi}{20}$. Then select the wrong alternative

(A) Velocity of wave is $100\ \text{ms}^{-1}$
(B) Angular velocity is $(200\pi)\ \text{rads}^{-1}$
(C) Amplitude of wave is 0.025 m
(D) None of the above

**9.** An observer starts moving with uniform acceleration $a$ towards a stationary sound source of frequency $f_0$. As the observer approaches the source, the apparent frequency $f$ heard by the observer varies with time $t$ as

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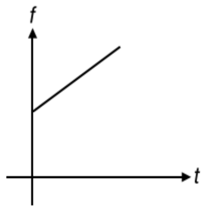


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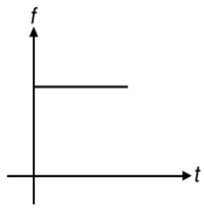


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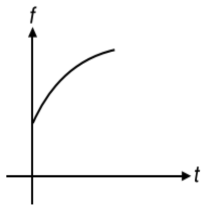


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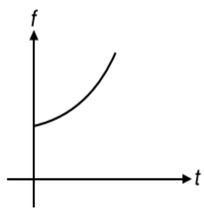



**10.** At $t = 0$, a transverse wave pulse in a wire is described by the function $y = \frac{6}{x^2 - 3}$ where $x$ and $y$ are in metre. The function $y(x, t)$ that describes this wave equation if it is travelling in the positive $x$ direction with a speed of $4.5\ \text{ms}^{-1}$ is

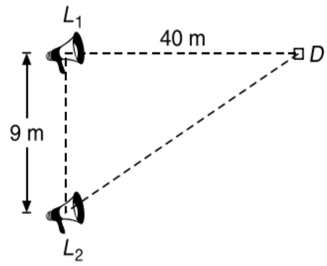
(A) $y = \frac{6}{(x + 4.5t)^2 - 3}$

(B) $y = \frac{6}{(x - 4.5t)^2 + 3}$

(C) $y = \frac{6}{(x + 4.5t)^2 + 3}$

(D) $y = \frac{6}{(x - 4.5t)^2 - 3}$

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

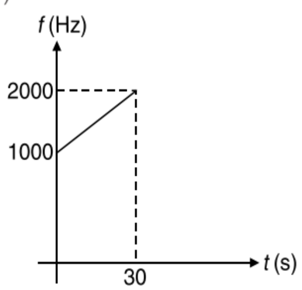



(A) 165 Hz (B) 330 Hz
(C) 495 Hz (D) 660 Hz

**12.** A glass tube 1 m long is filled with water. The water can be drained out slowly at the bottom of the tube. If a vibrating tuning fork of frequency 500 Hz is brought at the upper end of the tube and the velocity of sound is 300 ms$^{-1}$, then the total number of resonances obtained will be
(A) 4 (B) 3
(C) 2 (D) 1

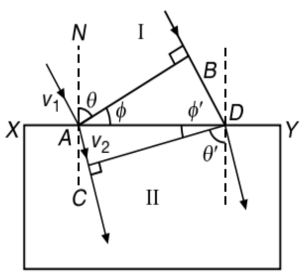
**13.** Two strings $A$ and $B$, made of the same material, have same thickness. The length of $A$ is half that of $B$ while the tension on $A$ is twice that on $B$. The ratio of the velocities of transverse waves in $A$ and $B$ is
(A) $\sqrt{2}:1$ (B) $2:1$
(C) $1:\sqrt{2}$ (D) $1:2$

**14.** 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 $(g = 10 \text{ ms}^{-2})$




(A) 330 ms$^{-1}$ (B) 350 ms$^{-1}$
(C) 300 ms$^{-1}$ (D) 310 ms$^{-1}$

**15.** In the diagram a wavefront $AB$ is incident from rarer Medium I to denser Medium II. Its position inside Medium II is $CD$. The ratio of velocity of sound in Medium I to Medium II i.e., $\frac{v_1}{v_2}$ is




(A) $\frac{\sin\phi}{\sin\theta}$ (B) $\frac{\sin\theta}{\sin\phi}$
(C) $\frac{BD}{AC}$ (D) $\frac{AB}{CD}$

**16.** A closed organ pipe and an open organ pipe of same length produce 2 beats when they are set into vibrations simultaneously in their fundamental mode. The length of open organ pipe is now halved and of closed organ pipe is doubled, the number of beats produced will be
(A) 8 (B) 7
(C) 4 (D) 2

**17.** A train is moving at 30 ms$^{-1}$ in still air. The frequency of the locomotive whistle is 500 Hz and the speed of sound is 345 ms$^{-1}$. The apparent wavelengths of sound in front of and behind the locomotive are respectively
(A) 0.63 m, 0.80 m (B) 0.63 m, 0.75 m
(C) 0.60 m, 0.85 m (D) 0.60 m, 0.75 m

**18.** In PROBLEM 17, what would be the apparent wavelengths as heard by stationary listeners in front of and behind the locomotive if a wind of speed 10 ms$^{-1}$ were blowing in the same direction as that in which the locomotive is travelling?
(A) 0.65 m, 0.73 m (B) 0.60 m, 0.73 m
(C) 0.65 m, 0.78 m (D) 0.60 m, 0.71 m

**19.** The amplitude of wave disturbance propagating in positive $x$-axis is given by $y = \frac{1}{1+x^2}$ at $t = 0$ and $y = \frac{1}{1+(x-1)^2}$ at $t = 2$ s, where $x$ and $y$ are in metres. The shape of the disturbance does not change during the propagation. The velocity of the wave is
(A) 1 ms$^{-1}$ (B) 0.5 ms$^{-1}$
(C) 2 ms$^{-1}$ (D) 4 ms$^{-1}$

**20.** Which of the following is not the standard form of a sine wave?
(A) $y = A\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$ (B) $y = A\sin(vt - kx)$
(C) $y = A\sin\omega\left(t - \frac{x}{v}\right)$ (D) $y = A\sin k(vt - x)$
where symbols have their usual meanings.

**21.** Two speakers connected to the same source of fixed frequency are placed 2.0 m apart in a box. A sensitive microphone placed at a distance of 4.0 m from their midpoint along the perpendicular bisector shows maximum response. The box is slowly rotated until the speakers are in line with the microphone. The distance between the midpoint of the speakers and the microphone remains unchanged. Exactly five maximum responses are observed in the microphone in doing this. The wavelength of the sound wave is
(A) 0.2 m (B) 0.4 m
(C) 0.6 m (D) 0.8 m

**22.** When beats are produced by two waves, viz., $y_1 = A\sin(1000\pi t)$ and $y_2 = A\sin(1008\pi t)$, the beat frequency will be
(A) 4 Hz (B) 8 Hz
(C) $4\pi$ Hz (D) $8\pi$ Hz

**23.** Two sound waves move in the same direction. If the average power transmitted across a cross section by them are equal while their wavelengths are in the ratio of $1:2$. Their pressure amplitudes would be in the ratio of

(A) 1 (B) 2

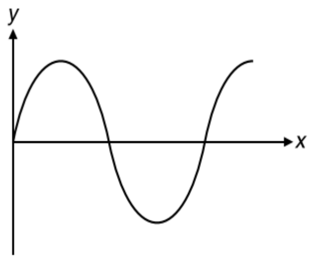
(C) 4 (D) $\frac{1}{2}$

**24.** It is noticed that if the rate of clapping is 100 per minute, the original sound cannot be distinguished from the sound reflected from a wall. If the speed of sound is 330 $ms^{-1}$, the distance of wall from the man is

(A) 33 m (B) 99 m

(C) 132 m (D) 198 m

**25.** In a sine wave, position of different particles at time $t = 0$ is shown in figure. The equation for this wave if it is travelling along positive $x$-axis can be




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

(C) $y = A\cos(\omega t - kx)$ (D) $y = A\cos(kx - \omega t)$

**26.** A car, sounding a horn of frequency 1000 Hz, is moving directly towards a huge wall at a speed of15 $ms^{-1}$. If speed of sound is 340 $ms^{-1}$, then the frequency of the echo heard by the driver is

(A) 1046 Hz (B) 954 Hz

(C) 1092 Hz (D) 908 Hz

**27.** A source of frequency 10 kHz when vibrated over the mouth of a closed organ pipe is in unison at 300 K. The beats produced when temperature rises by 1 K is

(A) 30 Hz (B) 13.33 Hz

(C) 16.67 Hz (D) 40 Hz

**28.** A string of length $2l$, obeying Hooke's law, is stretched so that its extension is $l$. The speed of transverse waves in the string is $v$. If the string is further stretched so that the extension (including the previous extension) becomes $4l$, the speed of transverse waves in the string will be

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

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

**29.** Two harmonic waves travelling in the same medium have frequency ratio $1:2$ and intensity ratio $1:36$. Their amplitude ratio is

(A) $1:3$ (B) $1:6$

(C) $1:8$ (D) $1:72$

**30.** A man standing in front of a mountain beats a drum at regular intervals. The rate of drumming is generally 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 m and finds that echo is again not heard when the drumming rate becomes 60 per minute. The distance between the mountain and the initial position of the man is

(A) 205 m (B) 300 m

(C) 180 m (D) 270 m

**31.** Two sounding bodies producing progressive waves given by $y_1 = 4\sin(400\pi t)$ and $y_2 = 3\sin(404\pi t)$, where $t$ is in seconds, are situated near the ears of a person. The person will hear

(A) 2 beats per second with intensity ratio $\frac{4}{3}$ between maxima and minima.

(B) 2 beats per second with intensity ratio 49 between maxima and minima.

(C) 4 beats per second with intensity ratio 7 between maxima and minima.

(D) 4 beats per second with intensity ratio $\frac{4}{3}$ between maxima and minima.

**32.** The path difference between the two waves $y_1 = a_1\sin\left(\omega t - \frac{2\pi x}{\lambda}\right)$ and $y_2 = a_2\cos\left(\omega t - \frac{2\pi x}{\lambda} + \phi\right)$ is

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

(C) $\frac{2\pi}{\lambda}\left(\phi - \frac{\pi}{2}\right)$ (D) $\frac{2\pi}{\lambda}\phi$

**33.** The frequency of a radar is 780 MHz. When it is reflected from an approaching aeroplane, the apparent frequency is more than the actual frequency by 2.6 kHz. The speed of the aeroplane is

(A) 0.25 $kms^{-1}$ (B) 0.5 $kms^{-1}$

(C) 1.0 $kms^{-1}$ (D) 2.0 $kms^{-1}$

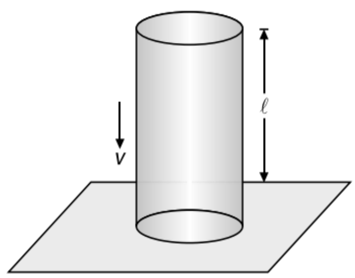
**34.** A string of mass 0.2 $kgm^{-1}$ has length $l = 0.6$ m is fixed at both ends and stretched such that it has a tension of 80 N. The string vibrates in 3 segments with maximum amplitude of 0.5 cm. The maximum transverse velocity amplitude is

(A) 1.57 $ms^{-1}$ (B) 6.28 $ms^{-1}$

(C) 3.14 $ms^{-1}$ (D) 9.42 $ms^{-1}$

**35.** An open pipe of sufficient length is dipping in water with a speed $v$ vertically. If at any instant $l$ is length of tube above water then the rate at which fundamental frequency of pipe changes, is

(speed of sound = $c$)




(A) $\frac{cv}{2l^2}$ (B) $\frac{cv}{4l^2}$

(C) $\frac{c}{2v^2l^2}$ (D) $\frac{c}{4v^2l^2}$

**36.** In Melde's experiment, a string of length 0.8 m and mass 1.0 g vibrates in 4 segments when the tension in the string is 0.4 kgwt. The frequency of the fork is

(A) 70 Hz (B) 90 Hz
(C) 140 Hz (D) 180 Hz

**37.** In PROBLEM 36, the tension in kgwt required to make the string vibrate in 5 segments is

(A) $0.4\left(\frac{4}{5}\right)$ (B) $0.4\left(\frac{4}{5}\right)^2$
(C) $0.4\left(\frac{5}{4}\right)$ (D) $0.4\left(\frac{5}{4}\right)^2$

**38.** A string is under tension so that its length is increased by $\frac{1}{n}$ times its original length. The ratio of fundamental frequency of longitudinal vibrations and transverse vibrations will be

(A) $1:n$ (B) $n^2:1$
(C) $\sqrt{n}:1$ (D) $n:1$

**39.** Equations 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 $x_2 = \frac{3\pi}{2k}$ are $\phi_1$ and $\phi_2$ respectively for the two waves. The ratio $\frac{\phi_1}{\phi_2}$ is

(A) 1 (B) $\frac{5}{6}$
(C) $\frac{3}{4}$ (D) $\frac{6}{7}$

**40.** The frequency of a sonometer wire is $f$. When the weights producing the tensions are completely immersed in water, then the frequency becomes $\frac{f}{2}$ and when the weights are immersed completely in a certain liquid frequency becomes $\frac{f}{3}$. The specific gravity of the liquid is

(A) $\frac{4}{3}$ (B) $\frac{16}{9}$
(C) $\frac{15}{12}$ (D) $\frac{32}{27}$

**41.** The equation of a travelling wave is given as $y = 5\sin[10\pi(t - 0.01x)]$ along the $x$-axis, where all quantities are in SI units. The phase difference between the points separated by a distance of 10 m along $x$-axis is

(A) $\frac{\pi}{2}$ (B) π
(C) 2π (D) $\frac{\pi}{4}$

**42.** The ratio of the velocities of sound in hydrogen and carbon dioxide at S.T.P. is

(A) $\sqrt{\frac{49}{45}\times 22}$ (B) $\sqrt{\frac{21\times 11}{10}}$
(C) $\sqrt{\frac{20}{11}\times 22}$ (D) $\sqrt{\frac{21}{25}\times 22}$

**43.** An air column, closed at one end and open at the other end, resonates with a tuning fork of frequency $v$ when its length is 45 cm, 99 cm and at two other lengths in between these values. The wavelength of sound in the air column is

(A) 180 cm (B) 108 cm
(C) 54 cm (D) 36 cm

**44.** A source of sound emitting a note of constant frequency is moving towards a stationary listener, and then recedes from the listener with constant velocity maintained throughout the motion. The frequency heard by the listener $(f)$ when plotted against time $(t)$ will give the following curve (s).

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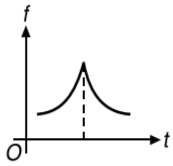


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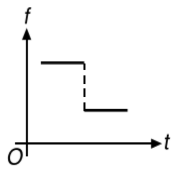


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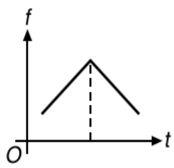


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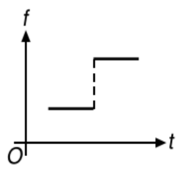



**45.** A wave travelling along positive $x$-axis is given by $y = A\sin(\omega t - kx)$. If it is reflected from rigid boundary such that 80% amplitude is reflected, then equation of reflected wave is

(A) $y = A\sin(\omega t + kx)$ (B) $y = -0.8A\sin(\omega t + kx)$
(C) $y = 0.8A\sin(\omega t + kx)$ (D) $y = A\sin(\omega t + 0.8kx)$

**46.** In PROBLEM 45, if the reflecting boundary is free and yet 80% of amplitude gets reflected, the equation of reflected wave is

(A) $y = A\sin(\omega t + kx)$ (B) $y = -0.8A\sin(\omega t + kx)$
(C) $y = 0.8A\sin(\omega t + kx)$ (D) $y = -0.8A\sin(\omega t + 0.8kx)$

**47.** The speed of sound in air at 15 °C and 76 cm of mercury is 340 ms$^{-1}$. The speed of sound in air at 30 °C and 75 cm of mercury will be

(A) $340\sqrt{\frac{303}{288}}$ (B) $340\sqrt{\frac{288}{303}}$
(C) $340\sqrt{2}$ (D) $340\sqrt{\frac{2\times 75}{76}}$

**48.** If the intensity of sound is doubled, the intensity level will increase by nearly

(A) 1 dB (B) 2 dB
(C) 3 dB (D) 4 dB

**49.** In a plane progressive harmonic wave particle speed is always less than the wave speed if

(A) amplitude of wave is less than $\frac{\lambda}{2\pi}$
(B) amplitude of wave is greater than $\frac{\lambda}{2\pi}$
(C) amplitude of wave is less than $\lambda$
(D) amplitude of wave is greater than $\frac{\lambda}{\mu}$

**50.** The difference between the apparent frequencies of a source of sound as perceived by a stationary observer during its approach and recession is 2% of the actual frequency of the source. If the speed of sound is 300 $ms^{-1}$, the speed of the source is

(A) 12 $ms^{-1}$ (B) 6 $ms^{-1}$
(C) 1.5 $ms^{-1}$ (D) 3 $ms^{-1}$

**51.** A conveyor belt moves to the right with speed $v = 300$ m $min^{-1}$. A pie man puts pies on the belt at a rate of 20 per minute while walking with speed 30 m $min^{-1}$ towards a receiver at the other end. The frequency with which they are received by the stationary receiver is

(A) 26.67 per minute (B) 30 per minute
(C) 22.22 per minute (D) 24 per minute

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

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

**53.** Wavelengths of two notes in air are $\frac{80}{195}$ m and $\frac{80}{193}$ m. Each note produces 5 bps with a third note of a fixed frequency. The speed of sound in air is

(A) 300 $ms^{-1}$ (B) 340 $ms^{-1}$
(C) 375 $ms^{-1}$ (D) 400 $ms^{-1}$

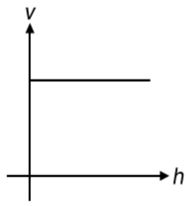
**54.** Velocity of sound in an open organ pipe is 330 $ms^{-1}$. The frequency of wave is 1.1 kHz and the length of tube is 30 cm. To which harmonic does this frequency corresponds

(A) $2^{nd}$ (B) $3^{rd}$
(C) $4^{th}$ (D) $5^{th}$

**55.** Two stretched wires are in unison. If the tension in one of the wires is increased by 1%, 3 beats are produced in2 s. The initial frequency of each wire is

(A) 150 Hz (B) 200 Hz
(C) 300 Hz (D) 450 Hz

**56.** A uniform rope having mass $m$ hangs vertically from a rigid support. A transverse wave pulse is produced at the lower end. The speed $(v)$ of wave pulse varies with height $(h)$ from the lower end as

(A)
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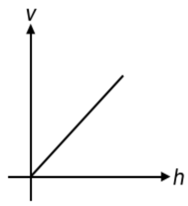


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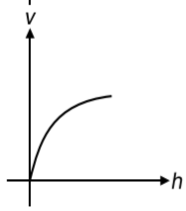


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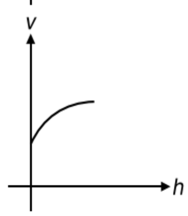



**57.** Two identical sonometer wires have a fundamental frequency of 500 Hz when kept under the same tension. The percentage increase in the tension of one wire that would cause an occurrence of 5 bps, when both wires vibrate together, is

(A) 1% (B) 1.5%
(C) 2% (D) 4%

**58.** A string stretched by a weight of 4 kg is vibrating in its fundamental mode. The additional weight required to produce an octave of the first is

(A) 4 kg (B) 8 kg
(C) 12 kg (D) 16 kg

**59.** The minimum distance of a reflector to hear the echo of monosyllabic sound is (speed of sound is 330 $ms^{-1}$)

(A) 16.5 m (B) 33 m
(C) 165 m (D) 330 m

**60.** Two wires of radii $r$ and $2r$ are welded together end to end. The combination is used as a sonometer wire and is kept under a tension $T$. The welded point is mid-way between the bridges. The ratio of the number of loops formed in the wires, such that the joint is a node when stationary vibrations are set up in the wires, is

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

**61.** A star emits light of wavelength $\lambda$ and it is receding from the earth with a speed $v_s$. The shift in the wavelength of the spectral line observed on the earth is

(A) $\lambda\frac{v_s^2}{c^2}$ (B) $-\lambda\frac{v_s^2}{c^2}$
(C) $-\lambda\frac{v_s}{c}$ (D) $\lambda\frac{v_s}{c}$

**62.** The frequency of the whistle of an engine is 600 Hz. It is moving with a speed of 30 $ms^{-1}$ towards a stationary observer. The apparent frequency is (speed of sound is 330 $ms^{-1}$)

(A) 630 Hz
(B) 660 Hz
(C) 570 Hz
(D) 540 Hz

**63.** Two waves of the same frequency and amplitude superpose to produce a resultant disturbance of the same amplitude. The phase difference between the waves is

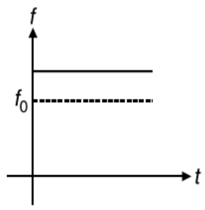
(A) ZERO (B) $\frac{\pi}{3}$
(C) $\frac{\pi}{2}$ (D) $\frac{2\pi}{3}$

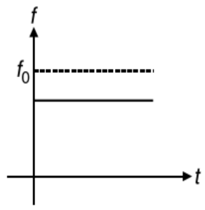
**64.** A tuning fork of frequency 340 Hz is vibrated just above a cylindrical tube of length 120 cm. Water is slowly poured in the tube. If the speed of sound in air is 340 $ms^{-1}$, then the minimum height of water required for resonance is

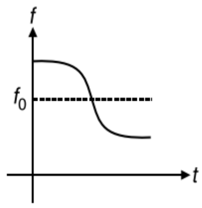
(A) 25 cm (B) 45 cm
(C) 75 cm (D) 95 cm

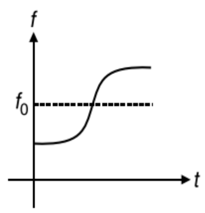
**65.** Source and observer both start moving simultaneously from origin one along $x$-axis and the other along $y$-axis with speed of source is 2 (speed of observer). The graph between the apparent frequency observed by observer $(f)$ and time $(t)$ would be

(Here $f_0$ =natural frequency of source)

(A)



(B)



(C)



(D)



**66.** The velocities of sound in an ideal gas at temperature $T_1$ and $T_2$ are found to be $V_1$ and $V_2$ respectively. If the r.m.s. velocities of the molecules of the same gas at the same temperatures $T_1$ and $T_2$ are $v_1$ and $v_2$, respectively, then

(A) $v_2 = v_1\left(\frac{V_1}{V_2}\right)$ (B) $v_2 = v_1\left(\frac{V_2}{V_1}\right)$

(C) $v_2 = v_1\left(\sqrt{\frac{V_2}{V_1}}\right)$ (D) $v_2 = v_1\left(\sqrt{\frac{V_1}{V_2}}\right)$

**67.** The maximum pressure variation that the human ear can tolerate in loud sound is about 30 $\text{Nm}^{-2}$. The corresponding maximum displacement for a sound wave in air having a frequency of $10^3$ Hz is (take velocity of sound in air as 300 $\text{ms}^{-1}$ and density of air 1.5 $\text{kgm}^{-3}$)

(A) $\frac{2\pi}{3}\times 10^{-2}$ m (B) $\frac{2\times 10^{-4}}{\pi}$ m

(C) $\frac{\pi}{3}\times 10^{-2}$ m (D) $\frac{10^{-4}}{3\pi}$ m

**68.** The equation of a wave is $y = 4\sin\left\{\frac{\pi}{2}\left(2t+\frac{x}{8}\right)\right\}$ where $y$, $x$ are in cm and time in second. The amplitude, wavelength, velocity and frequency of the wave are, respectively,

(A) 4 cm, 32 cm, 16 $\text{cms}^{-1}$, 0.5 Hz
(B) 8 cm, 16 cm, 32 $\text{cms}^{-1}$, 1.0 Hz
(C) 4 cm, 32 cm, 32 $\text{cms}^{-1}$, 0.5 Hz
(D) 8 cm, 16 cm, 16 $\text{cms}^{-1}$, 1.0 Hz

**69.** In PROBLEM 68, the phase difference between two positions of the same particle which are occupied at time interval of 0.4 s is

(A) $0.2\pi$ (B) $0.4\pi$
(C) $0.6\pi$ (D) $0.8\pi$

**70.** In PROBLEM 68, the phase difference at any instant between two particles 12 cm apart is

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

**71.** When a tuning fork $A$ of frequency 100 Hz is sounded with a tuning fork $B$, the number of beats per second is 2. On putting some wax on the prongs of $B$, the number of beats per second becomes 1. The frequency of the fork $B$ is

(A) 98 Hz (B) 99 Hz
(C) 101 Hz (D) 102 Hz

**72.** In a hall, a person receives direct sound waves from a source 120 m away. He also receives waves from the same source which reach him after being reflected from the 25 m high ceiling at a point half-way between them. The two waves interfere constructively for wavelengths (in metres) of

(A) 20, $\frac{20}{3}$, 4, ..... (B) 10, 5, $\frac{10}{3}$, .....
(C) 30, 20, 10, .... (D) 35, 25, 15, .....

**73.** When a source of sound approaches a stationary observer the intensity of the sound wave

(A) is increased
(B) is decreased
(C) remains constant
(D) may increase or decrease depending on the speed of source

**74.** A source of sound and a listener are both moving in the same direction, the source following the listener. If the respective velocities of sound, source and listener are $v$, $v_s$ and $v_l$, then the ratio of the actual frequency of the source and the apparent frequency as received by the listener is

(A) $\frac{v-v_l}{v-v_s}$ (B) $\frac{v-v_s}{v-v_l}$

(C) $\frac{v+v_l}{v+v_s}$ (D) $\frac{v+v_s}{v+v_l}$

**75.** An open and a closed pipe have same length. The ratio of frequencies of their $n^{\text{th}}$ overtone is

(A) $\frac{n+1}{2n+1}$ (B) $\frac{2(n+1)}{2n+1}$

(C) $\frac{n}{2n+1}$ (D) $\frac{n+1}{2n}$

**76.** String 1 has twice the length, twice the radius, twice the tension and twice the density of another string 2. The relation between the fundamental frequencies of 1 and 2 is

(A) $f_1 = 2f_2$ (B) $f_1 = 4f_2$
(C) $f_2 = 4f_1$ (D) $f_1 = f_2$

**77.** Identical wires $A$ and $B$ of different materials are hung from the ceiling of a room. The density of wire $A$ is greater than the density of wire $B$. Identical wave pulses are produced at the bottom of respective wires. The time taken by the pulse to reach the top is

(A) greater for wire $A$
(B) greater for wire $B$
(C) same for both the wires
(D) cannot be determined

**78.** An open organ pipe of length $l$ is sounded together with another open organ pipe of length $l+x$ in their fundamental tones. Speed of sound in air is $v$. The beat frequency heard will be $(x \ll l)$

(A) $\dfrac{vx}{4l^2}$ (B) $\dfrac{vl^2}{2x}$

(C) $\dfrac{vx}{2l^2}$ (D) $\dfrac{vx^2}{2l}$

**79.** A sample of oxygen at N.T.P. has volume $V$ and a sample of hydrogen at N.T.P. has volume $4V$. Both the gases are mixed and the mixture is maintained at N.T.P. If the speed of sound in hydrogen at N.T.P. is $1270\ \text{ms}^{-1}$, that in the mixture will be

(A) $317\ \text{ms}^{-1}$ (B) $635\ \text{ms}^{-1}$

(C) $830\ \text{ms}^{-1}$ (D) $950\ \text{ms}^{-1}$

**80.** A wave equation is given by $y = A\cos(\omega t - kx)$, where symbols have their usual meanings. If $v_p$ is the maximum particle velocity and $v$ is the wave velocity of the wave then

(A) $v_p$ can never be equal to $v$

(B) $v_p = v$ for $\lambda = 2\pi A$

(C) $v_p = v$ for $\lambda = \dfrac{A}{2\pi}$

(D) $v_p = v$ for $\lambda = \dfrac{A}{\pi}$

**81.** A police car with a siren of frequency $8\ \text{kHz}$ is moving with uniform velocity $36\ \text{kmhr}^{-1}$ towards a tall building which reflects the sound waves. The speed of sound in air is $320\ \text{ms}^{-1}$. The frequency of the siren heard by the car driver is

(A) 8.50 kHz (B) 8.25 kHz
(C) 7.75 kHz (D) 7.50 kHz

**82.** The first overtone of an open pipe has frequency $n$. The first overtone of a closed pipe of the same length will have frequency

(A) $\dfrac{n}{2}$ (B) $2n$

(C) $\dfrac{3n}{4}$ (D) $\dfrac{4n}{3}$

**83.** In a Kundt's tube, stationary waves of frequency $1000\ \text{Hz}$ are produced. If the distance between 6 successive nodes is $82.5\ \text{cm}$, the speed of sound in the gas filled in the tube is

(A) $300\ \text{ms}^{-1}$ (B) $330\ \text{ms}^{-1}$

(C) $360\ \text{ms}^{-1}$ (D) $390\ \text{ms}^{-1}$

**84.** If the amplitude of a wave at a distance $r$ from a point source is $A$, the amplitude at a distance $2r$ will be

(A) $2A$ (B) $A$

(C) $\dfrac{A}{2}$ (D) $\dfrac{A}{4}$

**85.** The fundamental frequency of a sonometer wire is $n$. If its length, diameter and tension are doubled, the material of the wire remaining the same, the new fundamental frequency will be

(A) $n$ (B) $\dfrac{n}{\sqrt{2}}$

(C) $\dfrac{n}{2}$ (D) $\dfrac{n}{2\sqrt{2}}$

**86.** A wire of density $9\times10^3\ \text{kgm}^{-3}$ is stretched between two clamps 1 m apart and is subjected to an extension of $4.9\times10^{-4}\ \text{m}$. If Young's modulus of the wire is $9\times10^{10}\ \text{Nm}^{-2}$, the lowest frequency of the transverse vibrations in the wire is

(A) 35 Hz (B) 70 Hz
(C) 105 Hz (D) 140 Hz

**87.** A sonometer wire vibrates with a frequency $f$. It is replaced by another wire of three times the diameter if tension and other parameters remain the same, the frequency of vibration of the wire will be

(A) $\dfrac{f}{9}$ (B) $\dfrac{f}{3}$

(C) $3f$ (D) $9f$

**88.** The lengths of two open organ pipes are $l$ and $l+\Delta l$, $(\Delta l << l)$. If $v$ is the speed of sound then the frequency of beats between them will be approximately (neglect end correction)

(A) $\dfrac{v}{2l}$ (B) $\dfrac{v}{4l}$

(C) $\dfrac{v\Delta l}{l^2}$ (D) $\dfrac{v\Delta l}{2l^2}$

**89.** A train is moving with a constant speed along a circular track. The engine of the train emits a sound of frequency $f$. The frequency heard by the guard at rear end of the train

(A) is less than $f$
(B) is greater than $f$
(C) is equal to $f$
(D) may be greater than, less than or equal to $f$ depending on the factors like speed of train, length of train and radius of circular track

**90.** Which of the following equations does not represent a progressive wave

(A) $y = A\sin\left\{\omega\left(t - \dfrac{x}{c}\right)\right\}$

(B) $y = A\sin\left\{\dfrac{2\pi}{\lambda}(ct - x)\right\}$

(C) $y = A\sin\left\{2\pi\left(\dfrac{t}{T} + \dfrac{x}{\lambda}\right)\right\}$

(D) $y = A\sin\left\{2\pi\left(\dfrac{t}{T} - \dfrac{x}{c}\right)\right\}$

**91.** Speed of transverse wave in a string of density $100\ \text{kgm}^{-3}$ and area of cross-section $10\ \text{mm}^2$ under a tension of $10^3\ \text{N}$ is

(A) $100\ \text{ms}^{-1}$ (B) $1000\ \text{ms}^{-1}$

(C) $200\ \text{ms}^{-1}$ (D) $2000\ \text{ms}^{-1}$

ICON



**92.** A person speaking normally produces a sound intensity of 40 dB at a distance of 1 m. If the threshold intensity for reasonable audibility is 20 dB, the maximum distance at which he can be heard clearly is

(A) 4 m (B) 5 m
(C) 10 m (D) 20 m

**93.** If two coherent waves of the same frequency but different amplitudes superpose at a point

(A) there will be no interference.
(B) the intensity of sound at any point will vary with time.
(C) there will be interference but the minimum intensity will not be zero.
(D) there will be interference with minimum intensity equal to zero.

**94.** Two interfering waves of the same frequency have amplitudes in the ratio $1:3$. If the intensity of the first wave is $I$, the intensity at the maxima of interference is

(A) $16I$ (B) $8I$
(C) $4I$ (D) $64I$

**95.** In PROBLEM 94, the intensity at the minima is

(A) ZERO (B) $2I$
(C) $4I$ (D) $8I$

**96.** A source of sound is moving towards a stationary observer with a speed of 50 $ms^{-1}$. The observer measures the frequency of the source as 1000 Hz. The speed of sound is 350 $ms^{-1}$. The apparent frequency measured by the observer when the source is moving away after crossing the observer is

(A) 750 Hz (B) 850 Hz
(C) 1150 Hz (D) 1250 Hz

**97.** A 10 watt source of sound of frequency 1000 Hz sends out waves in air. The displacement amplitude at a distance of 10 m from the source is (speed of sound in air = 340 $ms^{-1}$ and density of air = 1.29 $kgm^{-3}$)

(A) 0.62 $\mu m$ (B) 4.2 $\mu m$
(C) 1.6 $\mu m$ (D) 0.96 $\mu m$

**98.** Two tuning forks $A$ and $B$ vibrating simultaneously produce 5 bps. Frequency of $B$ is 512 Hz. If one arm of $A$ is filed, the number of beats per second increases. Frequency of $A$ is

(A) 502 Hz (B) 507 Hz
(C) 517 Hz (D) 522 Hz

**99.** If $\lambda_1$, $\lambda_2$ and $\lambda_3$ are the wavelengths of the waves giving resonance with the fundamental, first and second overtones respectively of a closed organ pipe. Then the ratio of wavelengths $\lambda_1 : \lambda_2 : \lambda_3$ is

(A) $1:2:3$ (B) $1:\frac{1}{3}:\frac{1}{5}$
(C) $1:3:5$ (D) $5:3:1$

**100.** In order to increase the frequency of transverse oscillations of a stretched wire by 50%, its tension must be increased by

(A) 50% (B) 100%
(C) 125% (D) 150%

**101.** Speed of sound wave in a gas is $v_1$ and r.m.s. speed of molecules of the gas at the same temperature is $v_2$. Then

(A) $v_1 = v_2$ (B) $v_1 < v_2$
(C) $v_1 > v_2$ (D) $v_1 \leq v_2$

**102.** A vibrating stretched string resonates with a tuning fork of frequency 512 Hz when the length of the string is 0.5 m. The length of the string required to vibrate resonantly with a tuning fork of frequency 256 Hz would be

(A) 0.25 m (B) 0.75 m
(C) 1.0 m (D) 2.0 m

**103.** Consider two pipes each having a length of 2 m. One is closed at one end and the other is open at both ends. The speed of sound in air is 340 $ms^{-1}$. The frequency at which both can resonate is

(A) 340 Hz (B) 510 Hz
(C) 42.5 Hz (D) None of these

**104.** If $l_1$ and $l_2$ are the lengths of air column for the first and second resonance when a turning fork of frequency $n$ is sounded on a resonance tube. Taking into account the end correction, the distance of the antinode from the top end of the resonance tube is

(A) $2(l_2 - l_1)$ (B) $\frac{1}{2}(2l_1 - l_2)$
(C) $\frac{l_2 - 3l_1}{2}$ (D) $\frac{l_2 - l_1}{2}$

**105.** The speed of sound wave in a gas, in which two waves of wavelengths 1 m and 1.02 m produce 6 beats per second is

(A) 350 $ms^{-1}$ (B) 306 $ms^{-1}$
(C) 380 $ms^{-1}$ (D) 410 $ms^{-1}$

**106.** Two interfering waves of the same frequency have an intensity ratio $16:1$. The ratio of intensities at the maxima and the minima is

(A) $\frac{25}{16}$ (B) 9
(C) 4 (D) $\frac{25}{9}$

**107.** A string of length $L$ is stretched by $\frac{L}{20}$ and speed of transverse wave along it is $v$. The speed of wave when it is stretched by $\frac{L}{10}$ will be (assume that Hooke's Law is applicable)

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

**108.** Two identical sounds $s_1$ and $s_2$ reach at a point $P$ in phase. The resultant loudness at point $P$ is $n$ decibel higher than the loudness of $s_1$. The value of $n$ is

(A) 2 (B) 4
(C) 5 (D) 6

Given $\log_{10}(2) = 0.3$

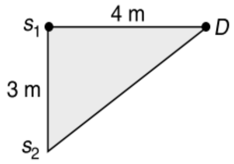
**109.** The frequency of the horn of a car as perceived by a stationary observer towards whom the car is moving differs from the actual frequency by 2.5%. If the speed of the sound in air is 320 $ms^{-1}$, the speed of the car is

(A) 6 $ms^{-1}$ (B) 7.2 $ms^{-1}$
(C) 7.8 $ms^{-1}$ (D) 9 $ms^{-1}$

**110.** If the tension in a string stretched between two fixed points is made four times, the frequency of the second harmonic will become
(A) two times (B) three times
(C) four times (D) six times

**111.** Two sound waves, each of amplitude $A$ and frequency $\omega$, superpose at a point with a phase difference of $\frac{\pi}{2}$. The amplitude and the frequency of the resultant wave are, respectively
(A) $\frac{A}{\sqrt{2}}, \frac{\omega}{2}$ (B) $\frac{A}{\sqrt{2}}, \omega$
(C) $\sqrt{2}A, \frac{\omega}{2}$ (D) $\sqrt{2}A, \omega$

**112.** In the figure the intensity of waves arriving at $D$ from two coherent sources $s_1$ and $s_2$ is $I_0$. The wavelength of the wave is $\lambda = 4$ m. Resultant intensity at $D$ will be




(A) $4I_0$ (B) $I_0$
(C) $2I_0$ (D) ZERO

**113.** A stretched string of length 1 m has mass per unit length 0.5 g. The tension in the string is 20 N. If it is plucked at a distance of 25 cm from one end, the frequency of vibration will be
(A) 100 Hz (B) 200 Hz
(C) 300 Hz (D) 400 Hz

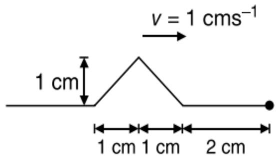
**114.** If $v_0$ and $v$ denote the sound velocity and the r.m.s. velocity of the molecules in a gas, then
(A) $v_o > v$
(B) $v_0 = v$
(C) $v_0 = v\sqrt{\frac{\gamma}{3}}$
(D) $v_0$ and $v$ are not related

**115.** A transverse sine wave of amplitude 10 cm and wavelength 200 cm travels from left to right along a long horizontal stretched string with a speed of 100 $cms^{-1}$. Take the origin at left end of the string. At time $t = 0$ the left end of the string is at the origin and is moving downward. Then the equation of the wave will be (in C.G.S. system)
(A) $y = 10\sin(0.01\pi x - \pi t)$
(B) $y = 10\sin(\pi t - 0.01\pi x)$
(C) $y = 10\sin(0.02\pi x - 0.01\pi t)$
(D) $y = 10\sin(\pi t - 0.02\pi x)$

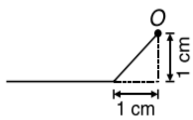
**116.** The speed of sound in air at S.T.P. is 300 $ms^{-1}$. If the air pressure becomes double, the temperature remaining the same, the speed of sound would become
(A) 1200 $ms^{-1}$ (B) 600 $ms^{-1}$
(C) $300\sqrt{2}$ $ms^{-1}$ (D) 300 $ms^{-1}$

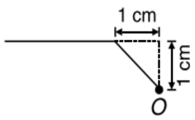
**117.** When a sound wave of frequency 300 Hz passes through a medium, the maximum displacement of a particle of the medium is 0.1 cm. The maximum velocity of particle is equal to
(A) $60\pi$ $cms^{-1}$ (B) $30\pi$ $cms^{-1}$
(C) 30 $cms^{-1}$ (D) 60 $cms^{-1}$

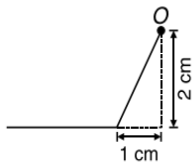
**118.** A wave pulse on a string has the dimension shown in figure. The wave speed is $v = 1$ $cms^{-1}$. If point $O$ is a free end. The shape of wave at time $t = 3$ s is




(A) 

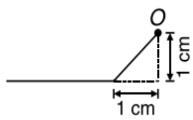
(B) 

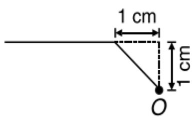
(C) 

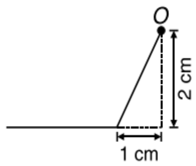
(D) 


**119.** In PROBLEM 118, shape of the wave at time $t = 3$ s if $O$ is a fixed end will be

(A) 

(B) 

(C) 

(D) 


**120.** A tuning fork, whose frequency as given by the manufacturer is 512 Hz, is being tested using an accurate oscillator. It is found that they produce 2 beats per second when the oscillator reads 514 Hz, and 6 beats second when it reads of 510 Hz. The actual frequency of the fork is
(A) 508 Hz (B) 512 Hz
(C) 516 Hz (D) 518 Hz

**121.** A travelling wave is partly reflected and partly transmitted from a rigid boundary. Let $a_i$, $a_r$ and $a_t$ be the amplitudes of incident wave, reflected wave and transmitted wave and $I_i$, $I_r$ and $I_t$ be the corresponding intensities. Then choose the correct alternative
(A) $\frac{I_i}{I_r} = \left(\frac{a_i}{a_r}\right)^2$ (B) $\frac{I_i}{I_t} = \left(\frac{a_i}{a_t}\right)^2$
(C) $\frac{I_r}{I_t} = \left(\frac{a_r}{a_t}\right)^2$ (D) $\frac{I_i}{I_r} = \left(\frac{a_r}{a_i}\right)^2$

**122.** A uniform circular hoop is rotating clockwise in the absence of gravity with tangential speed $v_0$. If $v$ be the velocity of transverse waves travelling on this string then,

(A) $v \neq v_0$ (B) $v < v_0$
(C) $v > v_0$ (D) $v = v_0$

**123.** Two sound waves have intensities of 10 and 500 $\mu$Wcm$^{-2}$. How many decibels is the sound louder than the other?

(A) 7 dB (B) 1.7 dB
(C) 2.7 dB (D) 3.7 dB

**124.** In a resonance tube, the first resonance is obtained when the level of water in the tube is at 16 cm from the open end. Neglecting end correction, the next resonance will be obtained when the level of water from the open end is

(A) 24 cm (B) 32 cm
(C) 48 cm (D) 64 cm

**125.** Waves from three sources of the same intensity and frequencies $(n-1)$, $n$ and $(n+1)$ Hz superpose. The number of beats per second is

(A) 0 (B) 1
(C) 2 (D) 3

**126.** The apparent wavelength of the light from a star, moving away from the earth is 0.01% more than its real wavelength. The speed of the star with respect to the earth is

(A) 10 kms$^{-1}$ (B) 15 kms$^{-1}$
(C) 30 kms$^{-1}$ (D) 60 kms$^{-1}$

**127.** The temperature at which the speed of sound in air becomes double its value at 0 °Cis

(A) 1092 °C (B) 819 K
(C) 819 °C (D) 546 °C

**128.** The equation for the vibration of a string fixed at both ends vibrating in its third harmonic is given by $y = 2\text{ cm} \sin\left[\left(0.6\text{ cm}^{-1}\right)x\right]\cos\left[\left(500\pi s^{-1}\right)t\right]$. The length of the string is

(A) 24.6 cm (B) 12.5 cm
(C) 20.6 cm (D) 15.7 cm

**129.** A stretched string of length 2 m vibrates in 4 segments. The distance between consecutive nodes is

(A) 0.5 m (B) 0.25 m
(C) 1.0 m (D) 0.75 m

**130.** An echo repeats two syllables. If the speed of sound is 330 ms$^{-1}$, then the minimum distance of reflecting surface is

(A) 16.5 m (B) 33.0 m
(C) 66.0 m (D) 330 m

**131.** A motion is described by $y = 3e^{x}e^{-3t}$ where $y$, $x$ are in metre and $t$ is in second.

(A) This represents equation of progressive wave propagating along $-x$ direction with 3 ms$^{-1}$.
(B) This represents equation of progressive wave propagating along $+x$ direction with 3 ms$^{-1}$.
(C) This does not represent a progressive wave equation.
(D) Data is insufficient to arrive at any conclusion of this sort.

**132.** A wave of frequency 500 Hz has a velocity 360 ms$^{-1}$. The distance between two nearest points which are 60° out of phase, is

(A) 0.7 cm (B) 12 cm
(C) 70 cm (D) 120 cm

**133.** The frequency of the first harmonic of a string stretched between two points is 100 Hz. The frequency of the third overtone is

(A) 200 Hz (B) 300 Hz
(C) 400 Hz (D) 600 Hz

**134.** The three lowest frequencies (in Hz) with which a 20 m long pipe, closed at one end, can vibrate are (speed of sound is 340 ms$^{-1}$)

(A) 425, 850, 1275
(B) 425, 1275, 2125
(C) 900, 1800, 2700
(D) 900, 2700, 4500

**135.** 65 tuning forks are arranged in order of increasing frequency. Any two successive forks produce 4 bps when sounded together. If the last fork gives an octave of the first, the frequency of the first fork is

(A) 252 Hz (B) 256 Hz
(C) 260 Hz (D) 264 Hz

**136.** The fundamental not produced by an open organ pipe has frequency $n$. The fundamental note produced by a closed organ pipe of the same length will have frequency

(A) $\frac{n}{2}$ (B) $2n$
(C) $\frac{n}{4}$ (D) $4n$

**137.** The ratio of the velocity of sound in a monatomic gas to that in a triatomic gas having same molar mass, under similar conditions of temperature and pressure, is

(A) 1.12 (B) 1.25
(C) 1.50 (D) 1.62

**138.** The equation of a wave disturbance is given as $y = 0.02\cos\left(\frac{\pi}{2} + 50\pi t\right)\cot(10\pi x)$, where $x$ and $y$ are in metres and $t$ in seconds. Select the incorrect statement.

(A) Antinode occurs at $x = 0.3$ m
(B) The wavelength is 0.2 m
(C) The speed of the constituent waves is 4 ms$^{-1}$
(D) Node occurs at $x = 0.15$ m

**139.** The minimum length of a tube, open at both ends, that resonates with a tuning fork of frequency 350 Hz is (velocity of sound in air is 350 ms$^{-1}$)

(A) 0.25 m (B) 0.5 m
(C) 1 m (D) 2 m

**140.** A tuning fork and a sonometer give 5 bps both when the length of the wire is 1 m and 1.05 m. The frequency of the fork is

(A) 420 Hz (B) 410 Hz
(C) 210 Hz (D) 205 Hz

141. A source and a listener are both moving towards each other with speed $\frac{v}{10}$, where $v$ is the speed of sound. If the frequency of the note emitted by the source is $f$, the frequency heard by the listener would be nearly
(A) $1.11f$ (B) $1.22f$
(C) $1.27f$ (D) $f$

142. A sonometer wire is vibrating in the second overtone. In the wire there are
(A) two nodes and two antinodes.
(B) one node and two antinodes.
(C) four nodes and three antinodes.
(D) three nodes and three antinodes.

143. Waves from two sources of intensities $I$ and $4I$ interfere at a point. The resultant intensity at a point where the phase difference is $\frac{\pi}{2}$ is
(A) $9I$ (B) $5I$
(C) $3I$ (D) $I$

144. A sufficiently long closed organ pipe has a small hole at its bottom. Initially the pipe is empty. Water is poured into the pipe at a constant rate. The fundamental frequency of the air column in the pipe
(A) continuously increases
(B) first increases and then becomes constant
(C) continuously decreases
(D) first decreases and then becomes constant

145. A sound has an intensity of $2\times10^{-8}$ Wm$^{-2}$. Its intensity level in decibels is $(\log_{10} 2 = 0.3)$
(A) 23 (B) 3
(C) 43 (D) 4.3

146. The fractional change in tension in a sonometer wire of fixed length to produce a note one octave lower than before is
(A) $\frac{1}{4}$ (B) $\frac{1}{2}$
(C) $\frac{2}{3}$ (D) $\frac{3}{4}$

147. Speed of sound wave is $v$. If a reflector moves towards a stationary source emitting waves of frequency $f$ with speed $u$, the wavelength of reflected wave will be
(A) $\frac{v-u}{v+u}f$ (B) $\frac{v+u}{v}f$
(C) $\frac{v+u}{v-u}f$ (D) $\frac{v-u}{v}f$

148. 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 velocity of train $B$ to that of train $A$ is
(A) $\frac{242}{252}$ (B) 2
(C) $\frac{5}{6}$ (D) $\frac{11}{6}$

149. A progressive wave of frequency 500 Hz is travelling with a speed of 350 ms$^{-1}$. A compressional maximum appears at a place at a given instant. The minimum time interval after which a rarefaction maximum occurs at the same point is
(A) $\frac{1}{250}$ s (B) $\frac{1}{500}$ s
(C) $\frac{1}{1000}$ s (D) $\frac{1}{350}$ s

150. In PROBLEM 149, the minimum distance between a centre of compression and a centre of rarefaction at any instant is
(A) 1.4 m (B) 0.70 m
(C) 0.35 m (D) 0.175 m

151. If the amplitude of sound is doubled and the frequency reduced to one-fourth, the intensity will
(A) increase by a factor of 2
(B) decrease by a factor of 2
(C) decrease by factor of 4
(D) remain unchanged

152. A standing wave is maintained in a homogeneous string of cross-sectional area $a$ and density $\rho$. It is formed by the superposition of two waves travelling in opposite directions given by the equation

$$y_1 = a\sin(\omega t - kx) \text{ and } y_2 = 2a\sin(\omega t + kx)$$

The total mechanical energy confined between the sections corresponding to the adjacent antinodes is
(A) $\frac{3\pi s\rho\omega^2a^2}{2k}$ (B) $\frac{\pi s\rho\omega^2a^2}{2k}$
(C) $\frac{5\pi s\rho\omega^2a^2}{2k}$ (D) $\frac{2\pi s\rho\omega^2a^2}{2k}$

153. If the intensity of sound increases by a factor of $10^5$, the increase in the intensity level is
(A) 5 dB (B) 10 dB
(C) 25 dB (D) 50 dB

154. The ratio of intensities between two coherent sound sources is $4:1$. The difference of loudness decibels (dB) between maximum and minimum intensities, when they interfere in space is
(A) $10\log(2)$ (B) $20\log(3)$
(C) $20\log_e(3)$ (D) $20\log(2)$

155. The intensity in Wm$^{-2}$ of a 70 dB noise is
(A) $10^{-5}$ (B) $10^{-7}$
(C) $10^5$ (D) $10^7$

156. Two sound sources are moving in opposite directions with velocities $v_1$ and $v_2$ $(v_1 > v_2)$. Both are moving away from a stationary observer. The frequency of both the sources is 900 Hz. For what value of $v_1 - v_2$ the beat frequency

observed by the observer is 6 Hz. Given, speed of sound $v = 300\ ms^{-1}$ and that $v_1$ and $v_2$ both $\ll v$.

(A) $1\ ms^{-1}$ (B) $2\ ms^{-1}$
(C) $3\ ms^{-1}$ (D) $4\ ms^{-1}$

**157.** A source of sound is moving with a constant speed of $20\ ms^{-1}$ emitting a note of a fixed frequency. The ratio of the frequencies observed by a stationary observer when the source is approaching him and after it has crossed him is

(A) 9 : 8 (B) 8 : 9
(C) 10 : 9 (D) 9 : 10

**158.** A stretched rope having linear mass density $5 \times 10^{-2}\ kgm^{-1}$ is under a tension of 80 N. The power that has to be supplied to the rope to generate harmonic waves at a frequency of 60 Hz and an amplitude of 6 cm is

(A) 215 W (B) 251 W
(C) 512 W (D) 521 W

**159.** The frequency changes by 10% as the source approaches a stationary observer with constant speed $v_s$. What would be the percentage change in frequency as the source recedes the observer with the same speed. Given that $v_s \ll v$ ($v$ = speed of sound in air)

(A) 14.3% (B) 20%
(C) 16.7% (D) 10%

**160.** A column of air at 51 °C and a tuning fork produce 4 bps when sounded together. As the temperature of the air column is decreased, the number of bps tends to decrease and when the temperature is 16 °C, the two produce 1 bps. The frequency of the fork is

(A) 50 Hz (B) 75 Hz
(C) 100 Hz (D) 150 Hz

**161.** A train moves towards a stationary observer with $34\ ms^{-1}$. The train sounds a whistle and its frequency registered by the observer is $f_1$. If the train's speed is reduced to $17\ ms^{-1}$, the frequency registered is $f_2$. If the speed of sound is $340\ ms^{-1}$, then the ratio $\frac{f_1}{f_2}$ is

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

**162.** An engine is moving on a circular track with a constant speed. It is blowing a whistle of frequency 500 Hz. The frequency received by an observer standing stationary at the centre of the track is

(A) 500 Hz.
(B) more than 500 Hz.
(C) less than 500 Hz.
(D) more or less than 500 Hz depending on the actual speed of the engine.

**163.** Two tuning forks of frequencies 256 Hz and 258 Hz are sounded together. The time interval, between two consecutive maxima heard by an observer is

(A) 0.5 s (B) 2 s
(C) 250 s (D) 252 s

**164.** How many times more intense is a 90 dB sound than a 40 dB sound?

(A) 2.5 (B) 5
(C) 50 (D) $10^5$

**165.** Two steel wires of the same length are stretched by the same tension. The frequency of the fundamental note emitted by one is four times that of the other. The ratio of their diameters is

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

**166.** First overtone frequency of a closed organ pipe is equal to the first overtone frequency of an open organ pipe. Further $n$th harmonic of closed organic pipe is also equal to the $m$th harmonic of open pipe, where $n$ and $m$ are

(A) 5, 4 (B) 7, 5
(C) 9, 6 (D) 7, 3

**167.** A source of sound is travelling towards a stationary observer. The frequency of sound heard by the observer is 25% more than the actual frequency. If the speed of sound is $v$, that of the source is

(A) $\frac{v}{5}$ (B) $\frac{v}{4}$
(C) $\frac{v}{3}$ (D) $\frac{v}{2}$

**168.** 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

(A) $\frac{f}{2}$ (B) $f$
(C) $\frac{3f}{4}$ (D) $2f$

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

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

**170.** In an experiment it was found that string vibrates in $n$ loops when a mass $M$ is placed on the pan. What mass should be placed on the pan to make it vibrate in $2n$ loops with same frequency. (Neglect the mass of pan)

(A) $2M$ (B) $\frac{1}{4}M$
(C) $4M$ (D) $\frac{1}{2}M$

**171.** For a certain organ pipe, three successive resonance frequencies are observed at 425, 595 and 765 Hz. The speed of sound in air is $340\ ms^{-1}$. The pipe is a

(A) closed pipe of length 1 m.
(B) closed pipe of length 2 m.
(C) open pipe of length 1 m.
(D) open pipe of length 2 m.

172. In PROBLEM 171, the fundamental frequency of the pipe is
(A) 425 Hz (B) 340 Hz
(C) 170 Hz (D) 85 Hz

173. The ratio of the velocities of sound in hydrogen and oxygen at S.T.P. is
(A) 16 : 1 (B) 8 : 1
(C) 4 : 1 (D) 2 : 1

174. A heavy rope is suspended from a rigid support. A wave pulse is set up at the lower end, then
(A) the pulse will travel with uniform speed
(B) the pulse will travel with increasing speed
(C) the pulse will travel with decreasing speed
(D) the pulse cannot travel through the rope

175. A boat of anchor is rocked by waves of velocity 25 $ms^{-1}$, having crests 100 m apart. They reach the boat once every
(A) 4.0 s (B) 8.0 s
(C) 2.0 s (D) 0.25 s

176. For the stationary wave

$$y(\text{in cm}) = 4\sin\left(\frac{\pi x}{15}\right)\cos(96\pi t)$$

the distance between a node and the nearest antinode is
(A) 7.5 cm (B) 15 cm
(C) 22.5 cm (D) 30 cm

177. For a certain organ pipe three successive resonance frequencies are observed at 425 Hz, 595 Hz and 765 Hz respectively. If the speed of sound in air is 340 $ms^{-1}$, then the length of the pipe is
(A) 2 m (B) 0.4 m
(C) 1 m (D) 0.2 m

178. In a stationary wave that forms as a result of reflection of waves from an obstacle, 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) $\left(\frac{n}{n+1}\right)^2$

179. Consider 10 identical sources of sound all giving the same frequency but having phase angles which are random. If the average intensity of each source is $I_0$, the average of resultant intensity due to all these ten sources will be
(A) $I_0$ (B) $\sqrt{10}\,I_0$
(C) $10I_0$ (D) $100I_0$

180. The fundamental frequency of a closed organ pipe is 50 Hz. The frequency of the second overtone is
(A) 100 Hz (B) 150 Hz
(C) 200 Hz (D) 250 Hz

181. A tuning fork of frequency 90 Hz is sounded and moved towards a stationary observer with a speed equal to one-tenth the speed of sound. The note heard by the observer will have a frequency
(A) 100 (B) 110
(C) 80 (D) 70

182. The speed of sound in a gas in which two waves of wavelengths 50 cm and 50.4 cm produce 6 beats per second is
(A) 338 $ms^{-1}$ (B) 350 $ms^{-1}$
(C) 378 $ms^{-1}$ (D) 400 $ms^{-1}$

183. When a source of sound of frequency $f$ crosses a stationary observer with a speed $v_s$ ($\ll$ speed of sound $v$), the apparent change in frequency $\Delta f$ is given by
(A) $\frac{2fv_s}{v}$ (B) $2fvv_s$
(C) $\frac{2fv}{v_s}$ (D) $\frac{fv_s}{v}$

## MULTIPLE CORRECT CHOICE TYPE QUESTIONS

This section contains Multiple Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct.

1. A wire of $9.8\times10^{-3}$ $kgm^{-1}$ passes over a frictionless light pulley fixed on the top of a frictionless inclined plane which makes an angle of 30° with the horizontal. Masses $m$ and $M$ are tied at the two ends of wire such that $m$ rests on the plane and $M$ hangs freely vertically downwards. The entire system is in equilibrium and a transverse wave propagates along the wire with a velocity of 100 $ms^{-1}$.
(A) $m = 20$ kg (B) $M = 5$ kg
(C) $\frac{m}{M} = \frac{1}{2}$ (D) $\frac{m}{M} = 2$

2. A wave equation which gives the displacement along the $y$-direction is given by

$$y = 10^{-4}\sin(60t + 2x)$$

where $x$ and $y$ are in metres and $t$ is time in seconds. This represents a wave
(A) travelling with a velocity of 30 $ms^{-1}$ in the negative $x$-direction
(B) of wavelength $\pi m$
(C) of frequency $\frac{30}{\pi}$ hertz
(D) of amplitude $10^{-4}$ m travelling along the negative $x$-direction

3. The displacement of a particle in a medium due to a wave travelling in the $x$-direction through the medium is given by $y = a\sin(\alpha t - \beta x)$ where $t$ is time in second, $\alpha$ and $\beta$ are constants.
(A) The frequency of the wave is $\alpha$.
(B) The time period of the wave is $\frac{2\pi}{\alpha}$.

(C) The wavelength of the wave is $\frac{2\pi}{\beta}$.

(D) The velocity of the wave is $\frac{\alpha}{\beta}$.

**4.** Any progressive wave equation in differential form is

(A) $\frac{1}{\omega^2}\frac{\partial^2 y}{\partial t^2}=\frac{1}{k^2}\frac{\partial^2 y}{\partial x^2}$ (B) $\frac{1}{\omega}\frac{\partial y}{\partial t}=-\frac{1}{k}\frac{\partial y}{\partial x}$

(C) $\frac{1}{\omega^2}\frac{\partial^2 y}{\partial t^2}=-\frac{1}{k^2}\frac{\partial^2 y}{\partial x^2}$ (D) $\frac{1}{\omega}\frac{\partial y}{\partial t}=\frac{1}{k}\frac{\partial y}{\partial x}$

**5.** A plane progressive wave of frequency 25 Hz amplitude $2.5\times10^{-5}$ m and initial phase zero propagates along negative $x$-direction with a velocity of 300 ms$^{-1}$. At any instant, the phase difference between the oscillations at two points 6 m apart along the line is $\phi$ and the corresponding amplitude difference is $A$.

(A) $A=0$ (B) $\phi=0$
(C) $A=2.5\times10^{-5}$ m (D) $\phi=\pi$

**6.** 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 $v=10$ ms$^{-1}$, then $\lambda$ and $f$ are given by

(A) $\lambda=2\pi\times10^{-2}$ m (B) $\lambda=10^{-3}$ m
(C) $f=\frac{10^3}{2\pi}$ Hz (D) $f=10^4$ Hz

**7.** The tension in a stretched string fixed at both ends is changed by 2%, the fundamental frequency is found to get changed by 15 Hz. Select the correct statement(s).

(A) Wavelength of the string of fundamental frequency does not change
(B) Velocity of propagation of wave changes by 2%
(C) Velocity of propagation of wave changes by 1%
(D) Original frequency is 1500 Hz

**8.** Two identical straight wires are stretched so as to produce 6 beats per second when vibrating simultaneously. On changing the tension slightly in one of them, the beat frequency remains unchanged. Denoting by $T_1$, $T_2$ the higher and the lower initial tension in the strings, then it could be said that while making the above changes in tension

(A) $T_2$ was decreased (B) $T_2$ was increased
(C) $T_1$ was decreased (D) $T_1$ was increased

**9.** To raise the pitch of a stringed musical instrument the player can

(A) loosen the string. (B) tighten the string.
(C) shorten the string. (D) lengthen the string.

**10.** Two vehicles, each moving with speed $u$ on the same horizontal straight road, are approaching each other. Wind blows along the road with velocity $w$. One of these vehicles blows a whistle of frequency $f_1$. An observer in the other vehicle hears the frequency of the whistle to be $f_2$. The speed of sound in still air is $V$. The correct statement(s) is (are)

(A) If the wind blows from the observer to the source, $f_2>f_1$
(B) If the wind blows from the source to the observer, $f_2>f_1$
(C) If the wind blows from observer to the source, $f_2<f_1$
(D) If the wind blows from the source to the observer, $f_2<f_1$

**11.** $Y(x,t)=\frac{0.8}{\left[(4x+5t)^2+5\right]}$ represents a moving pulse where $x$ and $y$ are in metres and in $t$ 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

**12.** An air column in a pipe, which is closed at one end, will be in resonance with a vibrating tuning fork of frequency 264 Hz, if the length of the column in cm is

(A) 31.25 (B) 62.50
(C) 93.75 (D) 125

**13.** A metallic wire of length $\ell$ is held between two rigid supports. If the wire is cooled through a temperature $t$, $Y$ is the Young's modulus of elasticity, $\rho$ is the density and $\alpha$ is the thermal coefficient of linear expansion of the wire, then the frequency of oscillation is proportional to

(A) $\frac{1}{\ell}$ (B) $\sqrt{Y}$
(C) $\sqrt{\frac{\alpha}{\rho}}$ (D) $\sqrt{t}$

**14.** A wave is represented by the equation

$$y=A\sin\left(10\pi x+15\pi t+\frac{\pi}{3}\right)$$

where $x$ is in meters and $t$ is in seconds. The expression represents

(A) a wave travelling in the positive $x$-direction with a velocity 1.5 ms$^{-1}$
(B) a wave travelling in the negative $x$-direction with a velocity 1.5 ms$^{-1}$
(C) a wave travelling in the negative $x$-direction with a wavelength 0.2 m
(D) a wave travelling in the positive $x$-direction with a wavelength 0.2 m

**15.** In a plane progressive harmonic wave

(A) phase difference between displacement and acceleration of particle is zero
(B) phase difference between displacement and acceleration of particle is $\pi$
(C) phase difference between displacement and velocity of particle is $\frac{\pi}{2}$
(D) phase difference between velocity and acceleration of particle is $\frac{\pi}{2}$

16. As a wave propagates
(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 centered at the source remains constant at all times

17. The velocity of sound in air is affected by change in the
(A) atmospheric pressure. (B) moisture content of air.
(C) temperature of air. (D) composition of air.

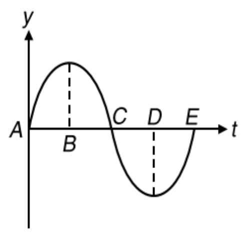
18. A driver in a stationary car blows a horn which produces monochromatic sound waves of frequency 1000 Hz normally towards a reflecting wall. The wall approaches the car with a speed of $3.3\ \text{ms}^{-1}$.
(A) The frequency of sound reflected from wall and heard by the driver is 1020 Hz.
(B) The frequency of sound reflected from wall and heard by the driver is 980 Hz.
(C) The percentage increase in frequency of sound after reflection from wall is 2%.
(D) The percentage decrease in frequency of sound after reflection from wall is 2%.

19. A horizontal stretched string, fixed at two ends, is vibrating in its fifth harmonic according to the equation,

$$y(x, t) = (0.01\ \text{m})\sin\left[(62.8\ \text{m}^{-1})x\right]\cos\left[(628\ \text{s}^{-1})t\right].$$

Assuming $\pi = 3.14$, the correct statement(s) is (are)
(A) The number of nodes is 5
(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 0.01 m
(D) The fundamental frequency is 100 Hz

20. Sound wave is travelling along positive $x$-direction. Displacement $(y)$ of particles from their mean positions at any time $t$ is shown in figure. Choose the correct alternative(s)

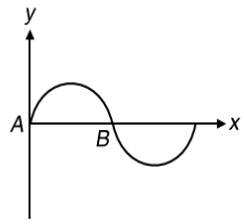



(A) particle located at $E$ has its velocity in negative $x$-direction
(B) particle located at $D$ has zero velocity
(C) particles located near $C$ are under compression
(D) change in pressure at $D$ is zero

21. Standing waves can be produced
(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

22. Which of the following functions of $x$ and $t$ represents a progressive wave
(A) $y = \sin(4t - 3x)$ (B) $y = \dfrac{1}{4 + (4t - 3x)^2}$
(C) $y = \dfrac{1}{4t + 3k}$ (D) All of the above

23. The figure shows an instantaneous profile of a rope carrying a progressive wave moving from left to right, then

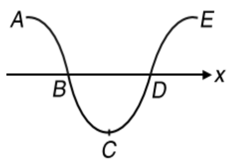



(A) the phase at $A$ is greater than the phase at $B$
(B) the phase at $B$ is greater than the phase at $A$
(C) $A$ is moving upwards
(D) $B$ is moving upwards

24. The equation of a wave travelling on a string is given by $y = 8\sin\left[(5\ \text{m}^{-1})x - (4\ \text{s}^{-1})t\right]$. Then
(A) velocity of wave is $0.8\ \text{ms}^{-1}$
(B) the displacement of a particle of the string at $t = 0$ and $x = \dfrac{\pi}{30}$ m from the mean position is 4 m
(C) the displacement of a particle from the mean position at $t = 0$, $x = \dfrac{\pi}{30}$ m is 8 m
(D) velocity of the wave is $8\ \text{ms}^{-1}$

25. The equation of a wave disturbance is given as $y = 0.02\sin\left(\dfrac{\pi}{2} + 50\pi t\right)\cos(10\pi x)$ where $x$ and $y$ are in metres and $t$ is in second. Select the correct statement(s).
(A) The wavelength of wave is 0.2 m.
(B) The displacement node occurs at $x = 0.15$ m.
(C) The displacement antinode occurs at $x = 0.3$ m.
(D) The speed of constituent waves is $0.2\ \text{ms}^{-1}$.

26. The figure represents a longitudinal wave travelling in positive $x$-direction. Then




(A) part $ABC$ represents compression
(B) part $ABC$ represents rarefaction
(C) part $CDE$ represents compression
(D) part $CDE$ represents rarefaction

27. 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 the 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 $\frac{vf}{c-v}$

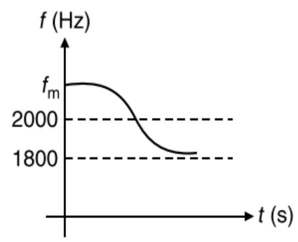
**28.** When a wave goes from one medium to another, there is a change in the
(A) velocity (B) amplitude
(C) frequency (D) wavelength

**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

**30.** The equation of a stationary wave in a string is $y=(4\text{ mm})\sin[(3.14\text{ m}^{-1})x]\cos\omega t$. Select the correct alternative(s).
(A) The amplitude of component waves is 2 mm
(B) The amplitude of component waves is 4 mm
(C) The smallest possible length of string is 0.5 m
(D) The smallest possible length of string is 1.0 m

**31.** A uniform rope of mass $M$ length $L$ hangs vertically from the ceiling, with its lower end free. A disturbance on the rope travelling upwards starting from the lower end has a velocity $v$ at a point $P$ at distance $x$ from the lower end.
(A) Tension at point $P$ is $Mg$
(B) $v=\sqrt{xg}$
(C) $v=\sqrt{2xg}$
(D) Tension at point $P$ is $\left(\frac{M}{L}\right)xg$

**32.** A stationary observer receives a sound of frequency $f_0 = 2200$ Hz. The apparent frequency $f$ varies with time as shown in figure. Speed of sound = 300 ms$^{-1}$. Choose the correct alternative(s)




(A) speed of source is 66.7 ms$^{-1}$
(B) $f_m$ shown in figure cannot be greater than 2500 Hz
(C) speed of source is 33.33 ms$^{-1}$
(D) $f_m$ shown in figure cannot be greater than 2250 Hz

**33.** Velocity of sound in air is 320 ms$^{-1}$. A pipe closed at one end has a length of 1 m. Neglecting end corrections, the air column in the pipe can resonate for sound of frequency
(A) 80 Hz
(B) 240 Hz
(C) 320 Hz
(D) 400 Hz

**34.** Mechanical waves
(A) are longitudinal only.
(B) are transverse only.
(C) can be both longitudinal and transverse.
(D) require a medium for propagation.

**35.** The $(x, y)$ co-ordinates 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)

(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) $a\cos\left(\frac{2\pi x}{L}\right)\sin\left(\frac{\pi y}{L}\right)$

**36.** A closed organ pipe of length 1.2 m vibrates in its first overtone mode. The pressure variation is maximum at
(A) 0.8 m from the open end
(B) 0.4 m from the open end
(C) closed end
(D) 1.0 m from the open end

**37.** In a wave motion $y=a\sin(kx-\omega t)$, $y$ can represent
(A) electric field
(B) magnetic field
(C) displacement
(D) pressure

**38.** The equation $y=4+2\sin(6t-3x)$ represents a wave motion with
(A) amplitude 6 units
(B) amplitude 2 units
(C) wave speed 2 units
(D) wave speed $\frac{1}{2}$ unit

## REASONING BASED QUESTIONS

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

**Bubble (A)** If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.
**Bubble (B)** If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.
**Bubble (C)** If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.
**Bubble (D)** If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

1. **Statement-1:** If oil of density higher than of water is used in place of water in a resonance tube, the frequency decreases.
**Statement-2:** Frequency does not depend on change of medium in resonance tube.

2. **Statement-1:** In Doppler's effect, the red shift means, shifting towards the red end of the spectrum.
**Statement-2:** In red shift, the apparent wavelength increases.

3. **Statement-1:** Solids can support both longitudinal and transverse waves, but only longitudinal waves can propagate in gases.
**Statement-2:** Solids possess two types of elasticity.

4. **Statement-1:** A tuning fork is in resonance with a closed pipe. But the same tuning fork cannot be in resonance with an open pipe of the same length.
**Statement-2:** The same tuning fork will not be in resonance with open pipe of same length due to end correction of pipe.

5. **Statement-1:** Coefficient of adiabatic elasticity of air is greater than the coefficient of isothermal elasticity.
**Statement-2:** Heat is exchanged freely in an isothermal change, but not in an adiabatic change.

6. **Statement-1:** Sound waves cannot be polarised.
**Statement-2:** Only transverse waves can be polarised.

7. **Statement-1:** After Laplace's correction for Newton's formula for finding the speed of sound in gases, we got $v = \sqrt{\frac{\gamma P}{\rho}}$.
**Statement-2:** According to Laplace, the wave propagates so much fast that it does not find any time to interact with its surroundings.

8. **Statement-1:** The fundamental frequency of an open organ pipe increases as the temperature is increased.
**Statement-2:** As the temperature increases the velocity of sound increases more rapidly than length of pipe.

9. **Statement-1:** Intensity of sound waves does not change when the listener moves towards or away from stationary source.
**Statement-2:** The motion of listener causes the apparent change in wavelength.

10. **Statement-1:** Velocity of particles while crossing mean position (in stationary waves) varies from maximum at antinodes to zero at nodes.
**Statement-2:** Amplitude of vibration at antinodes is maximum and at nodes, the amplitude is zero and all particles between two successive nodes cross the mean position together.

11. **Statement-1:** The bells are made of metals and not of wood.
**Statement-2:** Wood offers high damping on the sound waves.

12. **Statement-1:** The sound of a train coming from some distance can be easily detected by placing out ears near the rails.
**Statement-2:** Sound travels faster in air than solids.

13. **Statement-1:** We can recognise our friend by listening their voices.
**Statement-2:** The quality of sound produced by different persons are different.

14. **Statement-1:** The change in air pressure at constant temperature effects the speed of sound.
**Statement-2:** The speed of sound in gases is proportional to the square root of absolute temperature.

15. **Statement-1:** In a stationary wave, there is not transfer of energy.
**Statement-2:** There is no outward motion of disturbance from one particle to adjoining particle in a stationary wave.

16. **Statement-1:** Whistle of the approaching railway engine is shriller than the receding engine.
**Statement-2:** Apparent frequency of railway engine is both cases is same.

17. **Statement-1:** In everyday life the Doppler's effect is observed readily for sound waves than light waves.
**Statement-2:** Velocity of light is greater than the sound.

18. **Statement-1:** In a sound wave, a displacement node is a pressure antinode and vice-versa.
**Statement-2:** Displacement node is a point of minimum displacement.

19. **Statement-1:** If two waves of same amplitude, produce a resultant wave of same amplitude, then the phase difference between them will be $120°$.
**Statement-2:** The resultant amplitude of two waves is equal to sum of amplitude of two waves.

20. **Statement-1:** The error in Newton's formula of velocity of sound in air was 16%.
**Statement-2:** The experimental value of velocity of sound in air was not accurate.

## LINKED COMPREHENSION TYPE QUESTIONS

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options)

### Comprehension 1

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.
Based on the above facts, answer the following questions.

**1.** Maximum displacement of a point at $x = 5$ cm is
(A) 4 cm (B) 2 cm
(C) $2\sqrt{3}$ cm (D) None of these

**2.** The nodes are located along the string at $x$ values given by
(A) 0, 7.5 cm, 15 cm, .........
(B) 0, 15 cm, 30 cm, .........
(C) 0, 30 cm, 60 cm, .........
(D) None of these

**3.** The velocity of the particle at $x = 7.5$ cm at $t = 0.25$ s is
(A) 0 (B) 384 $\text{cms}^{-1}$
(C) $192\sqrt{2}$ $\text{cms}^{-1}$ (D) None of these

**4.** The stationary wave $y = 4\sin\left(\frac{\pi x}{15}\right)\cos(96\pi t)$ is obtained by the superposition of two waves $y_1$ and $y_2$. Then
(A) $y_1 = 4\sin\left(\frac{\pi x}{15} - 96\pi t\right)$, $y_2 = 4\sin\left(\frac{\pi x}{15} + 96\pi t\right)$
(B) $y_1 = 2\sin\left(\frac{\pi x}{15} - 96\pi t\right)$, $y_2 = 2\sin\left(\frac{\pi x}{15} - 96\pi t\right)$
(C) $y_1 = 2\sin\left(\frac{\pi x}{15} + 96\pi t\right)$, $y_2 = 2\sin\left(\frac{\pi x}{15} + 96\pi t\right)$
(D) $y_1 = 2\sin\left(\frac{\pi x}{15} - 96\pi t\right)$, $y_2 = 2\sin\left(\frac{\pi x}{15} + 96\pi t\right)$

### Comprehension 2

An observer standing on a railway crossing receives frequencies of 2.2 kHz and 1.8 kHz when the train approaches and recedes from the stationary observer. The speed of sound in air is 300 $\text{ms}^{-1}$. Based on the above facts, answer the following questions.

**5.** The actual frequency is
(A) 2.2 kHz (B) 1.98 kHz
(C) 1.8 kHz (D) 2.4 kHz

**6.** The velocity of the train is
(A) 5 $\text{ms}^{-1}$ (B) 10 $\text{ms}^{-1}$
(C) 20 $\text{ms}^{-1}$ (D) 30 $\text{ms}^{-1}$

### Comprehension 3

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 $\text{ms}^{-1}$. 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. Based on the above facts, answer the following questions.

**7.** The length $L$ of the air column is
(A) $\frac{16}{15}$ m (B) $\frac{15}{16}$ m
(C) $\frac{5}{3}$ m (D) $\frac{3}{5}$ m

**8.** The corresponding wavelength to vibrate in second overtone is
(A) $\frac{2}{3}$ m (B) $\frac{3}{2}$ m
(C) $\frac{4}{3}$ m (D) $\frac{3}{4}$ m

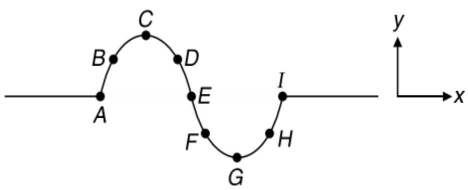
**9.** The amplitude of the pressure variation $(\Delta P)$ at the middle of the column is given by
(A) $\Delta P = \pm\Delta P_0$ (B) $\Delta P = \pm\frac{\Delta P_0}{2}$
(C) $\Delta P = \pm\frac{\Delta P_0}{\sqrt{2}}$ (D) $\Delta P = \pm\frac{\sqrt{3}\Delta P_0}{2}$

**10.** If $P_{max}$ and $P_{min}$ be the maximum and the minimum pressures at the open end of the pipe, then
(A) $P_{max} = P_{min} < P_0$ (B) $P_{max} = P_{min} > P_0$
(C) $P_{max} = P_{min} = P_0$ (D) $P_{max} = P_{min} = \frac{P_0}{2}$

**11.** If $P'_{max}$ and $P'_{min}$ be the maximum and the minimum pressures at the closed end of the pipe, then
(A) $P'_{max} = P_0 + \Delta P_0$; $P'_{min} = P_0$
(B) $P'_{max} = P_0 + \Delta P_0$; $P'_{min} = P_0 - \Delta P_0$
(C) $P'_{max} = P_0 - \Delta P_0$; $P_{min} = P_0 - 2\Delta P_0$
(D) $P'_{max} = P_0$; $P'_{min} = P_0 - \Delta P_0$

### Comprehension 4

A progressive wave pulse is generated on a string is travelling in –ve $X$ direction as shown in figure. Based on above information, answer the following questions.



**12.** Kinetic energy is maximum for the particle

(A) $D$ (B) $E$
(C) $F$ (D) $G$

**13.** Potential energy is maximum for the particle

(A) $D$ (B) $E$
(C) $F$ (D) $G$

**14.** Particle $B$ and $D$ are moving respectively

(A) $\uparrow\uparrow$ (B) $\downarrow\downarrow$
(C) $\uparrow\downarrow$ (D) $\downarrow\uparrow$

## Comprehension 5

When two pulses are allowed to pass through a string in opposite direction with same speed, the shape of string varies. Each pulse passes the overlap region as if the other pulse were not present there. The superposition principle can be applied to deal with the two waves in opposite direction. If two wave pulses are identical in shape, except that one is inverted with respect to another, at some instant displacement will be zero, but not their velocities. When reflection takes place from denser medium's surface or a rigid body, there will be phase difference of $\pi$. The corresponding path difference and time difference can be analysed. Based on above information, answer the following questions.

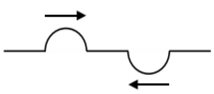
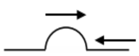
**15.** If the wave travelling in the string is given by $y = A\cos(\omega t + kx + \phi)$, then the wave reflected from denser medium's surface is

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

**16.** When displacement is zero as two wave pulses are moving in opposite direction, then which of the following will remain non-zero?

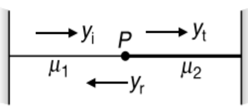
(A) Amplitude of each wave.
(B) Velocity of each wave.
(C) Both (A) and (B).
(D) Net amplitude and net velocity.

**17.** As the two waves are moving in opposite direction in a string, which of the following is not possible

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

## Comprehension 6

Consider two stretched strings 1 and 2, joined at a point $(P)$ as shown in the figure. The linear mass densities of the two strings are $\mu_1$ and $\mu_2$ as shown in the figure.




The tension in both the strings is same. Let a transverse wave represented by $y_i = A_i\sin(k_i x - \omega t)$ be incident at the joint from the left string, as shown in the figure. Then, some part of the wave is transmitted to the right string and some part is reflected to the left string. The transmitted and the reflected waves can be represented by equations

$$y_t = A_t\sin(k_t x - \omega t) \text{ (transmitted wave)}$$

$$y_r = A_r\sin(k_i x + \omega t) \text{ (reflected wave)}$$

where, all the terms in above equations have their usual meanings. In the above two equations, $\omega$ is same in both transmitted and reflected waves. This is due to the fact that frequency of the wave remains unchanged when a wave travels in different media. Assuming origin to be at the point $P$ (shown in figure), then at the point $P$, we must have the same value for $y$ as well as the slope. So, mathematically, at the point $P$, we must have

$$y_i + y_r = y_t \text{ (at point } P) \quad \text{...(1)}$$

$$\frac{\partial y_i}{\partial x} + \frac{\partial y_r}{\partial x} = \frac{\partial y_t}{\partial x} \text{ (at point } P) \quad \text{...(2)}$$

Based on the above facts, answer the following questions.

**18.** Amplitude of reflected wave is

(A) $A_r = \dfrac{2(\sqrt{\mu_1})}{(\sqrt{\mu_1} + \sqrt{\mu_2})}A_i$ (B) $A_r = \dfrac{(\sqrt{\mu_1} - \sqrt{\mu_2})}{(\sqrt{\mu_1} + \sqrt{\mu_2})}A_i$

(C) $A_r = \dfrac{(\sqrt{\mu_1} - \sqrt{\mu_2})}{(\sqrt{\mu_1} + \sqrt{\mu_2})}A_i$ (D) None of these

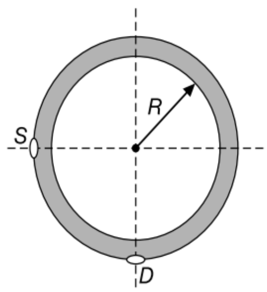
**19.** Amplitude of transmitted wave is

(A) $A_t = \dfrac{2(\sqrt{\mu_1})}{(\sqrt{\mu_1} + \sqrt{\mu_2})}A_i$ (B) $A_t = \dfrac{(\sqrt{\mu_1} - \sqrt{\mu_2})}{(\sqrt{\mu_1} + \sqrt{\mu_2})}A_i$

(C) $A_t = \dfrac{(\sqrt{\mu_1})}{(\sqrt{\mu_1} + \sqrt{\mu_2})}A_i$ (D) None of these

## Comprehension 7

A narrow tube is bent in the form of circle of radius $R$ as shown. Two small holes $S$ and $D$ are made in the tube at the positions right angles to each other. A source placed at $S$ generates 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 part waves meet at point $D$ where a detector is placed. Based on above information, answer the following questions.




**20.** Maximum intensity produced at $D$ is given by

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

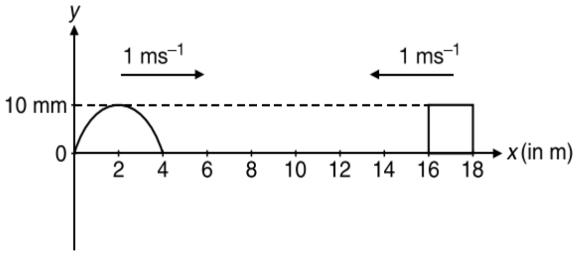
**21.** The maximum value of wavelength $\lambda$ to produce a maximum at $D$ is given by

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

22. The maximum value of wavelength $\lambda$ to produce a minimum at $D$ is given by
(A) $\pi R$ (B) $2\pi R$
(C) $\frac{\pi R}{2}$ (D) $\frac{3\pi R}{2}$

## Comprehension 8

A sinusoidal pulse is generated at $x=0$ and $t=0$ on a string lying along $x$-axis. The pulse is travelling with speed $1\ \text{ms}^{-1}$. A rectangular pulse is generated at $t=0$ s and is travelling in opposite direction with speed $1\ \text{ms}^{-1}$ as shown in figure. Based on the above facts, answer the following questions.




23. The velocity of particle at $x=4$ m and $t=0$ s is
(A) ZERO (B) $\frac{\pi}{4}\ \text{cms}^{-1}$
(C) $\frac{\pi}{2}\ \text{cms}^{-1}$ (D) $\frac{\pi}{6}\ \text{cms}^{-1}$

24. The displacement of particle at $x=9$ m and $t=8$ s is
(A) $\left(\frac{\sqrt{2}+1}{\sqrt{2}}\right)$ cm (B) $(\sqrt{2}+1)$ cm
(C) $\left(\frac{3}{2}\right)$ cm (D) $(\sqrt{2})$ cm

25. The velocity of particle at $x=9$ m and $t=8$ s is
(A) $\frac{\pi}{4}\ \text{cms}^{-1}$ in negative $y$-direction
(B) $\frac{\pi}{4}\ \text{cms}^{-1}$ in positive $y$-direction
(C) $\frac{\pi}{4\sqrt{2}}\ \text{cms}^{-1}$ in negative $y$-direction
(D) $\frac{\pi}{2\sqrt{2}}\ \text{cms}^{-1}$ in negative $y$-direction

## Comprehension 9

When a wire is fixed between two rigid supports, and we pluck the mid-point of string, it starts to vibrate between two extreme positions. During this oscillation, some points of string vibrate with maximum amplitude while other points vibrate with minimum amplitude. These are known as antinodes and nodes respectively. Suppose we have a 2 m wire which is fixed at both ends and which is vibrating in its fundamental mode, the tension in the wire is 40 N and the mass of the wire is 0.1 kg. At the mid-point of wire, the amplitude is 2 cm. At any instant the amplitude at $x$ is calculated from the expression $y = 0.02\ \text{m} \sin\left(\frac{\pi x}{2}\right)$, then answer the following questions.

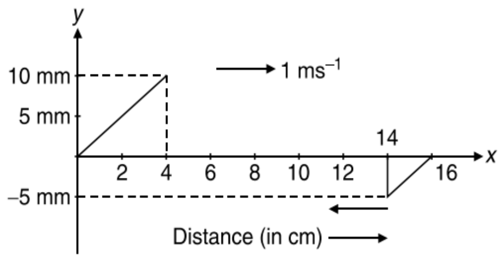
26. The distance between any two consecutive nodal points is
(A) $\frac{\lambda}{2}$ (B) $\lambda$
(C) $2\lambda$ (D) $3\lambda$

27. The angular frequency of the wire is (approximately)
(A) $44\ \text{rad sec}^{-1}$ (B) $88\ \text{rad sec}^{-1}$
(C) $22\ \text{rad sec}^{-1}$ (D) $176\ \text{rad sec}^{-1}$

28. The kinetic energy of a particle of the wire is zero
(A) at the nodal points at all times
(B) at centre or position of antinodes at all times
(C) at $x=1.5$ m at all times
(D) at $x=0.5$ m at all times

## Comprehension 10

Two wave pulses are travelling in opposite direction with speed $1\ \text{ms}^{-1}$. Figure shows the shape of pulse at $t=0$. Based on the above facts, answer the following questions.




29. The speed of particle at $x=2$ cm and $t=0$ is
(A) $1\ \text{ms}^{-1}$ (B) $0.75\ \text{ms}^{-1}$
(C) $0.5\ \text{ms}^{-1}$ (D) $0.25\ \text{ms}^{-1}$

30. The displacement of particle at $x=8$ cm and $t=6$ sec is
(A) 10 mm (B) 5 mm
(C) –5 mm (D) ZERO

31. The speed of particle at $x=8$ cm and $t=6$ sec is
(A) ZERO (B) $0.125\ \text{ms}^{-1}$
(C) $0.25\ \text{ms}^{-1}$ (D) None of these

## Comprehension 11

The displacement of the medium in a sound wave is given by the equation $y_i = A\cos(ax+bt)$ 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. Based on the above facts, answer the following questions.

32. The wavelength of the incident wave is
(A) $\lambda=\frac{\pi}{a}$ (B) $\lambda=\frac{\pi}{2a}$
(C) $\lambda=\frac{2\pi}{a}$ (D) $\lambda=\frac{4\pi}{a}$

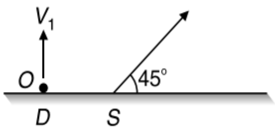
33. The frequency of the incident wave is
(A) $f=\frac{b}{\pi}$ (B) $f=\frac{b}{2\pi}$
(C) $f=\frac{b}{4\pi}$ (D) $f=\frac{b}{3\pi}$

34. The equation for the reflected wave is
(A) $y_r = 0.8A\cos(ax - bt)$
(B) $y_r = -0.8A\cos(ax + bt)$
(C) $y_r = -0.8A\cos(ax - bt)$
(D) None of these

35. For the resultant wave formed after reflection, if $v_{max}$ and $v_{min}$ be the maximum and the minimum values of the particle speeds in the medium, then
(A) $v_{max} = 0.2$ Ab, $v_{min} = 0$
(B) $v_{max} = 0.8$ Ab, $v_{min} = 0.2$ Ab
(C) $v_{max} = -1.8$ Ab, $v_{min} = 0.2$ Ab
(D) $v_{max} = 1.8$ Ab, $v_{min} = 0$

## Comprehension 12

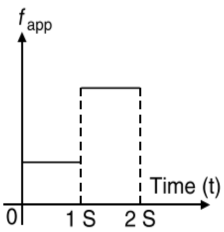
Consider the situation in which a source emitting sound of frequency $f_0 = 960$ Hz is projected with velocity $10\sqrt{2}$ ms$^{-1}$ at angle $\theta = 45°$ making with horizontal. Simultaneously a detector is projected at speed $v_1 = 10$ ms$^{-1}$ vertically upwards as shown in the figure. (Take velocity of sound as 310 ms$^{-1}$ and air to be still). After the source and detector fall to the ground, they come to rest.

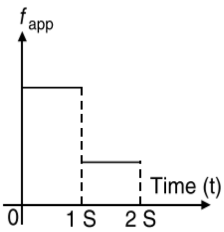


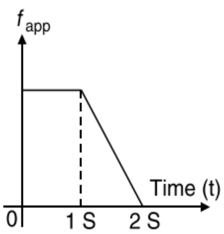

Taking acceleration due to gravity as 10 ms$^{-2}$. Based on above information, answer the following questions.

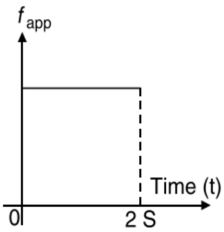
36. The maximum apparent frequency received by the detector is equal to
(A) 992 Hz (B) 930 Hz
(C) 960 Hz (D) 682 Hz

37. The graph of $f_{app}$ vs time is best represented as (for time $0 \le t \le 2$ s)

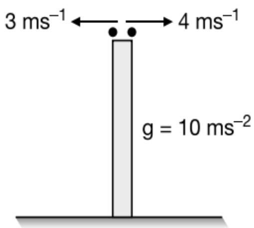
(A)



(B)



(C)



(D)



38. Suppose the source and detector are projected horizontally in opposite directions from a high tower as shown, then




(A) The apparent frequency received by detector will be constant till the source and detector fall on ground.
(B) The apparent frequency received by detector will continuously decrease till the source and detector fall on ground.
(C) The apparent frequency must be same as frequency emitted by source at least once during the complete journey.
(D) The apparent frequency received by detector will continuously increase till the source and detector fall on ground.

## Comprehension 13

A number of waveforms can be described in terms of the combination of travelling waves which can be analysed by using the Principle of Superposition. Consider two wave pulses $y_1$ and $y_2$ described by $y_1 = \frac{5}{(3x - 4t)^2 + 2}$ and $y_2 = \frac{-5}{(3x + 4t - 6)^2 + 2}$ travelling on same string. Based on the above facts, answer the following questions.

39. The direction in which each pulse is travelling is
(A) $y_1$ is in positive $x$-axis, $y_2$ is in positive $x$-axis
(B) $y_1$ is in negative $x$-axis, $y_2$ is in negative $x$-axis
(C) $y_1$ is in positive $x$-axis, $y_2$ is in negative $x$-axis
(D) $y_1$ is in negative $x$-axis, $y_2$ is in positive $x$-axis

40. The time when the two waves cancel everywhere is
(A) 1 s (B) 0.5 s
(C) 0.25 s (D) 0.75 s

41. The point where two waves always cancel is
(A) 0.25 m (B) 0.5 m
(C) 0.75 m (D) 1 m

## Comprehension 14

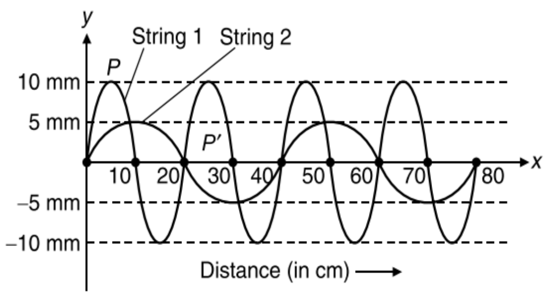
A point sound source is situated in a medium of bulk modulus $1.6 \times 10^5$ Nm$^{-2}$. An observer standing at a distance 10 m from the source, writes down the equation for the wave as $y = A\sin(15\pi x - 6000\pi t)$, where $y$ and $x$ are in metre and $t$ is in second. The maximum pressure amplitude received by the observer's ear is $24\pi$ Pa. Based on the above facts, answer the following questions.

42. The density of the medium is
(A) 1 kgm$^{-3}$ (B) 2 kgm$^{-3}$
(C) 3 kgm$^{-3}$ (D) $\frac{1}{2}$ kgm$^{-3}$

43. If another sound wave of the same form, having same phase is emitted from some other point, then the intensity of sound at a point which is equidistant from both the sources is
(A) $0.72\pi^2$ (B) $1.44\pi^2$
(C) $2.16\pi^2$ (D) $2.88\pi^2$

## Comprehension 15

Two identical strings 1 and 2 are stretched by the same force and waves are generated in the two strings travelling in +ve $x$-direction. Shapes of string 1 and 2 at some instant is shown in figure. Based on the above facts, answer the following questions.




**44.** Ratio of intensity of wave in the string 1 and 2 is

(A) 1:1 (B) 1:4

(C) 16:1 (D) 4:1

**45.** Phase difference between point $P$ (on first string) and $P'$ (on second string) at the instant shown is

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

(C) $\pi$ (D) ZERO

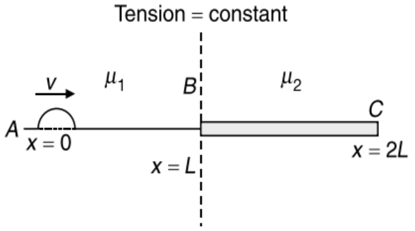
**46.** Phase difference between particles of string 1 and 2 at $x = 20$ cm at the instant shown is

(A) ZERO (B) $\frac{\pi}{2}$

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

## Comprehension 16

The speed of a transverse wave depends on the linear mass density of the string and the tension in the string. Consider two strings of equal lengths to be joined at $B$. The mass of the string $BC$ is four times the mass of string $AB$. If a wave pulse is generated in string $AB$, which travels towards boundary at $B$ with speed $v$ and the equation of incident pulse is given by $y_i = A_i \sin(\omega t - kx)$. Based on above information, answer the following questions.




**47.** Amplitude of wave reflected back after incident on boundary at point $B$

(A) $-\frac{A_i}{3}$ (B) $-\frac{2A_i}{3}$

(C) $\frac{A_i}{3}$ (D) $\frac{2A_i}{3}$

**48.** Speed of transmitted wave on string $BC$ is

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

(C) $2v$ (D) None of these

**49.** Equations of reflected and transmitted waves respectively are

(A) $y_r = -\frac{A_i}{3}\sin(\omega t + kx),\ y_t = -\frac{2A_i}{3}\sin(\omega t - 2kx)$

(B) $y_r = \frac{A_i}{3}\sin(\omega t + kx),\ y_t = \frac{2A_i}{3}\sin(\omega t + 2kx)$

(C) $y_r = -\frac{A_i}{3}\sin(\omega t + kx),\ y_t = \frac{2A_i}{3}\sin(\omega t - 2kx)$

(D) $y_r = -\frac{A_i}{3}\sin(\omega t - kx),\ y_t = \frac{2A_i}{3}\sin\left(\omega t + \frac{k}{2}x\right)$

## Comprehension 17

A thin string is held at one end and oscillated vertically, so that $y(x = 0,\ t) = 8\sin(4t)$ cm. The string's density is 0.2 $\text{kgm}^{-1}$ and its tension is 1 N. The string passes through a bath filled with 1 kg water. Due to friction, heat is transferred to the bath. The heat transfer efficiency is 50%. Specific heat of water is 1 $\text{kcalkg}^{-1}\text{K}^{-1}$. Based on the above facts, answer the following questions.

**50.** The wave function representing the wave on string is

(A) $y(x,t) = 8\sin\left(t - \frac{4}{\sqrt{5}}x\right)$

(B) $y(x,t) = 8\sin\left(4t - \frac{4}{\sqrt{5}}x\right)$

(C) $y(x,t) = 8\sin\left(4t - \frac{1}{\sqrt{5}}x\right)$

(D) $y(x,t) = 8\sin(t - x)$

**51.** The average power transported by wave over one period is

(A) 0.02 W (B) 0.2 W

(C) 2 W (D) 20 W

**52.** The time taken for the temperature of bath to rise by 1 K is

(A) $4 \times 10^5$ s (B) 40 s

(C) 4 s (D) $4 \times 10^2$ s

## Comprehension 18

A train approaching a hill at a speed of 40 $\text{kmhr}^{-1}$ 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 $\text{kmhr}^{-1}$ is blowing in the direction of motion of the train. Taking velocity of sound in air = 1200 $\text{kmhr}^{-1}$. Based on the above facts, answer the following questions.

**53.** The frequency of the whistle as heard by an observer on the hill is approximately

(A) 499 Hz (B) 599 Hz

(C) 699 Hz (D) 799 Hz

**54.** The distance from the hill at which the echo from the hill is heard by the driver is

(A) 935 m (B) 900 m

(C) 1000 m (D) 1035 m

**55.** The echo frequency heard by the driver is approximately

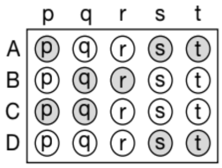
(A) 321 Hz (B) 421 Hz

(C) 521 Hz (D) 621 Hz

## MATRIX MATCH/COLUMN MATCH TYPE QUESTIONS

Each question in this section contains statements given in two columns, which have to be matched. The statements in **COLUMN-I** are labelled A, B, C and D, while the statements in **COLUMN-II** are labelled p, q, r, s (and t). Any given statement in **COLUMN-I** can have correct matching with **ONE OR MORE** statement(s) in **COLUMN-II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

If the correct matches are A → p, s and t; B → q and r; C → p and q; and D → s and t; then the correct darkening of bubbles will look like the following:




**1.** Match the standing waves formed in **COLUMN-II** due to plane progressive waves and also the conditions in **COLUMN-I**.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Incident wave is $y_i = A\sin(kx - \omega t)$ | (p) $y = 2A\cos(kx)\sin(\omega t)$ |
| (B) Incident wave is $y_i = A\cos(kx - \omega t)$ | (q) $y = 2A\sin(kx)\sin(\omega t)$ |
| (C) $x = 0$ is rigid support | (r) $y = 2A\sin(kx)\cos(\omega t)$ |
| (D) $x = 0$ is flexible support | (s) $y = 2A\cos(kx)\cos(\omega t)$ |

**2.** The equation of a travelling wave is given by (all quantities are in SI units) $y = (0.02)\sin 2\pi(10t - 5x)$. Match the quantities in **COLUMN-I** with the SI values in **COLUMN-II**.

| COLUMN-I | COLUMN-II (in SI units) |
|---|---|
| (A) Speed of wave | (p) 10 |
| (B) Angular frequency of wave | (q) $0.4\pi$ |
| (C) Wavelength of wave | (r) 2 |
| (D) Maximum particle speed | (s) 0.2 |

**3.** For a closed organ pipe, match the quantities in **COLUMN-I** with respective values in **COLUMN-II**.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Third overtone frequency is $x$ times the fundamental frequency $x$, equals | (p) 3 |
| (B) Number of nodes in second overtone | (q) 4 |
| (C) Number of antinodes in third overtone | (r) 5 |
| (D) Harmonic corresponding to second overtone | (s) 7 |

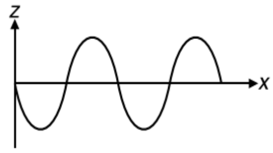
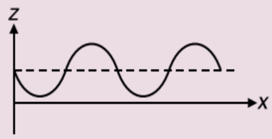
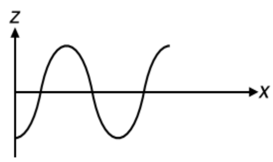
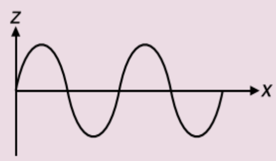
**4.** A wave is transmitted from a denser to rarer medium. Then match the following

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Frequency of wave | (p) will increase |
| (B) Speed of wave | (q) will decrease |
| (C) Wavelength of wave | (r) will remain unchanged |
| (D) Amplitude of wave | (s) may increase or decrease |

**5.** The displacement equation of a standing wave in air is given by

$$y = A\cos(kx)\cos(\omega t)$$

Match the physical quantities in the **COLUMN-I**, to the correct plots in the **COLUMN-II**. Note that the physical quantities in **COLUMN-I** have been denoted by symbol $Z$ in **COLUMN-II**.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Displacement $y$ of the particles at $t = \frac{T}{2}$ | (p)   |
| (B) Particle velocity at $t = \frac{T}{4}$ | (q)   |
| (C) Change in pressure of the medium at $t = 0$ | (r)   |
| (D) Density of the medium at $t = \frac{T}{2}$ | (s)   |

6. A source emits sound of frequency $f$. The source and listener both have same speed. For the apparent frequency heard by listener match the following

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Listener is approaching the source but source is receding from the listener | (p) more than $f$ |
| (B) Listener and source both approaching towards each other | (q) less than $f$ |
| (C) Listener and source both receding from each other | (r) equal to $f$ |
| (D) Source is approaching but listener is receding | |

7. From a single source, two wave trains are sent in two different strings. String 2 is 4 times heavy than string 1. The two wave equations are: (area of cross-sectional and tension of both strings is same).

$$y_1 = A\sin(\omega_1 t - k_1 x) \text{ and } y_2 = 2A\sin(\omega_2 t - k_2 x)$$

Suppose $u =$ energy density, $P =$ power transmitted, $I =$ intensity of the wave and $v$ be velocity of the wave, then match the following

| COLUMN-I | COLUMN-II |
|---|---|
| (A) $\frac{u_1}{u_2} =$ | (p) $\frac{1}{8}$ |
| (B) $\frac{P_1}{P_2} =$ | (q) $\frac{1}{16}$ |
| (C) $\frac{I_1}{I_2} =$ | (r) 2 |
| (D) $\frac{v_1}{v_2} =$ | (s) $\frac{1}{4}$ |

8. In the equation, $y = A\sin 2\pi\left(ax + bt + \frac{\pi}{4}\right)$, match the quantities in **COLUMN-I** to the values in **COLUMN-II**.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Frequency of wave | (p) $a$ |
| (B) Wavelength of wave | (q) $b$ |
| (C) Phase difference between two points $\frac{1}{4a}$ distance apart | (r) $\pi$ |
| (D) Phase difference of a point after a time interval of $\frac{1}{8b}$ | (s) $\frac{\pi}{2}$ |
| | (t) None of these |

9. Match the quantities in **COLUMN-I** to respective properties in **COLUMN-II**.

| 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 $\pi$ takes place |

10. Regarding speed of sound in gas match the following

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Temperature of gas is made 4 times and pressure 2 times | (p) Speed becomes $2\sqrt{2}$ times |
| (B) Only pressure is made 4 time without change in temperature | (q) Speed becomes 2 times |
| (C) Only temperature is changed to 4 times | (r) Speed remains unchanged |
| (D) Molecular mass of the gas is made 4 times | (s) Speed remains half |

11. The equation of a stationary wave (all quantities are in SI units) is given by $y = (0.06)\sin(2\pi x)\cos(5\pi t)$. Match the quantities in **COLUMN-I** to the values (in SI units) in **COLUMN-II**.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Amplitude of constituent wave is | (p) 0.06 |
| (B) Position of node is at $x_1$, given by | (q) 0.5 |
| (C) Position of anti node is at $x_2$, given by | (r) 0.25 |
| (D) Amplitude at $x = \frac{3}{4}$ m is | (s) 0.03 |
| | (t) None of these |

12. Fundamental frequency of closed pipe is 100 Hz and that of an open pipe is 200 Hz. Match the following $(v_s = 330\ \text{ms}^{-1})$

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Length of closed pipe | (p) 0.825 m |
| (B) Length of open pipe | (q) 1.65 m |
| (C) Lowest harmonic of closed pipe which is equal to any of the harmonic of open | (r) 2 |
| (D) Ratio of second overtone of open pipe to the first overtone of closed pipe is | (s) 5 |
| | (t) None of these |

## INTEGER/NUMERICAL ANSWER TYPE QUESTIONS

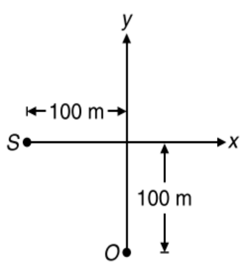
In this section, the answer to each question is a numerical value obtained after doing series of calculations based on the data given in the question(s).

1. A road passes at some distance from a standing man. A truck is coming on the road with some acceleration. The truck driver blows a whistle of frequency 500 Hz when the line joining the truck and the man makes an angle of $\theta$ with the road. The man hears a note having a frequency of 600 Hz when the truck is closest to him. Also, the speed of truck has got doubled during this time. Find the value of $\theta$, in degree.

2. An organ pipe open at both ends sounds in unison with a tuning fork at 20 °C. When the fork and the pipe are sounded together at 30 °C, 5 beats per second are heard. Determine the frequency of the fork, in Hz, assuming that it is not affected by the temperature change.

3. A stationary source is emitting sound at a fixed frequency $f_0$, which is reflected by two cars approaching the source. The difference between the frequencies of sound reflected from the cars is 1.2% of $f_0$. What is the difference in the speeds of the cars (in km per hour) to the nearest integer? The cars are moving at constant speeds much smaller than the speed of sound which is $330\ \text{ms}^{-1}$.

4. At $t = 0$, a source of sonic oscillations $S$ and an observer $O$ start moving along $x$ and $y$ axes with velocity $5\ \text{ms}^{-1}$ and $10\ \text{ms}^{-1}$ respectively. The figure gives their position at $t = 0$. The frequency of sonic oscillations of source is 1000 Hz. Obtain the frequency of signals, in Hz, received by the observer after 5 seconds. Speed of sound is $330\ \text{ms}^{-1}$.




5. A simple harmonic wave of amplitude 8 units travels along positive $x$-axis. At any given instant of time, for a particle at a distance of 10 cm from the origin, the displacement is +6 units and for a particle at a distance of 25 cm from the origin, the displacement is +4 units. Calculate the wavelength, in cm.

6. In a stationary wave pattern that forms as a result of reflection of waves from an obstacle the ratio of the amplitude at an antinode and a node is $\beta = 1.5$. What percentage of the energy passes across the obstacle?

7. An astronaut approaching moon is sending radio signal of $5 \times 10^9$ Hz and finds out that the frequency shift of the echo received is $10^3$ Hz. Calculate his speed of approach in $\text{ms}^{-1}$.

8. A guitar string is 90 cm long and has a fundamental frequency of 124 Hz. Where should it be pressed, in cm, from one end to produce a fundamental frequency of 186 Hz.

9. Two radio stations broadcast their programmes at the same amplitude $A_0$ and intensity $I_0$. Their frequency difference $f_1 - f_2$ is $10^3$ Hz. A detector receives the signals from the two stations simultaneously. It can detect signals of intensity $\geq 2I_0$. Find the time, in $\mu$s, for which the detector remains idle in each cycle of the intensity of the signal.

10. A point source of sound emits a constant power with intensity inversely proportional to the square of the distance from the source. By how many decibels does the sound intensity level drop when you move from point $P_1$ to $P_2$. Distance of $P_2$ from the source is two times the distance of source from $P_1$.

11. Standing waves are set up in a string of length 240 cm clamped horizontally at both ends. The separation between any two consecutive points where the displacement amplitude is $3\sqrt{2}$ mm is 20 cm.
    (a) Find the maximum displacement amplitude, in mm.
    (b) Determine the overtone in which the string is vibrating.

12. A wave moves with speed $300\ \text{ms}^{-1}$ on a wire which is under a tension of 50 N. By how much the tension must be changed, in newton, to increase the speed to $312\ \text{ms}^{-1}$?

13. A source of sound of frequency 900 Hz moves uniformly along a straight line with velocity 0.8 times velocity of sound. An observer is located at a distance $l = 250$ m from the line. Find the
    (a) frequency of the sound, in Hz, at the instant when the source is closest to the observer.
    (b) distance of the source, in metre, when he observes no change in the frequency.

**14.** At a distance 20 m from a point source of sound the loudness level is 30 dB. Neglecting the damping, find
(a) the loudness at 10 m from the source, in decibel.
(b) the distance from the source (in metre) at which sound is not heard.

**15.** A string has a linear mass density $\mu$ of 625 $gm^{-1}$ and is stretched with a tension $T$ of 49 N. A wave of frequency 125 Hz and amplitude 9 mm, is travelling along the string. At what average rate (in watt) is the wave transporting energy through the string?

**16.** 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, in cm, when it reaches the top of the rope.

**17.** A long glass tube is held vertically, dipping into water, while a tuning fork of frequency 500 Hz is repeatedly struck and held over the open end. Strong resonance is obtained, when the length of the tube above the surface of water is 60 cm and again 85 cm, but not at any intermediate point. Find the speed of sound in air, in $ms^{-1}$.

**18.** Calculate the velocity of transverse wave, in $ms^{-1}$, in a string of mass $3\times10^{-2}$ kg length 2 mto which a load of 15 kg is attached. Take $g = 10\ ms^{-2}$

**19.** A sonometer wire has a total length of 1.1 m between the fixed ends. Where should the two bridges be placed from the ends, in cm, below the wire so that the three segments of the wire have their fundamental frequencies in the ratio $1:2:3$?

**20.** A string of mass $m$ is fixed at both ends. The fundamental tone oscillation are excited in the string with angular frequency $\omega$ and maximum displacement amplitude $A$. The total energy contained in the string is $\frac{m\omega^2 A^2}{x}$, where $x$ is an integer from zero to 9. Find $x$.

**21.** A taut string for which $\mu = 5\times10^{-2}\ kgm^{-1}$ is under a tension of 80 N. How much power, in watt, must be supplied to the string to generate sinusoidal waves at a frequency of 60 Hz and an amplitude of 6 cm?

**22.** The vibrations from an 800 Hz tuning fork set up standing waves in a string clamped at both ends. The wave speed in the string is known to be 400 $ms^{-1}$ for the tension used. The standing wave is observed to have four antinodes. Calculate the length of the string in metre.

**23.** A wire made of material of Young's modulus $20\times10^{10}\ Nm^{-2}$ is stretched by 0.1%. If its length is one metre and density of the material of the wire is 8000 $kgm^{-3}$. Calculate the fundamental frequency of wire, in Hz.

**24.** Third overtone of a closed organ pipe of length 7 cm is in unison with fourth harmonic of an open organ pipe. Find the length of open organ pipe, in cm.

**25.** Calculate the speed of longitudinal waves, in $ms^{-1}$, in the following gases at 0 °C and 1 atm$(=10^5\ Pa)$.
(a) Oxygen for which the Bulk's modulus is $1.41\times10^5$ Pa and density is 1.43 $kgm^{-3}$.
(b) Helium for which the Bulk's modulus is $1.7\times10^5$ Pa and the density is 0.18 $kgm^{-3}$.

**26.** A string fixed at both ends is vibrating in the lowest possible mode of vibration for which a point at quarter of its length from one end is a point of maximum displacement. The frequency of vibration in this mode is 100 Hz. What will be the frequency emitted, in Hz, when it vibrates in the next mode such that this point is again a point of maximum displacement?

## ARCHIVE: JEE MAIN

**1. [Online September 2020]**
Two identical strings $X$ and $Z$ made of same material have tension $T_X$ and $T_Z$ in them. It their fundamental frequencies are 450 Hz and 300 Hz, respectively, then the ratio $\frac{T_X}{T_Z}$ is

(A) 0.44 (B) 1.5
(C) 2.25 (D) 1.25

**2. [Online September 2020]**
A wire of density $9\times10^{-3}\ kgcm^{-3}$ is stretched between two clamps 1 m apart. The resulting strain in the wire is $4.9\times10^{-4}$. The lowest frequency of the transverse vibrations in the wire is (Young's modulus of wire $Y = 9\times10^{10}\ Nm^{-2}$) (to the nearest integer)_______.

**3. [Online September 2020]**
A uniform thin rope of length 12 m and mass 6 kg hangs vertically from a rigid support and a block of mass 2 kg is attached to its free end. A transverse short-wave train of wavelength 6 cm is produced at the lower end of the rope. What is the wavelength of the wave train (in cm) when it reaches the top of the rope?

(A) 9 (B) 12
(C) 6 (D) 3

**4. [Online September 2020]**
For a transverse wave travelling along a straight line, the distance between two peaks (crests) is 5 m, while the distance between one crest and one trough is 1.5 m. The possible wavelengths (in m) of the waves are

(A) 1, 2, 3, …

(B) $\frac{1}{2}, \frac{1}{4}, \frac{1}{6}, \ldots$

(C) 1, 3, 5, ….

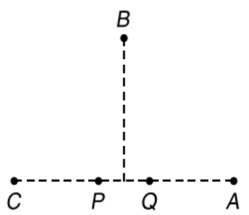
(D) $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}, \ldots$

5. **[Online September 2020]**
In a resonance tube experiment when the tube is filled with water up to height of 17.0 cm from bottom, it resonates with a given tuning fork. When the water level is raised the next resonance with the same tuning fork occurs at a height of 24.5 cm. If the velocity of sound in air is 330 $ms^{-1}$, the tuning fork frequency is
(A) 1100 Hz (B) 3300 Hz
(C) 2200 Hz (D) 550 Hz

6. **[Online September 2020]**
Assume that the displacement $s$ of air is proportional to the pressure difference $(\Delta p)$ created by a sound wave. Displacement $s$ further depends on the speed of sound $(v)$, density of air $(\rho)$ and the frequency $(f)$. If $\Delta p \sim 10$ Pa, $v \sim 300\ ms^{-1}$, $p \sim 1\ kgm^{-3}$ and $f \sim 1000$ Hz, then $s$ will be the order of (take multiplicative constant to be 1)
(A) 10 mm
(B) $\frac{3}{100}$ mm
(C) 1 mm
(D) $\frac{1}{10}$ mm

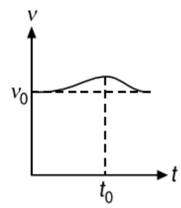
7. **[Online September 2020]**
A driver in a car, approaching a vertical wall notices that the frequency of his car horn, has changed from 440 Hz to 480 Hz, when it gets reflected from the wall. If the speed of sound in air is 345 $ms^{-1}$, then the speed of the car is
(A) 36 $kghr^{-1}$ (B) 24 $kmhr^{-1}$
(C) 18 $kmhr^{-1}$ (D) 54 $kmhr^{-1}$

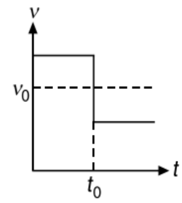
8. **[Online September 2020]**
In the figure below, $P$ and $Q$ are two equally intense coherent sources emitting radiation of wavelength 20 m. The separation between $P$ and $Q$ is 5 m and the phase of $P$ is ahead of that of $Q$ by 90°. $A$, $B$ and $C$ are three distinct points of observation, each equidistant from the midpoint of $PQ$. The intensities of radiation at $A$, $B$, $C$ will be in the ratio

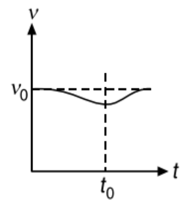



(A) $0:1:2$
(B) $4:1:0$
(C) $0:1:4$
(D) $2:1:0$

9. **[Online September 2020]**
A sound source $S$ is moving along a straight track with speed $v$, and is emitting sound of frequency $v_0$ (see figure). An observer is standing at a finite distance, at the point $O$, from the track. The time variation of frequency heard by the observer is best represented by: ($t_0$ represents the instant when the distance between the source and observer is minimum)

(A)



(B)



(C)
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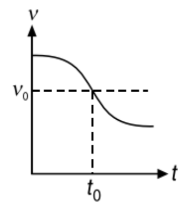



10. **[Online January 2020]**
Speed of a transverse wave on a straight wire (mass 6.0$g$, length 60 cm and area of cross-section 1.0 $mm^2$) is 90 $ms^{-1}$. If the Young's modulus of wire is $16 \times 10^{11}\ Nm^{-2}$, the extension of wire over its natural length is
(A) 0.02 mm (B) 0.04 mm
(C) 0.03 mm (D) 0.01 mm

11. **[Online January 2020]**
A stationary observer receives sound from two identical tuning forks, one of which approaches and the other one recedes with the same speed (much less than the speed of sound). The observer hears 2 bps. The oscillation frequency of each tuning fork is $v_0 = 1400$ Hz and the velocity of sound in air is 350 $ms^{-1}$. The speed of each tuning fork is close to
(A) $\frac{1}{8}\ ms^{-1}$ (B) $\frac{1}{2}\ ms^{-1}$
(C) 1 $ms^{-1}$ (D) $\frac{1}{4}\ ms^{-1}$

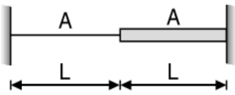
12. **[Online January 2020]**
A one meter long (both ends open) organ pipe is kept in a gas that has double the density of air at STP. Assuming the speed of sound in air at STP is 300 $ms^{-1}$, the frequency difference between the fundamental and second harmonic of this pipe is_______ Hz.

13. **[Online January 2020]**
A transverse wave travels on a taut steel wire with a velocity of $v$ when tension in it is $2.06 \times 10^4$ N. When the tension is changed to $T$, the velocity changed to $\frac{v}{2}$. The value of $T$ is close to
(A) $10.2 \times 10^2$ N
(B) $5.15 \times 10^3$ N
(C) $2.50 \times 10^4$ N
(D) $30.5 \times 10^4$ N

14. **[Online January 2020]**
Three harmonic waves having equal frequency $v$ and same intensity $I_0$, have phase angles 0, $\frac{\pi}{4}$ and $-\frac{\pi}{4}$ respectively. When they are superimposed the intensity of the resultant wave is close to
(A) $5.8I_0$ (B) $0.2I_0$
(C) $I_0$ (D) $3I_0$

**15. [Online January 2020]**
A wire of length $L$ and mass per unit length $6.0 \times 10^{-3}$ kgm$^{-1}$ is put under tension of 540 N. Two consecutive frequencies that it resonates at are 420 Hz and 490 Hz. Then $L$ in meters is
(A) 8.1 m (B) 5.1 m
(C) 1.1 m (D) 2.1 m

**16. [Online April 2019]**
A wire of length $2L$, is made by joining two wires $A$ and $B$ of same length but different radii $r$ and $2r$ and made of the same material. It is vibrating at a frequency such that the joint of the two wires forms a node. If the number of antinodes in wire $A$ is $p$ and that in $B$ is $q$ then the ratio $p:q$ is




(A) 4 : 9 (B) 1 : 2
(C) 3 : 5 (D) 1 : 4

**17. [Online April 2019]**
The pressure wave, $P = 0.01\sin[1000t - 3x]$ Nm$^{-2}$, corresponds to the sound produced by a vibrating blade on a day when atmospheric temperature is 0 °C. On some other day when temperature is $T$, the speed of sound produced by the same blade and at the same frequency is found to be 336 ms$^{-1}$. Approximate value of $T$ is
(A) 4 °C (B) 12 °C
(C) 15 °C (D) 11 °C

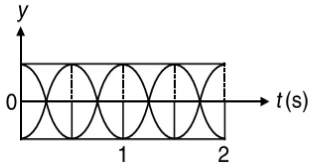
**18. [Online April 2019]**
A string is clamped at both the ends and it is vibrating in its 4$^{th}$ harmonic. The equation of the stationary wave is $y = 0.3\sin(0.157x)\cos(200\pi t)$. The length of the string is (All quantities are in SI units)
(A) 60 m (B) 20 m
(C) 40 m (D) 80 m

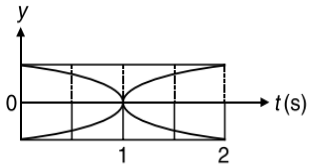
**19. [Online April 2019]**
Two cars $A$ and $B$ are moving away from each other in opposite directions. Both the cars are moving with a speed of 20 ms$^{-1}$ with respect to the ground. If an observer in car $A$ detects a frequency 2000 Hz of the sound coming from car $B$, what is the natural frequency of the sound source in car $B$? (speed of sound in air = 340 ms$^{-1}$)
(A) 2150 Hz (B) 2300 Hz
(C) 2060 Hz (D) 2250 Hz

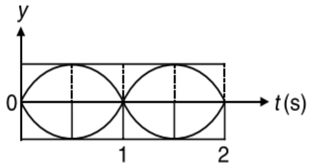
**20. [Online April 2019]**
A string 2.0 m long and fixed at its ends is driven by a 240 Hz vibrator. The string vibrates in its third harmonic mode. The speed of the wave and its fundamental frequency is
(A) 320 ms$^{-1}$, 120 Hz (B) 320 ms$^{-1}$, 80 Hz
(C) 180 ms$^{-1}$, 80 Hz (D) 180 ms$^{-1}$, 120 Hz

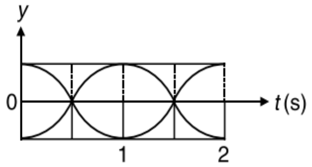
**21. [Online April 2019]**
A stationary source emits sound waves of frequency 500 Hz. Two observers moving along a line passing through the source detect sound to be of frequencies 480 Hz and 530 Hz. Their respective speeds are ...... in ms$^{-1}$. (Given speed of sound = 300 ms$^{-1}$)
(A) 12, 16 (B) 16, 14
(C) 8, 18 (D) 12, 18

**22. [Online April 2019]**
The correct figure that shows, schematically, the wave pattern produced by superposition of two waves of frequencies 9 Hz and 11 Hz, is

(A)



(B)



(C)



(D)


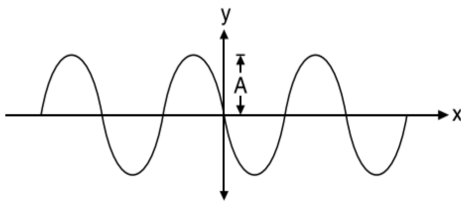

**23. [Online April 2019]**
A source of sound $S$ is moving with a velocity of 50 ms$^{-1}$ towards a stationary observer. The observer measures the frequency of the source as 1000 Hz. What will be the apparent frequency of the source when it is moving away from the observer after crossing him? (Take velocity of sound in air is 350 ms$^{-1}$)
(A) 857 Hz (B) 1143 Hz
(C) 807 Hz (D) 750 Hz

**24. [Online April 2019]**
A submarine $(A)$ travelling at 18 kmh$^{-1}$ is being chased along the line of its velocity by another submarine $(B)$ travelling at 27 kmh$^{-1}$. $B$ sends a sonar signal of 500 Hz to detect $A$ and receives a reflected sound of frequency $\nu$. The value of $\nu$ is close to (Speed of sound in water = 1500 ms$^{-1}$)
(A) 499 Hz (B) 504 Hz
(C) 507 Hz (D) 502 Hz

**25. [Online April 2019]**
A progressive wave travelling along the positive $x$-direction is represented by

$$y(x, t) = A\sin(kx - \omega t + \phi)$$

Its snapshot at $t = 0$ is given in the Figure.



For this wave, the phase $\phi$ is

(A) $\pi$ (B) $-\frac{\pi}{2}$

(C) $\frac{\pi}{2}$ (D) 0

**26. [Online April 2019]**
A small speaker delivers 2 W of audio output. At what distance from the speaker will one detect 120 dB intensity sound? [Given reference intensity of sound as $10^{-12}$ $Wm^{-2}$]
(A) 30 cm (B) 40 cm
(C) 10 cm (D) 20 cm

**27. [Online April 2019]**
Two sources of sound $S_1$ and $S_2$ produce sound waves of same frequency 660 Hz. A listener is moving from source $S_1$ towards $S_2$ with a constant speed $u$ $ms^{-1}$ and he hears 10 beats/s. The velocity of sound is 330 $ms^{-1}$. Then, $u$ equals
(A) 10.0 $ms^{-1}$ (B) 5.5 $ms^{-1}$
(C) 2.5 $ms^{-1}$ (D) 15.0 $ms^{-1}$

**28. [Online April 2019]**
A tuning fork of frequency 480 Hz is used in an experiment for measuring speed of sound $(v)$ in air by resonance tube method. Resonance is observed to occur at two successive lengths of the air column, $l_1 = 30$ cm and $l_2 = 70$ cm. Then, $v$ is equal to
(A) 332 $ms^{-1}$ (B) 384 $ms^{-1}$
(C) 379 $ms^{-1}$ (D) 338 $ms^{-1}$

**29. [Online January 2019]**
A heavy ball of mass $M$ is suspended from the ceiling of a car by a light string of mass $m(m \ll M)$. When the car is at rest, the speed of transverse waves in the string is 60 $ms^{-1}$. When the car has acceleration $a$, the wave-speed increases to 60.5 $ms^{-1}$. The value of $a$, in terms of gravitational acceleration $g$, is closest to

(A) $\frac{g}{30}$ (B) $\frac{g}{5}$

(C) $\frac{g}{20}$ (D) $\frac{g}{10}$

**30. [Online January 2019]**
A musician using an open flute of length 50 cm produces second harmonic sound waves. A person runs towards the musician from another end of a hall at a speed of 10 $kmh^{-1}$. If the wave speed is 330 $ms^{-1}$, the frequency heard by the running person shall be close to
(A) 500 Hz (B) 753 Hz
(C) 333 Hz (D) 666 Hz

**31. [Online January 2019]**
A train moves towards a stationary observer with speed 34 $ms^{-1}$. The train sounds a whistle and its frequency registered by the observer is $f_1$. If the speed of the train is reduced to 17 $ms^{-1}$, the frequency registered is $f_2$. If speed of sound is 340 $ms^{-1}$, then the ratio $\frac{f_1}{f_2}$ is

(A) $\frac{21}{20}$ (B) $\frac{20}{19}$

(C) $\frac{18}{17}$ (D) $\frac{19}{18}$

**32. [Online January 2019]**
A string of length 1 m and mass 5 g is fixed at both ends. The tension in the string is 8.0 N. The string is set into vibration using an external vibrator of frequency 100 Hz. The separation between successive nodes on the string is close to
(A) 33.3 cm (B) 10.0 cm
(C) 16.6 cm (D) 20.0 cm

**33. [Online January 2019]**
Equation of travelling wave on a stretched string of linear density 5 $gm^{-1}$ is $y = 0.03\sin(450t - 9x)$ where distance and time are measured in SI units. The tension in the string is
(A) 10 N (B) 7.5 N
(C) 5 N (D) 12.5 N

**34. [Online January 2019]**
A person standing on an open ground hears the sound of a jet aeroplane, coming from north at an angle 60° with ground level. But he finds the aeroplane right vertically above his position. If $v$ is the speed of sound, speed of the plane is

(A) $\frac{2v}{\sqrt{3}}$ (B) $\frac{\sqrt{3}}{2}v$

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

**35. [Online January 2019]**
A travelling harmonic wave is represented by the equation $y(x, t) = 10^{-3}\sin(50t + 2x)$, where $x$ and $y$ are in meter and $t$ is in seconds. Which of the following is a correct statement about the wave?
(A) The wave is propagating along the negative $x$-axis with speed 25 $ms^{-1}$
(B) The wave is propagating along the positive $x$-axis with speed 100 $ms^{-1}$
(C) The wave is propagating along the negative $x$-axis with speed 100 $ms^{-1}$
(D) The wave is propagating along the positive $x$-axis with speed 25 $ms^{-1}$

**36. [Online January 2019]**
A resonance tube is old and has jagged end. It is still used in the laboratory to determine velocity of sound in air. A tuning fork of frequency 512 Hz produces first resonance when the tube is filled with water to a mark 11 cm below a reference mark, near the open end of the tube. The experiment is repeated with another fork of frequency 256 Hz which produces first resonance when water reaches a mark 27 cm below the reference mark. The velocity of sound in air, obtained in the experiment, is close to
(A) 322 $ms^{-1}$
(B) 341 $ms^{-1}$
(C) 328 $ms^{-1}$
(D) 335 $ms^{-1}$

**37. [2018]**
A granite rod of 60 cm length is clamped at its middle point and is set into longitudinal vibrations. The density of granite is $2.7 \times 10^3$ kgm$^{-3}$ and its Young's modulus is $9.27 \times 10^{10}$ Pa. What will be the fundamental frequency of the longitudinal vibrations?
(A) 5 kHz (B) 2.5 kHz
(C) 10 kHz (D) 7.5 kHz

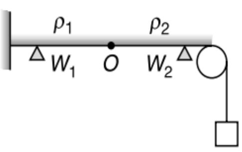
**38. [Online 2018]**
A tuning fork vibrates with frequency 256 Hz and gives one beat per second with the third normal mode of vibration of an open pipe. What is the length of the pipe? (Speed of sound in air is 340 ms$^{-1}$)
(A) 190 cm (B) 180 cm
(C) 200 cm (D) 220 cm

**39. [Online 2018]**
5 beats/second are heard when a tuning fork is sounded with a sonometer wire under tension, when the length of the sonometer wire is either 0.95 m or 1 m. The frequency of the fork will be
(A) 251 Hz (B) 300 Hz
(C) 195 Hz (D) 150 Hz

**40. [Online 2018]**
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 by 3 Hz. If the frequency of $A$ is 425 Hz, the original frequency of $B$ is
(A) 428 Hz (B) 430 Hz
(C) 420 Hz (D) 422 Hz

**41. [Online 2018]**
The end correction of a resonance column is 1 cm. If the shortest length resonating with the tuning fork is 10 cm, the next resonating length should be
(A) 36 cm (B) 40 cm
(C) 28 cm (D) 32 cm

**42. [Online 2017]**
Two wires $W_1$ and $W_2$ have the same radius $r$ and respective densities $\rho_1$ and $\rho_2$ such that $\rho_2 = 4\rho_1$. They are joined together at the point $O$, as shown in the figure. The combination is used as a sonometer wire and kept under tension $T$. The point $O$ is midway between the two bridges. When a stationary wave is set up in the composite wire, the joint is found to be a node. The ratio of the number of antinodes formed in $W_1$ to $W_2$ is




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

**43. [Online 2017]**
A standing wave is formed by the superposition of two waves travelling in opposite directions. The transverse displacement is given by

$$y(x, t) = 0.5\sin\left(\frac{5\pi}{4}x\right)\cos(200\pi t)$$

What is the speed of the travelling wave moving in the positive $x$ direction? ($x$ and $t$ are in meter and second, respectively.)
(A) 180 ms$^{-1}$ (B) 160 ms$^{-1}$
(C) 120 ms$^{-1}$ (D) 90 ms$^{-1}$

**44. [2016]**
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$^{-2}$)
(A) $\sqrt{2}$ s (B) $2\pi\sqrt{2}$ s
(C) 2 s (D) $2\sqrt{2}$ s

**45. [2016, 2012]**
A pipe open at both ends has a fundamental frequency $f$ in air. The pipe is dipped vertically in water so that half of it is in water. The fundamental frequency of the air column is now
(A) $f$ (B) $\frac{f}{2}$
(C) $\frac{3f}{4}$ (D) $2f$

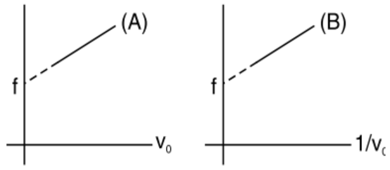
**46. [Online 2016]**
Two engines pass each other moving in opposite directions with uniform speed of 30 ms$^{-1}$. One of them is blowing a whistle of frequency 540 Hz. Calculate the frequency heard by driver of second engine before they pass each other. Speed of sound is 330 ms$^{-1}$.
(A) 450 Hz
(B) 540 Hz
(C) 270 Hz
(D) 648 Hz

**47. [Online 2016]**
A toy car blowing its horn is moving with a steady speed of 5 ms$^{-1}$ away from a wall. An observer, towards whom the toy car is moving, is able to hear 5 bps. If the velocity of sound in air is 340 ms$^{-1}$, the frequency of the horn of the toy car is close to
(A) 680 Hz (B) 510 Hz
(C) 340 Hz (D) 170 Hz

**48. [2015]**
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
(A) 6% (B) 12%
(C) 18% (D) 24%

**49. [Online 2015]**
A bat moving at $10\ \text{ms}^{-1}$ towards a wall sends a sound signal of 8000 Hz towards it. On reflection it hears a sound of frequency $f$. The value of $f$ in Hz is close to (speed of sound $= 320\ \text{ms}^{-1}$)
(A) 8258 (B) 8516
(C) 8000 (D) 8424

**50. [Online 2015]**
A source of sound emits sound waves at frequency $f_0$. It is moving towards an observer with fixed speed $v_s (v_s < v$, where $v$ is the speed of sound in air). If the observer were to move towards the source with speed $v_0$, one of the following two graphs ($A$ and $B$) will give the correct variation of the frequency $f$ heard by the observer as $v_0$ is changed. The variation of $f$ with $v_0$ is given correctly by




(A) graph $A$ with slope $= \dfrac{f_0}{(v - v_s)}$
(B) graph $A$ with slope $= \dfrac{f_0}{(v + v_s)}$
(C) graph $B$ with slope $= \dfrac{f_0}{(v - v_s)}$
(D) graph $B$ with slope $= \dfrac{f_0}{(v + v_s)}$

**51. [2014]**
A pipe of length 85 cm is closed from one end. Find the number of possible natural oscillations of air column in the pipe whose frequencies lie below 1250 Hz. The velocity of sound in air is $340\ \text{ms}^{-1}$.
(A) 4 (B) 12
(C) 8 (D) 6

**52. [2013]**
A sonometer wire of length 1.5 m 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 $7.7 \times 10^3\ \text{kgm}^{-3}$ and $2.2 \times 10^{11}\ \text{Nm}^{-2}$ respectively?
(A) 188.5 Hz (B) 178.2 Hz
(C) 200.5 Hz (D) 770 Hz

**53. [2011]**
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
(A) wave moving in $+x$ direction with speed $\sqrt{\dfrac{a}{b}}$
(B) wave moving in $-x$ direction with speed $\sqrt{\dfrac{b}{a}}$
(C) standing wave of frequency $\sqrt{b}$
(D) standing wave of frequency $\dfrac{1}{\sqrt{b}}$

**54. [2010]**
The equation of a wave on a string of linear mass density $0.04\ \text{kgm}^{-1}$ is given by

$$y = 0.02(\text{m})\sin\left[2\pi\left(\frac{t}{0.04(\text{s})} - \frac{x}{0.50(\text{m})}\right)\right]$$

The tension in the string is
(A) 6.25 N (B) 4.0 N
(C) 12.5 N (D) 0.5 N

**55. [2009]**
Three sound waves of equal amplitudes have frequencies $(v-1), v, (v+1)$. They superpose to give beats. The number of beats produced per second will be
(A) 4 (B) 3
(C) 2 (D) 1

**56. [2009]**
A motor cycle starts from rest and accelerates along a straight path at $2\ \text{ms}^{-2}$. 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 $= 330\ \text{ms}^{-1}$).
(A) 49 m (B) 98 m
(C) 147 m (D) 196 m

# ARCHIVE: JEE ADVANCED

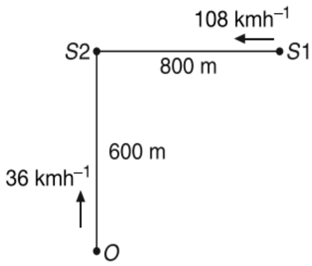
## Single Correct Choice Type Problems

(In this section each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct)

**1. [IIT-JEE 2012]**
A student is performing the experiment of resonance column. The diameter of the column tube is 4 cm. The frequency of the tuning fork is 512 Hz. The air temperature is 38 °C in which the speed of sound is $336\ \text{ms}^{-1}$. The zero of the meter scale coincides with the top end of the resonance column tube. When the first resonance occurs, the reading of the water level in the column is
(A) 14 cm (B) 15.2 cm
(C) 16.4 cm (D) 17.6 cm

**2. [IIT-JEE 2010]**
A hollow pipe of length 0.8 m is closed at one end. At its open end a 0.5 m long uniform string is vibrating in its second harmonic and it resonates with the fundamental frequency of the pipe. If the tension in the wire is 50 N and the speed of sound is $320\ \text{ms}^{-1}$, the mass of the string is
(A) 5 gram (B) 10 gram
(C) 20 gram (D) 40 gram

**3. [IIT-JEE 2008]**
A transverse sinusoidal wave moves along a string in the positive $x$-direction at a speed of $10\ \text{cms}^{-1}$. 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



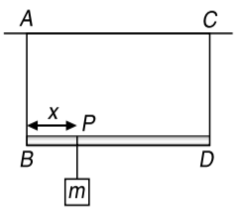

(A) $\frac{\sqrt{3}\pi}{50}\hat{j}$ ms$^{-1}$ (B) $-\frac{\sqrt{3}\pi}{50}\hat{j}$ ms$^{-1}$

(C) $\frac{\sqrt{3}\pi}{50}\hat{i}$ ms$^{-1}$ (D) $-\frac{\sqrt{3}\pi}{50}\hat{i}$ ms$^{-1}$

**4. [IIT-JEE 2008]**
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 bps 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 bps. Assuming the velocity of sound in air to be 340 ms$^{-1}$, the frequency $n$ of the tuning fork in Hz is

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

**5. [IIT-JEE 2006]**
A massless rod $BD$ is suspended by two identical massless strings $AB$ and $CD$ of equal lengths. A block of mass $m$ is suspended from 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




(A) $\frac{l}{5}$ (B) $\frac{l}{4}$

(C) $\frac{4l}{5}$ (D) $\frac{3l}{4}$

**6. [IIT-JEE 2005]**
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. Assuming that the speed of sound is 330 ms$^{-1}$, the error in calculating speed of sound is

(A) 204.1 cms$^{-1}$ (B) 110 cms$^{-1}$
(C) 58 cms$^{-1}$ (D) 280 cms$^{-1}$

**7. [IIT-JEE 2005]**
An open pipe is in resonance in 2$^{nd}$ 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 $n$th harmonic. Choose the correct option

(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) $n = 5$, $f_2 = \frac{3}{4}f_1$

**8. [IIT-JEE 2004]**
A source of sound of frequency 600 Hz is placed inside water. The speed of sound in water is 1500 ms$^{-1}$ and in air it is 300 ms$^{-1}$. 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

**9. [IIT-JEE 2004]**
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

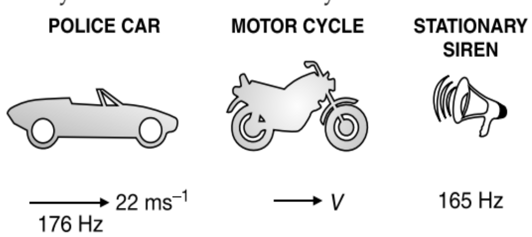
(A) $\frac{L}{3}$ (B) $\frac{4L}{3}$

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

**10. [IIT-JEE 2003]**
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 mg

**11. [IIT-JEE 2003]**
A police car moving at 22 ms$^{-1}$ chases a motorcyclist. 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 its is given that the motorcyclist does not observe any beats




(A) 33 ms$^{-1}$ (B) 22 ms$^{-1}$
(C) ZERO (D) 11 ms$^{-1}$

**12. [IIT-JEE 2002]**
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 $M$, the wire resonates with the same tuning fork forming three antinodes for the same position of bridges. The value of $M$ is

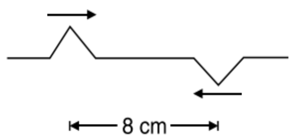
(A) 25 kg (B) 5 kg

(C) 12.5 kg (D) $\frac{1}{25}$ kg

**13. [IIT-JEE 2002]**
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 kHz while approaching the same siren. The ratio of the velocity of train $B$ to that train $A$ is

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

**14. [IIT-JEE 2001]**
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 $\text{cms}^{-1}$. After 2 seconds the total energy of the pulses will be




(A) ZERO
(B) purely kinetic
(C) purely potential
(D) partly kinetic and partly potential

**15. [IIT-JEE 2001]**
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

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

**16. [IIT-JEE 2000]**
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 $\nu_1$ and the other with frequency $\nu_2$. The ratio $\frac{\nu_1}{\nu_2}$ is given by

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

**17. [IIT-JEE 2000]**
A train moves towards a stationary observer with speed 34 $\text{ms}^{-1}$. The train sounds a whistle and its frequency registered by the observer is $f_1$. If the train's speed is reduced to 17 $\text{ms}^{-1}$, the frequency registered is $f_2$. If the speed of sound is 340 $\text{ms}^{-1}$ then the ratio $\frac{f_1}{f_2}$ is

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

**18. [IIT-JEE 2000]**
Two monoatomic ideal gases 1 and 2 of molecular masses $m_1$ and $m_2$ respectively are enclosed in separate containers kept at the same temperature. The ratio of the speed of sound in gas 1 to that in gas 2 is given by

(A) $\sqrt{\frac{m_1}{m_2}}$ (B) $\sqrt{\frac{m_2}{m_1}}$
(C) $\frac{m_1}{m_2}$ (D) $\frac{m_2}{m_1}$

**19. [IIT-JEE 1999]**
The ratio of the speed of sound in nitrogen gas to that in helium gas, at 300 K is

(A) $\sqrt{\left(\frac{2}{7}\right)}$ (B) $\sqrt{\left(\frac{1}{7}\right)}$
(C) $\frac{(\sqrt{3})}{5}$ (D) $\frac{(\sqrt{6})}{5}$

**20. [IIT-JEE 1998]**
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. Identical wave pulses are produced at one end at equal intervals of time $\Delta t$. The value of $\Delta t$ which allows constructive interference between successive pulses is
(A) 0.05 s (B) 0.10 s
(C) 0.20 s (D) 0.40 s

**21. [IIT-JEE 1997]**
A travelling wave in a stretched string is described by the equation, $y = A\sin(kx - \omega t)$. The maximum particle velocity is

(A) $A\omega$ (B) $\frac{\omega}{k}$
(C) $\frac{d\omega}{dk}$ (D) $\frac{x}{\omega}$

**22. [IIT-JEE 1997]**
A whistle giving out 450 Hz approaches a stationary observer at a speed of 33 $\text{ms}^{-1}$. The frequency heard by the observer (in Hz) is
(A) 409 (B) 429
(C) 517 (D) 500

**23. [IIT-JEE 1996]**
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) $1.22v$ (B) $0.61v$
(C) $1.50v$ (D) $0.75v$

**24. [IIT-JEE 1996]**
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

**25. [IIT-JEE 1995]**
An object of specific gravity $\rho$ 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) $300\left(\frac{2\rho-1}{2\rho}\right)$

**26. [IIT-JEE 1992]**
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
(A) two (B) three
(C) four (D) five
independent harmonic motions.

**27. [IIT-JEE 1988]**
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) $\frac{1}{3}$

**28. [IIT-JEE 1988]**
A wave represented by the equation $y = a\cos(kx - \omega t)$ is superposed with another wave to form a stationary wave such that the point $x = 0$ is a node. The equation for the other wave is
(A) $y = a\sin(kx \times \omega t)$ (B) $y = -a\cos(kx + \omega t)$
(C) $y = -a\cos(kx - \omega t)$ (D) $y = -a\sin(kx - \omega t)$

**29. [IIT-JEE 1987]**
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) $\cos(k^2x^2 - \omega^2t^2)$

**30. [IIT-JEE 1986]**
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

**31. [IIT-JEE 1984]**
A transverse wave is described by the equation $y = y_0 \sin 2\pi\left(ft - \frac{x}{\lambda}\right)$. 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) $\lambda = 2\pi\, y_0$

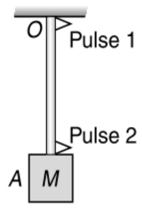
**32. [IIT-JEE 1981]**
A cylindrical tube, open at both ends, has a fundamental frequency $f$ in air. The tube is dipped vertically in water so that half of its in water. The fundamental frequency of the air column in now

(A) $\frac{f}{2}$ (B) $\frac{3f}{4}$
(C) $f$ (D) $2f$

## Multiple Correct Choice Type Problems

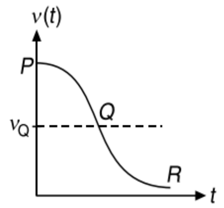
(In this section each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct)

**1. [JEE (Advanced) 2017]**
A block $M$ hangs vertically at the bottom end of a uniform rope of constant mass per unit length. The top end of the rope is attached to a fixed rigid support at $O$. A transverse wave pulse (Pulse 1) of wavelength $\lambda_0$ is produced at point $O$ on the rope. The pulse takes time $T_{OA}$ to reach point $A$ (Pulse 2) without disturbing the position of $M$ it takes time $T_{AO}$ to reach point $O$. Which of the following options is/are correct?

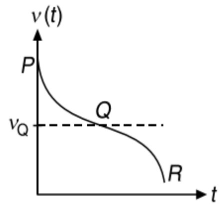



(A) The time $T_{AO} = T_{OA}$
(B) The wavelength of Pulse 1 becomes longer when it reaches point $A$
(C) The velocity of any pulse along the rope is independent of its frequency and wavelength
(D) The velocities of the two pulses (Pulse 1 and Pulse 2) are the same at the mid-point of rope

**2. [JEE (Advanced) 2016]**
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 mid-point $Q$ of the line $MN$ and moves towards $Q$ constantly at 60 $\text{kmh}^{-1}$ along the perpendicular bisector of $MN$. It crosses $Q$ and eventually reaches a point $R$, 1800 m away from $Q$. Let $v(t)$ represent the beat frequency measured by a person sitting in the car at time $t$. Let $v_P$, $v_Q$ and $v_R$ be the beat frequencies measured at locations $P$, $Q$ and $R$ respectively. The speed of sound in air is 300 $\text{ms}^{-1}$. Which of the following statement(s) is (are) true regarding the sound heard by the person?
(A) $v_P + v_R = 2v_Q$
(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 rep represents schematically the variations of beat frequency with time




**3. [JEE (Advanced) 2014]**

A student is performing an experiment using a resonance column and a tuning fork of frequency 244 $s^{-1}$. He is told that the air in the tube has been replaced by another gas (assume that the column remains filled with the gas). If the minimum height at which resonance occurs is $(0.350 \pm 0.005)$ m, the gas in the tube is

**(Useful information:** $\sqrt{167RT} = 640 \text{ J}^{\frac{1}{2}} \text{ mole}^{-\frac{1}{2}}$; $\sqrt{140RT} = 590 \text{ J}^{\frac{1}{2}} \text{ mole}^{-\frac{1}{2}}$. The molar masses $M$ in grams are given in the options. Take the value of $\sqrt{\frac{10}{M}}$ for each gas as given there.**)**

(A) Neon$\left(M = 20, \sqrt{\frac{10}{20}} = \frac{7}{10}\right)$

(B) Nitrogen$\left(M = 28, \sqrt{\frac{10}{28}} = \frac{3}{5}\right)$

(C) Oxygen$\left(M = 32, \sqrt{\frac{10}{32}} = \frac{9}{16}\right)$

(D) Argon$\left(M = 36, \sqrt{\frac{10}{36}} = \frac{17}{32}\right)$

**4. [JEE (Advanced) 2014]**

One end of a taut string of length 3 m along 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 wave is (are)

(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) $y(t) = A\sin\frac{5\pi x}{2}\cos 250\pi t$

**5. [JEE (Advanced) 2013]**

Two vehicles, each moving with speed $u$ on the same horizontal straight road, are approaching each other. Wind blows along the road with velocity $w$. One of these vehicles blows a whistle of frequency $f_1$. An observer in the other vehicle hears the frequency of the whistle to be $f_2$. The speed of sound in still air is $V$. The correct statement(s) is (are)

(A) If the wind blows from the observer to the source, $f_2 > f_1$

(B) If the wind blows from the source to the observer, $f_2 > f_1$

(C) If the wind blows from observer to the source, $f_2 < f_1$

(D) If the wind blows from the source to the observer, $f_2 < f_1$

**6. [IIT-JEE 2012]**

A person blows into open-end of a long pipe. As a result, a high-pressure pulse of air travels down the pipe. When this pulse reaches the other end of the pipe,

(A) a high-pressure pulse starts travelling up the pipe, if the other end of the pipe is open

(B) a low-pressure pulse starts travelling up the pipe, if the other end of the pipe is open

(C) a low-pressure pulse starts travelling up the pipe, if the other end of the pipe is closed

(D) a high-pressure pulse starts travelling up the pipe, if the other end of the pipe is closed

**7. [IIT-JEE 2012]**

A horizontal stretched string, fixed at two ends, is vibrating in its fifth harmonic according to the equation,

$$y(x, t) = (0.01 \text{ m})\sin\left[(62.8 \text{ m}^{-1})x\right]\cos\left[(628 \text{ s}^{-1})t\right]$$

Assuming $\pi = 3.14$, the correct statement(s) is (are)

(A) The number of nodes is 5

(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 0.01 m

(D) The fundamental frequency is 100 Hz

**8. [IIT-JEE 2009]**

A student performed the experiment to measure the speed of sound in air using resonance air-column method. Two resonances in the air-column were obtained by lowering the water level. The resonance with the shorter air-column is the first resonance and that with the longer air column is the second resonance. Then,

(A) the intensity of the sound heard at the first resonance was more than that at the second resonance

(B) the prongs of the tuning fork were kept in a horizontal plane above the resonance tube

(C) the amplitude of vibration of the ends of the prongs is typically around 1 cm

(D) the length of the air-column at the first resonance was somewhat shorter than $\frac{1}{4}$th of the wavelength of the sound in air

**9. [IIT-JEE 1999]**
Standing waves can be produced
(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

**10. [IIT-JEE 1999]**
In a wave motion $y = a\sin(kx - \omega t)$, $y$ can represent
(A) electric field (B) magnetic field
(C) displacement (D) pressure

**11. [IIT-JEE 1999]**
$Y(x,t) = \frac{0.8}{[(4x+5t)^2+5]}$ represents a moving pulse where $x$ and $y$ are in metres and in $t$ 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

**12. [IIT-JEE 1999]**
As a wave propagates
(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 centered at the source remains constant at all times

**13. [IIT-JEE 1998]**
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 $v = 10\ \text{ms}^{-1}$, then $\lambda$ and $f$ are given by
(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

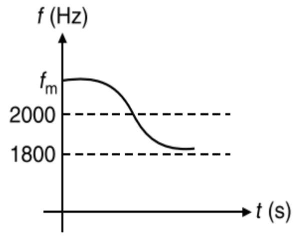
**14. [IIT-JEE 1998]**
The $(x, y)$ co-ordinates of the corners of a square plate are $(0,0)$, $(L,0)$, $(L,L)$ and $(0,L)$. The edges of the plate are clamped and transverse standing waves are set up in it. If $u(x,y)$ denotes the displacement of the plate at the point $(x,y)$ at some instant of time, the possible expression(s) for $u$ is (are) ($a$ = positive constant)
(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) $a\cos\left(\frac{2\pi x}{L}\right)\sin\left(\frac{\pi y}{L}\right)$

**15. [IIT-JEE 1995]**
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 metres and $t$ in seconds
(A) A displacement node occurs at $x = 0.15$ m
(B) An antinode occurs at $x = 0.3$ m
(C) The wavelength of the wave is 0.2 m
(D) The speed of the wave is 5 $\text{ms}^{-1}$

**16. [IIT-JEE 1995]**
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 the 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 $\frac{vf}{c-v}$

**17. [IIT-JEE 1991]**
Two identical straight wires are stretched so as to produce 6 beats per second when vibrating simultaneously. On changing the tension slightly in one of them, the beat frequency remains unchanged. Denoting by $T_1$, $T_2$ the higher and the lower initial tension in the strings, then it could be said that while making the above changes in tension
(A) $T_2$ was decreased
(B) $T_2$ was increased
(C) $T_1$ was decreased
(D) $T_1$ was increased

**18. [IIT-JEE 1990]**
A stationary observer receives a sound of frequency $f_0 = 2200$ Hz. The apparent frequency $f$ varies with time as shown in figure. Speed of sound = 300 $\text{ms}^{-1}$. Choose the correct alternative(s)




(A) speed of source is 66.7 $\text{ms}^{-1}$
(B) $f_m$ shown in figure cannot be greater than 2500 Hz
(C) speed of source is 33.33 $\text{ms}^{-1}$
(D) $f_m$ shown in figure cannot be greater than 2250 Hz

**19. [IIT-JEE 1989]**
Velocity of sound in air is $320 \text{ ms}^{-1}$. A pipe closed at one end has a length of 1 m. Neglecting end corrections, the air column in the pipe can resonate for sound of frequency
(A) 80 Hz (B) 240 Hz
(C) 320 Hz (D) 400 Hz

**20. [IIT-JEE 1985]**
An air column in a pipe, which is closed at one end, will be in resonance with a vibrating tuning fork of frequency 264 Hz, if the length of the column in cm is
(A) 31.25 (B) 62.50
(C) 93.75 (D) 125

**21. [IIT-JEE 1981]**
A wave equation which gives the displacement along the $y$-direction is given by

$$y = 10^{-4} \sin(60t + 2x)$$

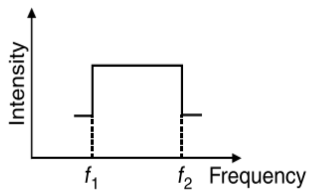
where $x$ and $y$ are in metres and $t$ is time in seconds. This represents a wave
(A) travelling with a velocity of $30 \text{ ms}^{-1}$ in the negative $x$-direction
(B) of wavelength $\pi m$
(C) of frequency $\frac{30}{\pi}$ hertz
(D) of amplitude $10^{-4}$ m travelling along the negative $x$-direction

## Linked Comprehension Type Questions

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options)

### *Comprehension I*

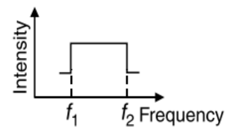
Two trains $A$ and $B$ are moving with speeds $20 \text{ ms}^{-1}$ and $30 \text{ ms}^{-1}$ respectively in the same direction on the same straight track, with $B$ ahead of $A$. The engines are at the front ends. The engine of train $A$ blows a long whistle.

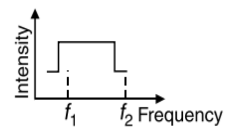


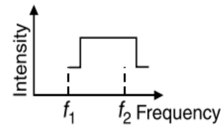

Assume that the sound of the whistle is composed of components varying in frequency from $f_1 = 800$ Hz to $f_2 = 1120$ Hz, as shown in the figure. The spread in the frequency (highest frequency – lowest frequency) is thus 320 Hz. The speed of sound in still air is $340 \text{ ms}^{-1}$. Based on the above facts, answer the following questions.

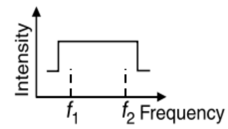
**1. [IIT-JEE 2007]**
The speed of sound of the whistle is
(A) $340 \text{ ms}^{-1}$ for passengers in $A$ and $310 \text{ ms}^{-1}$ for passengers in $B$
(B) $360 \text{ ms}^{-1}$ for passengers in $A$ and $310 \text{ ms}^{-1}$ for passengers in $B$
(C) $310 \text{ ms}^{-1}$ for passengers in $A$ and $360 \text{ ms}^{-1}$ for passengers in $B$
(D) $340 \text{ ms}^{-1}$ for passengers in both the trains

**2. [IIT-JEE 2007]**
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. [IIT-JEE 2007]**
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

### *Comprehension 2*

Two plane harmonic sound waves are expressed by the equations.

$$y_1(x,t) = A\cos(0.5\pi x - 100\pi t)$$

$$y_2(x,t) = A\cos(0.46\pi x - 92\pi t)$$

(All parameters are in SI)
Based on the above facts, answer the following questions.

**4. [IIT-JEE 2006]**
How many times does an observer hear maximum intensity in one second?
(A) 4 (B) 10
(C) 6 (D) 8

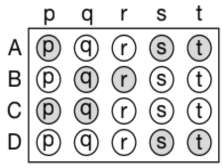
**5. [IIT-JEE 2006]**
The speed of the sound is
(A) $200 \text{ ms}^{-1}$
(B) $180 \text{ ms}^{-1}$
(C) $192 \text{ ms}^{-1}$
(D) $96 \text{ ms}^{-1}$

**6. [IIT-JEE 2006]**
At $x = 0$, how many times the amplitude of $y_1 + y_2$ becomes zero in one second?
(A) 192 (B) 48
(C) 100 (D) 96

## Matrix Match/Column Match Type Questions

Each question in this section contains statements given in two columns, which have to be matched. The statements in **COLUMN-I** are labelled A, B, C and D, while the statements in **COLUMN-II** are labelled p, q, r, s (and t). Any given statement in **COLUMN-I** can have correct matching with **ONE OR MORE** statement(s) in **COLUMN-II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

If the correct matches are A $\rightarrow$ p, s and t; B $\rightarrow$ q and r; C $\rightarrow$ p and q; and D $\rightarrow$ s and t; then the correct darkening of bubbles will look like the following:




Answer Q. 1 and Q. 2 by appropriately matching the lists based on the information given in the paragraph.

A musical instrument is made using four different metal strings. 1, 2, 3 and 4 with mass per unit length $\mu$, $2\mu$, $3\mu$ and $4\mu$ respectively. The instrument is played by vibrating the strings by varying the free length in between the range $L_0$ and $2L_0$. It is found that in string-1 $(\mu)$ at free length $L_0$ and tension $T_0$ the fundamental mode frequency is $f_0$.

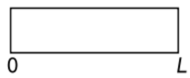
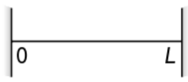
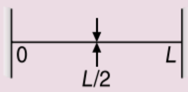
**COLUMN-I** gives the above four strings while **COLUMN-II** lists the magnitude of some quantity.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) String-1 $(\mu)$ | (p) 1 |
| (B) String-2 $(2\mu)$ | (q) $\frac{1}{2}$ |
| (C) String-3 $(3\mu)$ | (r) $\frac{1}{\sqrt{2}}$ |
| (D) String-4 $(4\mu)$ | (s) $\frac{1}{\sqrt{3}}$ |
| | (t) $\frac{3}{16}$ |
| | (u) $\frac{1}{16}$ |

1. **[JEE (Advanced) 2019]**
If the tension in each string is $T_0$, the correct match for the highest fundamental frequency in $f_0$ units will be
(A) A-p, B-q, C-t, D-s
(B) A-p, B-r, C-s, D-q
(C) A-q, B-s, C-r, D-p
(D) A-q, B-p, C-r, D-t

2. **[JEE (Advanced) 2019]**
The length of the strings 1, 2, 3 and 4 are kept fixed at $L_0$, $\frac{3L_0}{2}$, $\frac{5L_0}{4}$ and $\frac{7L_0}{4}$ respectively. Strings 1, 2, 3 and 4 are vibrated at their $1^{st}$, $3^{rd}$, $5^{th}$, and $14^{th}$ harmonics, respectively such that all the strings have same frequency. The correct match for the tension in the four strings in the units of $T_0$ will be
(A) A-p, B-r, C-t, D-u (B) A-p, B-q, C-t, D-u
(C) A-p, B-q, C-r, D-t (D) A-t, B-q, C-r, D-u

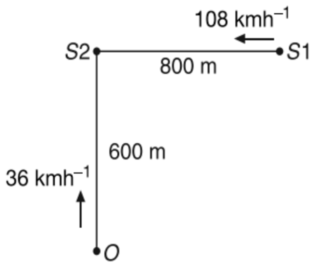
3. **[IIT-JEE 2011]**
**COLUMN-I** shows four systems, each of the same length $L$, for producing standing waves. The lowest possible natural frequency of a system is called its fundamental frequency, whose wavelength is denoted as $\lambda_f$. Match each system with statements given in **COLUMN-II** describing the nature and wavelength of the standing waves.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Pipe closed at one end  | (p) Longitudinal waves |
| (B) Pipe open at both ends  | (q) Transverse waves |
| (C) Stretched wire clamped at both ends  | (r) $\lambda_f = L$ |
| (D) Stretched wire clamped at both ends and at mid-point  | (s) $\lambda_f = 2L$ |
| | (t) $\lambda_f = 4L$ |

## Integer/Numerical Answer Type Questions

In this section, the answer to each question is a numerical value obtained after series of calculations based on the data provided in the question(s).

1. **[JEE (Advanced) 2019]**
A train $S1$, moving with a uniform velocity of 108 km$h^{-1}$, approaches another train $S2$ standing on a platform. An observer $O$ moves with a uniform velocity of 36 km$h^{-1}$ towards $S2$, as shown in figure. Both the trains are blowing whistles of same frequency 120 Hz. When $O$ is 600 m away from $S2$ and distance between $S1$ and $S2$ is 800 m, the number of beats heard by $O$ is ............... [Speed of the sound = 330 m$s^{-1}$]




2. **[JEE (Advanced) 2017]**
A stationary source emits sound of frequency $f_0 = 492$ Hz. The sound is reflected by a large car approaching the source with a speed of $2\ \text{ms}^{-1}$. The reflected signal is received by the source and superposed with the original. What will be the beat frequency of the resulting signal in Hz? (Given that the speed of sound in air is $330\ \text{ms}^{-1}$ and the car reflects the sound at the frequency it has received).

3. **[JEE (Advanced) 2016]**
Four harmonic waves of equal frequencies and equal intensities $I_0$ have phase angles 0, $\frac{\pi}{3}$, $\frac{2\pi}{3}$ and $\pi$. When they are superposed, the intensity of the resulting wave is $nI_0$. The value of $n$ is

4. **[IIT-JEE 2010]**
When two progressive waves $y_1 = 4\sin(2x - 6t)$ and $y_2 = 3\sin\left(2x - 6t - \frac{\pi}{2}\right)$ are superimposed, the amplitude of the resultant wave is $x$ unit. Find $x$.

5. **[IIT-JEE 2009]**
A 20 cm long string, having a mass of 1 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.

# ANSWER KEYS–TEST YOUR CONCEPTS AND PRACTICE EXERCISES

## Test Your Concepts-I
## (Based on Wave Equation & Properties)

1. $(0.06\text{ m})\sin(23562t - 78.5x)$
2. $150\text{ ms}^{-1}$
3. NO ANSWER
4. NO ANSWER
5. [0.12 m]
6. $e^{-(x-vt)^2}$
7. NO ANSWER
8. $y = 0.02\cos(10t - 100x)$ metre, 0.0628 m
9. $30\text{ ms}^{-1}$
10. $v = 2\text{ ms}^{-1}$ along $-x$ direction, 2 units
11. $4\text{ ms}^{-1}$, along $+x$ direction
12. $y_1$ along $+x$, $y_2$ along $-x$, 0.75 s, 1 m

## Test Your Concepts-II
## (Based on Transverse Wave in a String & Properties)

1. $\sqrt{\dfrac{8\ell_0}{g}}$
2. $\dfrac{1}{15\alpha}\left[(\mu_0 + \alpha l)^{\frac{3}{2}} - \mu_0^{\frac{3}{2}}\right]$
3. $80\text{ ms}^{-1}$, $63.24\text{ ms}^{-1}$
4. $\dfrac{1}{2}\rho A^2\omega^2\cos^2(kx - \omega t)$
5. $0.06\sqrt{3}$ m
6. 0.02 mm
7. 0.47 s
8. $\dfrac{P_1}{8}$
9. [$32\text{ ms}^{-1}$]
10. [0.25]
11. (a) 0.14 s, (b) –1.5 cm, 2 cm
12. String 2
13. [0.05 s]

## Test Your Concepts-III
## (Based on Sound Waves & Properties)

1. (a) $4.98\text{ Nm}^{-2}$ (b) $3\times10^{-6}$ m
2. $\sqrt{\dfrac{7}{15}}$
3. [68 dB, 75 dB]
4. 5.84 m
5. 3%
6. 0.173 J
7. –249.7 °C
8. $5.27\times10^{3}\text{ ms}^{-1}$
9. $0.94\text{ Nm}^{-2}$
10. (a) $2\times10^{-4}\text{ Nm}^{-2}$ (b) $y = 2\times10^{-9}\sin\left(500t - \dfrac{5}{2}x\right)$
11. $591\text{ ms}^{-1}$
12. $4.4\times10^{-12}\text{ Wm}^{-2}$
13. $1.1\times10^{-11}$ m

## Test Your Concepts-IV
## (Based on Interference)

1. $0.28\sin\left(x - 3t + \dfrac{\pi}{4}\right)$, ±1.29 rad
2. $\dfrac{1}{16}$
3. $\dfrac{5}{6}A, -\tan^{-1}\left(\dfrac{3}{4}\right)$
4. 1440 Hz
5. 26.46 m, $(5x + 25t + 0.714)$ rad
6. $\phi_1 = \pi$, $\phi_2 = 4\pi$, $0.6\times10^{-3}$ W
7. [$(188n)$ Hz]
8. (a) 1000 Hz, 2000 Hz, 3000 Hz,….
   (b) 500 Hz, 1500 Hz, 2500 Hz,….
9. 17.54 cm
10. (a) 3 m, (b) 0.6 m
11. [2:1:0]
12. $\sqrt{(x+5)^2 + y^2} - \sqrt{(x-5)^2 + y^2} = (16n - 8)$ $n = 1, 2, 3,\ldots$..

## Test Your Concepts-V
## (Based on Stationary Waves & Beats)

1. (a) $\dfrac{15}{\pi}$ Hz, 0.2 cm, $60\text{ cms}^{-1}$ (b) $10.12\text{ cms}^{-1}$
2. (a) 144 cm (b) 17 Hz
3. (a) 2.56 mm (b) 4 cm, $2\text{ ms}^{-1}$
   (c) $78.5\text{ cms}^{-1}$
   (d) Nodes at $x = 0$, 2 cm, 4 cm, ….., Number of loops = 5
4. (a) $500\sqrt{2}$ Hz (b) 11 Hz
5. 18 cm, 24 cm, 72 cm
6. 2.142 m
7. $0.04I_i$
8. (a) 0.36 m (b) 9939 Hz,
   (c) $y = 2.57\times10^{-6}\sin(62400t + \phi)$
9. (a) $\pi kA^2T\sin^2(\omega t)$ (b) $\pi kA^2T$
   (c) $\dfrac{\pi kA^2T}{2}$

**10.** $353.6\ ms^{-1}$
**11.** 41.25 cm
**12.** 82.5 Hz, 81.675 N
**13.** Closed organ pipe is $\ell_1 = 0.75$ m, Open pipe is either $\ell_2 = 0.99$ m or 1.0067 m
**14.** (a) 283.33 Hz (b) 51.5 cm
**15.** 367 Hz
**16.** 27.04 N
**17.** $A\cos(3.93x)\sin(1297t)$

## Test Your Concepts-VI (Based on Doppler's Effect)

1. $1.5\ ms^{-1}$
2. (a) 0.364 m (b) 1320 Hz (c) $332\ ms^{-1}$ (d) 0.2 m
3. $f_{min} = 495$ Hz, $f_{max} = 594$ Hz
4. (a) 970.6 Hz (b) 1031.3 Hz (c) 60.7 Hz
5. (a) 0.35 m (b) 1014.5 Hz
6. $180\ kmh^{-1}$
7. 374.8 Hz
8. (a) 10% (b) No change (c) Percentage increase in frequency is 10%
9. $0.752\ ms^{-1}$
10. $R_1$
11. $1.5\times10^6\ ms^{-1}$
12. $f_{min} = 278.62$ Hz, $f_{max} = 323$ Hz
13. 1340 Hz
14. $\dfrac{Rv\cos^{-1}(R/h)}{\sqrt{h^2 - R^2}}$

## Single Correct Choice Type Questions

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. B | 2. A | 3. C | 4. D | 5. B | 6. B | 7. B | 8. D | 9. A | 10. D |
| 11. B | 12. D | 13. B | 14. C | 15. C | 16. B | 17. B | 18. A | 19. B | 20. B |
| 21. B | 22. A | 23. A | 24. B | 25. B | 26. C | 27. C | 28. D | 29. A | 30. D |
| 31. B | 32. B | 33. B | 34. A | 35. B | 36. C | 37. B | 38. C | 39. D | 40. D |
| 41. B | 42. A | 43. D | 44. B | 45. B | 46. C | 47. A | 48. C | 49. A | 50. D |
| 51. C | 52. A | 53. D | 54. A | 55. C | 56. C | 57. C | 58. C | 59. B | 60. C |
| 61. D | 62. B | 63. D | 64. B | 65. B | 66. B | 67. D | 68. A | 69. B | 70. C |
| 71. D | 72. B | 73. A | 74. B | 75. B | 76. C | 77. C | 78. C | 79. B | 80. B |
| 81. A | 82. C | 83. B | 84. C | 85. D | 86. A | 87. B | 88. D | 89. C | 90. D |
| 91. B | 92. C | 93. C | 94. A | 95. C | 96. A | 97. D | 98. C | 99. B | 100. C |
| 101. B | 102. C | 103. D | 104. C | 105. B | 106. D | 107. C | 108. D | 109. C | 110. A |
| 111. D | 112. C | 113. B | 114. C | 115. A | 116. D | 117. A | 118. D | 119. A | 120. C |
| 121. A | 122. D | 123. B | 124. C | 125. C | 126. C | 127. C | 128. D | 129. A | 130. C |
| 131. B | 132. B | 133. C | 134. B | 135. B | 136. A | 137. A | 138. C | 139. B | 140. D |
| 141. B | 142. C | 143. B | 144. B | 145. C | 146. D | 147. C | 148. B | 149. C | 150. C |
| 151. C | 152. C | 153. D | 154. B | 155. A | 156. B | 157. A | 158. C | 159. D | 160. A |
| 161. D | 162. A | 163. A | 164. D | 165. B | 166. C | 167. A | 168. B | 169. D | 170. B |
| 171. A | 172. D | 173. C | 174. B | 175. A | 176. A | 177. C | 178. B | 179. C | 180. D |
| 181. A | 182. C | 183. A | | | | | | | |

## Multiple Correct Choice Type Questions

| | | | | |
|---|---|---|---|---|
| 1. A, D | 2. A, B, C, D | 3. B, C, D | 4. A, B | 5. A, D |
| 6. A, C | 7. B, C, D | 8. B, C | 9. B, C | 10. A, B |
| 11. B, C, D | 12. A, C | 13. A, B, C, D | 14. B, C | 15. B, C, D |
| 16. A, C, D | 17. B, C, D | 18. A, C | 19. B, C | 20. A, B, C, D |
| 21. A, B, C | 22. A, B | 23. A, D | 24. A, B | 25. A, B, C |
| 26. A, D | 27. A, B, C | 28. A, B, D | 29. B, C | 30. A, D |
| 31. B, D | 32. C, D | 33. A, B, D | 34. C, D | 35. B, C |
| 36. B, C | 37. A, B, C, D | 38. B, C | | |

## Reasoning Based Questions

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

## Linked Comprehension Type Questions

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** C | **2.** B | **3.** A | **4.** D | **5.** B | **6.** D | **7.** B | **8.** D | **9.** C | **10.** C |
| **11.** B | **12.** B | **13.** B | **14.** C | **15.** D | **16.** C | **17.** D | **18.** B | **19.** A | **20.** C |
| **21.** A | **22.** B | **23.** B | **24.** A | **25.** C | **26.** A | **27.** A | **28.** A | **29.** D | **30.** D |
| **31.** B | **32.** C | **33.** B | **34.** C | **35.** D | **36.** B | **37.** D | **38.** A | **39.** C | **40.** D |
| **41.** D | **42.** A | **43.** B | **44.** C | **45.** A | **46.** D | **47.** A | **48.** B | **49.** C | **50.** B |
| **51.** A | **52.** A | **53.** B | **54.** A | **55.** D | | | | | |

## Matrix Match/Column Match Type Questions

| | | | |
|---|---|---|---|
| **1.** A → (p, r) | B → (q, s) | C → (q, r) | D → (p, s) |
| **2.** A → (r) | B → (p) | C → (q) | D → (s) |
| **3.** A → (s) | B → (p) | C → (q) | D → (r) |
| **4.** A → (r) | B → (p) | C → (p) | D → (p) |
| **5.** A → (r) | B → (r) | C → (s) | D → (q) |
| **6.** A → (r) | B → (p) | C → (q) | D → (r) |
| **7.** A → (q) | B → (p) | C → (p) | D → (r) |
| **8.** A → (q) | B → (t) | C → (s) | D → (t) |
| **9.** A → (r) | B → (p, r) | C → (q, r) | D → (p, r, s) |
| **10.** A → (q) | B → (r) | C → (q) | D → (s) |
| **11.** A → (s) | B → (q) | C → (r) | D → (p) |
| **12.** A → (p) | B → (p) | C → (t) | D → (r) |

## Integer/Numerical Answer Type Questions

| | | | | |
|---|---|---|---|---|
| **1.** 60 | **2.** 296 | **3.** 7 | **4.** 1030 | **5.** 250 |
| **6.** 96 | **7.** 30 | **8.** 60 | **9.** 500 | **10.** 6 |
| **11.** (a) 6, (b) 5 | **12.** 4 | **13.** (a) 2500, (b) 320 | **14.** (a) 36, (b) 632 | **15.** 43, 7 |
| **16.** 12 | **17.** 350 | **18.** 100 | **19.** 60, 20 | **20.** 4 |
| **21.** 512 | **22.** 1 | **23.** 79 | **24.** 8 | **25.** (a) 314, (b) 972 |
| **26.** 300 | | | | |

# ARCHIVE: JEE MAIN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** C | **2.** 35 | **3.** B | **4.** D | **5.** C | **6.** B | **7.** D | **8.** D | **9.** D | **10.** C |
| **11.** D | **12.** 106 | **13.** B | **14.** A | **15.** D | **16.** B | **17.** A | **18.** D | **19.** D | **20.** B |
| **21.** D | **22.** A | **23.** D | **24.** D | **25.** A | **26.** B | **27.** C | **28.** D | **29.** B | **30.** D |
| **31.** D | **32.** D | **33.** D | **34.** C | **35.** A | **36.** C | **37.** A | **38.** C | **39.** C | **40.** C |
| **41.** D | **42.** B | **43.** B | **44.** D | **45.** A | **46.** D | **47.** D | **48.** B | **49.** B | **50.** A |
| **51.** D | **52.** B | **53.** B | **54.** A | **55.** C | **56.** B | | | | |

# ARCHIVE: JEE ADVANCED

## Single Correct Choice Type Problems

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** B | **2.** B | **3.** C | **4.** A | **5.** A | **6.** D | **7.** C | **8.** D | **9.** C | **10.** B |
| **11.** B | **12.** A | **13.** B | **14.** B | **15.** C | **16.** D | **17.** D | **18.** B | **19.** C | **20.** B |
| **21.** A | **22.** D | **23.** A | **24.** A | **25.** A | **26.** B | **27.** C | **28.** B | **29.** A | **30.** A |
| **31.** B | **32.** C | | | | | | | | |

## Multiple Correct Choice Type Problems

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

## Linked Comprehension Type Questions

| | | | | | |
|---|---|---|---|---|---|
| **1.** B | **2.** A | **3.** A | **4.** A | **5.** A | **6.** C |

## Matrix Match/Column Match Type Questions

| | | | |
|---|---|---|---|
| **1.** A → (p, r, s, q) | B → (q, p, r, t) | C → (q, s, r, p) | D → (p, q, t, s) |
| **2.** A → (p, q, r, t) | B → (p, q, t, u) | C → (p, r, t, u) | D → (t, q, r, u) |
| **3.** A → (p, t) | B → (p, s) | C → (q, s) | D → (q, r) |

## Integer/Numerical Answer Type Questions

| | | | | |
|---|---|---|---|---|
| **1.** 8.13 | **2.** 6 | **3.** 3 | **4.** 5 | **5.** 5 |