# Chapter 15

# Waves

## Solutions

### SECTION - A

**Objective Type Questions**

**(Transverse and Longitudinal Waves)**

1. Which of the following phenomenon cannot take place with sound waves?

   (1) Polarisation (2) Refraction (3) Diffraction (4) Reflection

**Sol.** Answer (1)

Polarisation is a phenomenon which cannot take place with mechanical waves.

2. The speed of sound in air is independent from its

   (1) Amplitude (2) Frequency (3) Phase (4) All of these

**Sol.** Answer (4)

Speed of sound in air ($v$) = $\sqrt{\dfrac{\gamma P}{\rho}}$

All the other options are function of the wave but speed of sound depends on the medium. Hence, answer will be (4).

3. The waves which cannot travel without medium are

   (1) X-rays (2) Radio waves (3) Light waves (4) Sound waves

**Sol.** Answer (4)

Sound waves being mechanical waves need a mechanical medium for their propagation.

4. When a wave propagating through a medium encounters a change in medium, then which of the following property remains same?

   (1) Speed (2) Amplitude (3) Frequency (4) Wavelength

**Sol.** Answer (3)

The energy carried by a wave is a function of its frequency. If there is no loss of energy in the charge of medium the frequency still remains the same.

5. A transverse wave travels along $x$-axis. The particles of medium move

(1) Along $x$-axis (2) Along $y$-axis

(3) Along $z$-axis (4) Either along $y$-axis or $z$-axis

**Sol.** Answer (4)

In a transverse wave the energy may transfer along $x$-direction but particles are displaced perpendicular to the transfer of energy.

6. The phenomenon of sound propagation in air is

(1) An isothermal process (2) An adiabatic process

(3) An isobaric process (4) An isochoric process

**Sol.** Answer (2)

The phenomenon of sound propagation was found to be almost an adiabatic process by Laplace's theory.

7. If at STP, velocity of sound in a gas ($\gamma$ = 1.5) is 600 m/s, the r.m.s. velocity of the gas molecules at STP will be

(1) 400 m/s (2) 600 m/s (3) $600\sqrt{2}$ m/s (4) $300\sqrt{2}$ m/s

**Sol.** Answer (3)

Velocity of sound = $\sqrt{\dfrac{\gamma RT}{M}}$

RMS speed = $\sqrt{\dfrac{3RT}{M}}$

$$\frac{v_s}{r_{\text{rms}}} = \sqrt{\frac{\gamma}{3}}$$

$$\frac{v_s}{r_{\text{rms}}} = \sqrt{\frac{1}{2}}$$

$$v_{\text{rms}} = 600\sqrt{2} \text{ m/s}$$

8. In a stretched string,

(1) Only transverse waves can exist

(2) Only longitudinal waves can exist

(3) Both transverse and longitudinal waves can exist

(4) None of these

**Sol.** Answer (1)

9. Two strings of same material are stretched to the same tension. If their radii are in the ratio 1 : 2, then respective wave velocities in them will be in ratio

(1) 4 : 1 (2) 2 : 1 (3) 1 : 2 (4) 1 : 4

**Sol.** Answer (2)

Let density of material be $\rho$

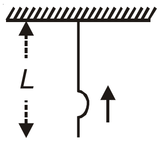
Areas of cross section $A_1 = \pi r_1^2$, $A_2 = \pi r_2^2$ where $r_2 = 2r_1$

$\therefore \quad \mu_1 = \pi r_1^2 \rho$, $\mu_2 = \pi 4 r_1^2 \rho$

$\therefore \quad v_1 = \sqrt{\dfrac{T}{\pi r_1^2 \rho}}$ and $v_2 = \dfrac{1}{2}\sqrt{\dfrac{T}{\pi r_1^2 \rho}}$

$\therefore \quad v_1 : v_2 = 2 : 1$

10. A pulse is generated at lower end of a hanging rope of uniform density and length $L$. The speed of the pulse when it reaches the mid point of rope is




(1) $\sqrt{2gL}$ (2) $\sqrt{gL}$ (3) $\sqrt{\dfrac{gL}{2}}$ (4) $\dfrac{\sqrt{gL}}{2}$

**Sol.** Answer (3)

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

Weight of the string below the rope stretching it = $\dfrac{\mu L}{2} g$

This is equal to $T$ at the middle.

$$\therefore \quad \text{Velocity at middle} = \sqrt{\frac{\mu L g}{2\mu}}$$

$$= \sqrt{\frac{gL}{2}}$$

11. The sound intensity level at a point 4 m from the point source is 10 dB, then the sound level at a distance 2 m from the same source will be

(1) 26 dB

(2) 16 dB

(3) 23 dB

(4) 32 dB

**Sol.** Answer (2)

$$I \propto \frac{1}{r^2}$$

$\therefore \quad$ If at two $m$ intensity is $I_1$ at 4 m, intensity is $\dfrac{I_1}{4}$

12. The tones that are separated by three octaves have a frequency ratio of

(1) 3

(2) 6

(3) 8

(4) 16

**Sol.** Answer (3)

Each octaves is double the frequency of the previous octave.

If initial frequency is $f$.

Final frequency = $2 \times 2 \times 2\, f$ or $2^3 f$ or $8\, f$

$\therefore$ Frequency ratio = 8 : 1.

**(Displacement Relation for a Progressive Wave)**

13. Which of the following equations represents a transverse wave travelling along –$y$ axis?

(1) $x = A \sin(\omega t - ky)$ (2) $x = A \sin(\omega t + ky)$ (3) $y_0 = A \sin(\omega t - kx)$ (4) $y_0 = A \sin(\omega t + kx)$

**Sol.** Answer (2)

Velocity of wave = $-\dfrac{\omega}{k}$

Also since the wave is travelling in the $y$ direction, displacement of the particles will be in $x$-direction.

So, equation will be of the form $x = A \sin(\omega t + ky)$

Putting positive values of $\omega$ and $k$ in the velocity equation will give negative value of velocity. Hence, wave is travelling in –ve direction.

14. A wave is represented by $x = 4\cos\left(8t - \dfrac{y}{2}\right)$, where $x$ and $y$ are in metre and $t$ in second. The frequency of the wave (in $s^{-1}$) is

(1) $\dfrac{4}{\pi}$ (2) $\dfrac{8}{\pi}$ (3) $\dfrac{2}{\pi}$ (4) $\dfrac{\pi}{4}$

**Sol.** Answer (1)

$$x = 4\cos\theta\left(8t - \frac{y}{2}\right)$$

Comparing with $x = A \sin(kx - \omega t)$

$\omega = 8$

and $\omega = 2\pi f$

$f = \dfrac{8}{2\pi}$

$f = \dfrac{4}{\pi}$

15. A wave is represented by the equation $y = A\sin\left(10\pi x + 15\pi t + \frac{\pi}{6}\right)$ where $x$ is in metre and $t$ in second. The expression represents

(1) A wave travelling in negative $x$-direction with a velocity of 1.5 m/s

(2) A wave travelling in positive $x$ direction with a velocity of 1.5 m/s

(3) A wave traveling in positive $x$-direction with wavelength 0.2 m

(4) A wave travelling in negative $x$-direction with a velocity of 150 m/s

**Sol.** Answer (1)

$$y = A\sin\left(10\pi x + 15\pi t + \frac{\pi}{6}\right)$$

$$v = -\frac{\omega}{k}$$

$$v = -\frac{15\pi}{10\pi}$$

$\therefore$ $v = -1.5$ m/s

Hence, velocity is 1.5 m/s in negative $x$-direction.

16. A travelling wave in a string is represented by $y = 3\sin\left(\frac{\pi}{2}t - \frac{\pi}{4}x\right)$. The phase difference between two particles separated by a distance 4 cm is (Take $x$ and $y$ in cm and $t$ in seconds)

(1) $\frac{\pi}{2}$ rad (2) $\frac{\pi}{4}$ rad (3) $\pi$ rad (4) 0

**Sol.** Answer (3)

$$y = 3\sin\left(\frac{\pi}{2}t - \frac{\pi}{4}x\right)$$

Take x = 0 and x = 4 cm

$$y_1 = 3\sin\frac{\pi}{2}t \text{ and } y_2 = 3\sin\frac{\pi}{2}t - \pi$$

Phase difference in between the two particles is $\pi$.

17. A transverse wave is described by the equation $y = A\sin 2\pi(nt - x/\lambda_0)$. The maximum particle velocity is equal to 3 times the wave velocity if

(1) $\lambda_0 = \frac{\pi A}{3}$ (2) $\lambda_0 = \frac{2\pi A}{3}$

(3) $\lambda_0 = \pi A$ (4) $\lambda_0 = 3\pi A$

**Sol.** Answer (2)

$$y = A\sin 2\pi(nt - x/\lambda_0)$$

Particle velocity is $\frac{dy}{dt}$ and maximum particle velocity is $A\omega$.

$\omega = 2\pi n$

$\therefore \quad A\omega = 2\pi nA$

Wave velocity $(v) = \dfrac{\omega}{k} = \dfrac{2\pi n}{2\pi / \lambda_0}$

$2\pi nA = 3\lambda_0 n$

$\lambda_0 = \dfrac{2\pi A}{3}$

18. If $\vec{u}$ is instantaneous velocity of particle and $\vec{v}$ is velocity of wave, then

(1) $\vec{u}$ is perpendicular to $\vec{v}$

(2) $\vec{u}$ is parallel to $\vec{v}$

(3) $|\vec{u}|$ is equal to $|\vec{v}|$

(4) $|\vec{u}| = (\text{slope of wave form})|\vec{v}|$

**Sol.** Answer (4)

$\vec{u}$ may be perpendicular or parallel to $\vec{v}$ depending on whether it is a transverse or longitudinal wave.

$y = A\sin kx - \omega t$

$\dfrac{dy}{dt} = A\omega\cos kx - \omega t$

$\dfrac{dy}{dt} = v$

$u = -A\omega\cos kx - \omega t$

$|v| = \dfrac{\omega}{k}$

Slope of $y = A\sin kx - \omega t$

$\dfrac{dy}{dx} = Ak\cos kx - \omega t$

$\left|\dfrac{dy}{dx}\right| = |v|\left|\dfrac{dy}{dx}\right|$

$u = |v|$ (Slope of waveform)

19. In a simple harmonic wave, minimum distance between particles in same phase always having same velocity, is

(1) $\lambda/4$

(2) $\lambda/3$

(3) $\lambda/2$

(4) $\lambda$

**Sol.** Answer (4)

20. The tension in a wire is decreased by 19%. The percentage decrease in frequency will be

(1) 0.19% (2) 10% (3) 19% (4) 0.9%

**Sol.** Answer (2)

Velocity in a wave = $\sqrt{\frac{T}{\mu}}$

Fundamental frequency of waves $\frac{v}{2l}$

$$f = \sqrt{\frac{T}{\mu}} \times \frac{1}{2l} \quad \text{... (i)}$$

If $T$ decreases by 19% value of $T$ will be $T - 0.19$ T

Putting this value in (i)

$$f' = \sqrt{\frac{T}{\mu}} \frac{(1-0.19)^{1/2}}{2l}$$

$$f' = f\left(1 - \frac{1}{2} \times 0.19\right) \quad \text{[Binomial theorem]}$$

$$f' = f - 0.1\text{ f}$$

Hence, the frequency decreases by 0.1 f are 10% of initial value.

**(The Principle of Superposition of Waves)**

21. On the superposition of the two waves given as $y_1 = A_0 \sin(\omega t - kx)$ and $y_2 = A_0 \cos\left(\omega t - kx + \frac{\pi}{6}\right)$, the resultant amplitude of oscillations will be

(1) $\sqrt{3}A_0$ (2) $\frac{A_0}{2}$ (3) $A_0$ (4) $\frac{3}{2}A_0$

**Sol.** Answer (3)

Resultant amplitude is given by $A_r^2 = A_1^2 + A_2^2 + 2A_1A_2 \cos\phi$

$$y_1 = A_0 \sin(\omega t - kx)$$

$$y_2 = A_0 \cos\left(\omega t - kx + \frac{\pi}{6}\right)$$

or $$y_2 = A_0 \sin\left(\omega t - kx + \frac{\pi}{6} + \frac{\pi}{2}\right)$$

$$A_r^2 = A_0^2 + A_0^2 + 2A_0^2 \cos\frac{2\pi}{3}$$

$$A_r^2 = 2A_0^2 + 2A_0^2 \times \frac{-1}{2}$$

$\therefore$ $A_r = A_0$

22. Two waves of amplitudes $A_0$ and $xA_0$ pass through a region. If $x > 1$, the difference in the maximum and minimum resultant amplitude possible is

(1) $(x + 1)A_0$ (2) $(x - 1)A_0$ (3) $2xA_0$ (4) $2A_0$

**Sol.** Answer (4)

Amplitudes are $A_0$ and $xA_0$.

$\therefore$ Maximum amplitude where they are in phase are $A_0 + xA_0$.

Minimum amplitude $xA_0 - A_0$

Difference between the two = $2A_0$.

23. Which of the following represents a standing wave?

(1) $y = A \sin(\omega t - kx)$ (2) $y = Ae^{-bx} \sin(\omega t - kx + \alpha)$

(3) $y = A \sin kx \sin(\omega t - \theta)$ (4) $y = (ax + b) \sin(\omega t - kx)$

**Sol.** Answer (3)

In a standing wave, the amplitude is an oscillating function of $x$ in :

$y = A \sin kx \sin(\omega t + \theta)$

$A \sin kx$ represents the amplitude and is of the correct form to be a standing wave.

$$y = 3 \sin \frac{\pi x}{3} \cos 40 \pi t$$

24. The equation of standing wave in a stretched string is given by $y = 5\sin\left(\frac{\pi x}{3}\right)\cos(40\pi t)$, where $x$ and $y$ are in cm and $t$ in second. The separation between two consecutive nodes is (in cm)

(1) 1.5 (2) 3 (3) 6 (4) 4

**Sol.** Answer (2)

$$y = 5\sin\frac{\pi x}{3}\cos 40\pi t$$

At the nodes the values of $x$ is such that $y = 0$.

Taking position 1 at $x = 0$ to make sine function zero; the value of sine function will be zero node for $\frac{\pi x}{3} = \pi$.

$\therefore$ $x = 3$

Hence, shortest distance between two nodes is 3 cm.

25. In a stationary wave

(1) Strain is maximum at nodes

(2) Strain is minimum at nodes

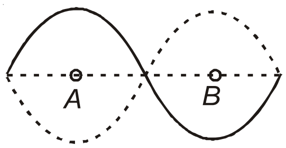
(3) Strain is maximum at antinodes

(4) Amplitude is zero at all points

**Sol.** Answer (1)

Where the slope of wave is higher the strain will be higher.

26. In the standing wave shown, particles at the positions *A* and *B* have a phase difference of




(1) 0 (2) $\frac{\pi}{2}$ (3) $\frac{5\pi}{6}$ (4) $\pi$

**Sol.** Answer (4)

Let, $y_A = A \sin \omega t$

$y_A = A \sin \omega t + \phi$

To convert $\sin\theta$ to $-\sin\theta$, $\phi$ must be $\pi$.

Hence phase difference between is $\pi$.

27. A 12 m long vibrating string has the speed of wave 48 m/s. To what frequency it will resonate?

(1) 2 cps (2) 4 cps (3) 6 cps (4) All of these

**Sol.** Answer (4)

$v = 48$ m/s, $l = 12$ m, $f = \frac{nv}{2l}$

$f = 2n$ (where $n = 1, 2, 3$ .....)

Hence answer is (4).

28. A certain string will resonant to several frequencies, the lowest of which is 200 cps. What are the next three higher frequencies to which it resonants?

(1) 400, 600, 800 (2) 300, 400, 500 (3) 100, 150, 200 (4) 200, 250, 300

**Sol.** Answer (1)

Resonant frequency occurs according to $\frac{nv}{2l}$ and when $n = 1$ frequency is minimum.

Hence $\frac{v}{2l} = 200$ $[n = 1]$

Other resonant frequencies will be simply multiples of fundamental frequency.

Hence (1) is the answer.

29. The length of a sonometer wire is 0.75 m and density $9 \times 10^3$ Kg/m$^3$. It can bear a stress of $8.1 \times 10^8$ N/m$^2$ without exceeding the elastic limit. The fundamental frequency that can be produced in the wire, is

(1) 200 Hz (2) 150 Hz (3) 600 Hz (4) 450 Hz

**Sol.** Answer (1)

$l = 0.75$ m $\rho = 9 \times 10^3$ Kg/m$^3$

Limiting stress $= 8.1 \times 10^8$ N/m$^2$

Let area be equal to *A*.

Tension ($T$) = Stress × Area

$= 8.1 \times 10^8 \times A$

Mass / length($\mu$) = $\rho A$

$$\text{Velocity } (v) = \sqrt{\frac{T}{\mu}} = \frac{8.1\times10^8\times A}{9\times10^3\times A}$$

$$= \sqrt{\frac{8.1\times10^5}{9}} = \sqrt{9\times10^4} = 3 \times 10^2 \text{ m/s}$$

$$\text{Maximum fundamental frequency} = \frac{v}{2l} = \frac{300}{2\times0.75} = 200 \text{ Hz}$$

30. An aluminium rod having a length 100 cm is clamped at its middle point and set into longitudinal vibrations. Let the rod vibrate in its fundamental mode. The density of aluminium is 2600 kg/m$^3$ and its Young's modulus is 7.8 × 10$^{10}$ N/m$^2$. The frequency of the sound produced is

(1) 1250 Hz (2) 2740 Hz (3) 2350 Hz (4) 1685 Hz

**Sol.** Answer (2)

$$v = \sqrt{\frac{y}{\rho}} = \sqrt{\frac{7.8\times10^{10}}{2600}} = 5480 \text{ ml}$$

Since rod is clamped at the middle, the middle point is a pressure antinode and free ends are nodes. In the fundamental mode there are no other nodes and antinodes. The length of the rod is therefore half the wavelength.

So, $\lambda = 2l = 2m$

$$\text{Frequency} = \frac{v}{\lambda} = \frac{5480}{2} = 2740 \text{ Hz}$$

31. The string of a violin has a frequency of 440 cps. If the violin string is shortened by one fifth, its frequency will be changed to

(1) 440 cps (2) 880 cps (3) 550 cps (4) 2200 cps

**Sol.** Answer (3)

$$\text{Fundamental frequency} = 440 \text{ cps} = \frac{v}{2l}$$

$$\text{If } l \text{ is made one fifth } \frac{v}{2\times\left(l-\frac{l}{5}\right)} \text{ or } \frac{5v}{8l} = 550 \text{ Hz}$$

32. A wire of length one metre under a certain initial tension emits a sound of fundamental frequency 256 Hz. When the tension is increased by 1 kg wt, the frequency of the fundamental node increases to 320 Hz. The initial tension is

(1) 3/4 kg wt (2) 4/3 kg wt

(3) 16/9 kg wt (4) 20/9 kg wt

**Sol.** Answer (3)

Let tension be $T$

$$f_1 = \sqrt{\frac{T}{\mu}}\times\frac{1}{2l} = 256 \qquad \text{... (i)}$$

$$f_2 = \sqrt{\frac{T+10}{\mu}} \times \frac{1}{2l} = 320 \quad \text{... (ii)}$$

$$\sqrt{\frac{T}{T+10}} = \frac{256}{320} \qquad \text{[Dividing (i) by (ii)]}$$

or $\frac{T}{T+10} = \frac{(16)^2}{(16)^2 \times (20)^2}$

or $\frac{T}{T+10} = \frac{16^2}{(20)^2}$

or $400\ T = 256\ T^2 + 2560$

or $144\ T = 2560$

or $T = \frac{2560}{144}$

or $T = \frac{2560}{16 \times 9}$

or $T = \frac{160}{9}$ Newton

$= \frac{16}{9}$ kg-wt

33. In case of closed pipe which harmonic the $p^{th}$ overtone will be

(1) $2p + 1$ (2) $2p - 1$ (3) $p + 1$ (4) $p - 1$

**Sol.** Answer (1)

In case of closed pipe the $p^{th}$ overtone will be $2p + 1$ harmonic.

34. The pitch of an organ pipe is highest when the pipe is filled with

(1) Air (2) Hydrogen (3) Oxygen (4) Carbon dioxide

**Sol.** Answer (2)

$v = f\lambda$

$= \lambda$ is constant for an organ pipe

$$v = \sqrt{\frac{\gamma RT}{M}}$$

$$v = \frac{1}{\sqrt{M}}$$

$v$ is maximum when $M$ is least. Thus, velocity of sound in air is maximum when $M$ is least.

Since $f \propto v$ so $f \propto \frac{1}{\sqrt{M}}$

Hence, frequency is maximum when M is least.

Hence, among options answer is $H_2$.

35. A cylindrical tube, open at both ends, has a fundamental frequency $f$ in air. The tube is dipped vertically in water so that half of it is in water. The fundamental frequency of the air column is now

(1) $\frac{f}{2}$ (2) $\frac{3f}{4}$ (3) $f$ (4) $2f$

**Sol.** Answer (3)

Fundamental frequency of open organ pipe is $f = \frac{v}{2l}$

If closed organ pipe $\frac{v}{4l}$

Initial length $l_1 = l$

$\therefore \quad f_1 = \frac{v}{2l}$

Final length of air column $l_2 = \frac{l}{2}$

$$f_2 = \frac{v}{4l/2} = \frac{v}{2l}$$

36. For a certain organ pipe, three successive resonance frequencies are observed at 425, 595, and 765, Hz respectively, Taking the speed of sound in air to be 340 m/s the fundamental frequency of the pipe (in Hz) is

(1) 425 (2) 170 (3) 85 (4) 245

**Sol.** Answer (3)

Frequencies are 425, 595, 765.

Among the options the HCF is here 85.

Since resonant frequencies are odd multiples of fundamental frequency.

The fundamental frequency is 85 Hz.

37. A closed pipe of length 10 cm has its fundamental frequency half that of the second overtone of an open pipe. The length of the open pipe

(1) 10 cm (2) 20 cm (3) 30 cm (4) 40 cm

**Sol.** Answer (3)

$l = 0.1$ m

Fundamental frequency of pipe $(f_1) = \frac{v}{4l}$ or $f_1 = \frac{v}{0.4}$

Frequency of $2^{nd}$ overtone of open pipe 2 :

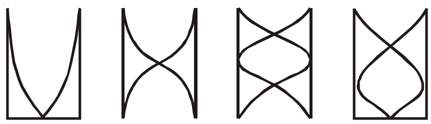
$$f_2 = \frac{3v}{2l}$$

$$2f_1 = f_2$$

$$2 \times \frac{v}{0.4} = \frac{3v}{2l}$$

$l = 0.3$ m

38. The vibrations of four air columns under identical conditions are represented in the figure below. The ratio of frequencies $n_p : n_q : n_r : n_s$ will be



p q r s

(1) 12 : 6 : 3 : 4 (2) 1 : 2 : 4 : 3 (3) 4 : 2 : 3 : 1 (4) 6 : 2 : 3 : 4

**Sol.** Answer (2)

*P*, *S*, will be 1st and 2nd harmonics of closed tube.

$$P = \frac{v}{4l},\ S = \frac{v}{4l}$$

*Q*, *R* are the 1st and 2nd harmonics of open pipe.

$$Q = \frac{v}{2l},\ R = \frac{v}{l}$$

$\therefore\quad P : Q : R : S = 1 : 2 : 4 : 3$

39. In resonance tube two successive positions of resonance are obtained at 15 cm and 48 cm. If the frequency of the fork is 500 cps, the velocity of sound is

(1) 330 m/s (2) 300 m/s (3) 1000 m/s (4) 360 m/s

**Sol.** Answer (1)

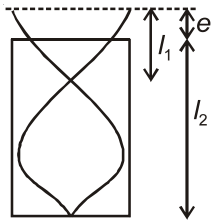
$$l_1 + e = \frac{\lambda}{4}$$

$$l_2 + e = \frac{3\lambda}{4}$$

$$l_2 - l_1 = \frac{\lambda}{2}$$

$$0.48 - 0.15 = \frac{\lambda}{2}$$

$$0\ \lambda = 0.66$$




Velocity = $f\lambda = 500 \times 0.66 = 330$ m/s

**(Reflection of Waves)**

40. Select the correct statement about the reflection and refraction of a wave at the interface between the medium 1 and 2 the

(1) Reflected wave has a phase change of $\pi$

(2) Wavelength of reflected wave is less than that of incident wave

(3) Frequency of transmitted wave is same as that of incident wave

(4) Frequency of wave changes as per nature of boundary

**Sol.** Answer (3)

It is not said which of waves 1 and 2 is denser. But frequency of a wave remains same in all media. Hence option (3) is correct.

**(Beats)**

41. During superposition of two waves of nearly equal frequencies, beats frequency is defined as the

(1) Sum of frequencies of interfering waves

(2) Number of times the resultant intensity becomes maximum or minimum in one second

(3) Average of frequencies of interfering waves

(4) Number of times the resultant amplitude becomes maximum or minimum in one second

**Sol.** Answer (2)

Beats is the difference in the frequencies of two superimposing waves. Beats are noticed when the resultant wave acquire its higher amplitudes, due to both waves, sounding higher than the regular sound.

The beats would occur $f_1 - f_2 = \Delta f$ times per second. Hence answer is (2).

42. A tuning fork of unknown frequency produces 4 beats per second when sounded with another tuning fork of frequency 254 Hz. It gives the same number of beats per second when unknown tuning fork loaded with wax. The unknown frequency before loading with wax is

(1) 258 (2) 254 (3) 250 (4) Can't be determined

**Sol.** Answer (1)

Since there are 4 beats. We know that the unknown frequency ($f$).

$f = 254 + 4$

Since in the second case after loading with wax frequency of 2$^{nd}$ fork must have reduced.

Initial frequency must be

$f = 254 + 4 = 258$ Hz

43. Ten tuning forks are arranged in increasing order of frequency in such a way that any two consecutive tuning forks produce 4 beats per second. The highest frequency is twice that of the lowest. Possible highest and lowest frequencies (in Hz) are

(1) 80 and 40 (2) 100 and 50 (3) 44 and 22 (4) 72 and 36

**Sol.** Answer (4)

Let frequencies be $f_1$, $f_2$ ... $f_{10}$.

So, $f_{10} = f_1 + 9 \times$ (number of beats)

$f_{10} = f_1 + 36$

Hence, answer must be (4).

44. The displacement at a point due to two waves are $y_1 = 4\sin(500\pi t)$ and $y_2 = 2\sin(506\pi t)$. The result due to their superposition will be

(1) 3 beats per second with intensity relation between maxima and minima equal to 2

(2) 3 beats per second with intensity relation between maxima and minima equal to 9

(3) 6 beats per second with intensity relation between maxima and minima equal to 2

(4) 6 beats per second with intensity relation between maxima and minima equal to 9

**Sol.** Answer (2)

$y_1 = 4\sin 500\pi t$

$y_2 = 2\sin 506\pi t$

Frequency of $y_1(f_1) = \frac{\omega}{2\pi} = \frac{500\pi}{2\pi}$ = 250 Hz

Frequency of $y_2(f_2) = \frac{\omega}{2\pi} = \frac{506\pi}{2\pi}$ = 253 Hz

Intensity relation $\frac{A_{max}}{A_{min}} = \frac{(A_1 + A_2)^2}{(A_1 - A_2)^2}$

$= \frac{36}{4} = 9$

45. A tuning fork vibrating with a sonometer having a wire of length 20 cm produces 5 beats per second. The beats frequency does not change if the length of the wire is changed to 21 cm. The frequency of the tuning fork must be

(1) 200 Hz (2) 210 Hz (3) 205 Hz (4) 215 Hz

**Sol.** Answer (3)

Let frequency of tuning fork be $f$.

From question we know the frequencies of sonometer wire $\left(\frac{v}{2l}\right)$ are

$\frac{v}{2\times 0.2}$ and $\frac{v}{2\times 0.21}$

Now $\frac{v}{0.4} - f = 8$ ... (i)

$f - \frac{v}{0.42} = 5$ ... (ii)

Solving (i) and (ii), answer is (3)

46. A tuning fork and an air column whose temperature is 51°C produce 4 beats in one second, when sounded together. When the temperature of air column decreases the number of beats per second decreases. When the temperature remains 16°C only one beat per second is produced. The frequency of the tuning fork is

(1) 100 Hz (2) 75 Hz (3) 150 Hz (4) 50 Hz

**Sol.** Answer (4)

$$\frac{F+4}{F+1} = \sqrt{\frac{273+51}{273+16}}$$

$$\frac{f+4}{f+1} = \sqrt{\frac{324}{289}}$$

$$\frac{f+4}{f+1} = \frac{18}{17}$$

$f = 50$ Hz

**(Doppler Effect)**

47. A man standing on a platform observes that the frequency of the sound of a whistle emitted by a train drops by 140 Hz. If the velocity of sound in air is 330 m/s and the speed of the train is 70 m/s, the frequency of the whistle is

(1) 571 Hz (2) 800 Hz (3) 400 Hz (4) 260 Hz

**Sol.** Answer (2)

Velocity of sound in air = 330 m/s.

Speed of train = 70 m/s

Let initial frequency be $f_0$.

$$f = f_0 \times \frac{v}{v+v_s}$$

$$f_0 - f = 140$$

$$f_0\left(1-\frac{330}{400}\right)=140$$

$$f_0 = 800 \text{ Hz}$$

48. A sound source is moving towards a stationary observer with (1/10) of the speed of sound. The ratio of apparent to real frequency is

(1) $\frac{10}{9}$ (2) $\frac{11}{10}$ (3) $\left(\frac{11}{10}\right)^2$ (4) $\left(\frac{9}{10}\right)^2$

**Sol.** Answer (1)

$$f = f_0 \frac{v}{v-v_s}$$

$$f = f_0 \frac{v}{v-v/10}$$

$$f = \frac{10f_0}{9}$$

$$\therefore \quad f : f_0 = \frac{10}{9}$$

49. A train moves towards a stationary observer with a speed 34 m/s. 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 m/s, the frequency registered is $f_2$.

If the speed of sound is 340 m/s then the ratio $\frac{f_1}{f_2}$ is

(1) $\frac{18}{19}$ (2) $\frac{1}{2}$ (3) 2 (4) $\frac{19}{18}$

**Sol.** Answer (4)

$$f = f_0 \frac{v}{v - v_s}$$

$$f_1 = f_0 \frac{340}{340 - 34}$$

$$f_2 = f_0 \frac{340}{340 - 17}$$

$$f_1 = \frac{10}{9} f_0$$

$$f_2 = \frac{20}{19}$$

$$\frac{f}{f_2} = \frac{19}{18}$$

50. An observer is approaching with a speed $v$, towards a stationary source emitting sound waves of wavelength $\lambda_0$. The wavelength shift detected by the observer is (Take $c$ = speed of sound)

(1) $\frac{\lambda_0 v}{c}$ (2) $\frac{\lambda_0 c}{v}$ (3) $\frac{\lambda_0 v^2}{c^2}$ (4) Zero

**Sol.** Answer (4)

In Doppler effect only change in frequency is observed and not change in wavelength if observer approaches the source.

## SECTION - B

**Objective Type Questions**

**(Transverse and Longitudinal Waves)**

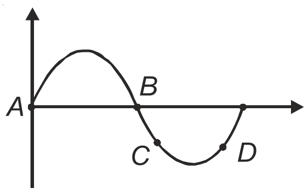
1. The longitudinal wave can be observed in

(1) Elastic media (2) Inelastic media (3) Both (1) & (2) (4) None of these

**Sol.** Answer (1)

Longitudinal waves travel due to compressions and rarefactions. If medium is inelastic it does not allow constituent compressions and rarefactions.

2. A transverse pulse is shown in the figure, on which 4 points are shown at any instant. Which of the following points are in a state to move upwards in subsequent time?




(1) $A$, $B$ (2) $A$, $D$ (3) $B$, $C$ (4) $B$, $D$

**Sol.** Answer (3)

$$y = A_0 \sin(\omega t - kx)$$

$$\frac{dy}{dt} = V_P = A_0\omega \cos(\omega t - kx)$$

Values for $V_P$ at $B$ and $C$ are positive force they are in a state to move upwards.

3. A rope of length $L$ and mass $M$ hangs freely from the ceiling. If the time taken by a transverse wave to travel from the bottom to the top of the rope is $T$, then time to cover first half length is

(1) $T$ (2) $T\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$ (3) $\frac{T}{\sqrt{2}}$ (4) $\frac{T}{2}$

**Sol.** Answer (3)

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

The tension $N$ in the string varies as :

$N = \pi\frac{Mg}{L}\times x$ where $x$ is length from the ground.

$$dt = \frac{dx}{v_x} \text{ and } v_x = \sqrt{\frac{Mgx}{L\times M/L}} = \sqrt{gx}$$

$$\int_0^T dt = \int_0^L \frac{dx}{\sqrt{gx}}$$

$$T = \int_0^L 2\sqrt{x}\,dx$$

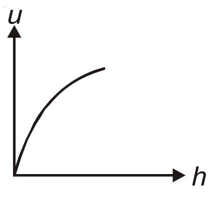
$$T = \int_0^L 2\sqrt{L_g} \quad \text{... (i)}$$

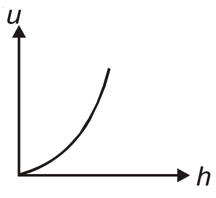
If time to cover half length is $T_2$.

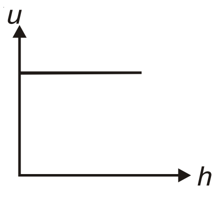
$T_2 = \sqrt{2Lg}$ [By putting limits 0 to $L/2$ in equation (i)]

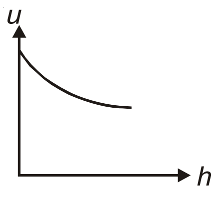
$$\frac{T}{\sqrt{2}} = T_2$$

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

(1)



(2)



(3)



(4)


**Sol.** Answer (1)

Velocity of wave at a distance $h$ from lower end is

$$v = \sqrt{gh}$$

or $v^2 = gh$

This is of the form of a parabola ($y = kx^2$).

Hence answer is (1)

5. A transverse pulse generated at the bottom of a uniform rope of length $L$, travels in upward direction. The time taken by it to travel the full length of rope will be

(1) $\sqrt{\dfrac{L}{2g}}$ (2) $\sqrt{\dfrac{2L}{g}}$ (3) $\sqrt{\dfrac{L}{g}}$ (4) $\sqrt{\dfrac{4L}{g}}$

**Sol.** Answer (4)

Velocity of wave at a distance $x$ from lower end is

$$v_x = \sqrt{2gx}$$

$$\text{Time } dt = \frac{dx}{\sqrt{2gx}}$$

Integrating for 0 to $L$ we get

$$\sqrt{\frac{4l}{g}}$$

6. In a sinusoidal wave, the time required for a particular point to move from maximum displacement to zero displacement is 0.170 s. The frequency of wave is

(1) 0.73 Hz (2) 0.36 Hz (3) 1.47 Hz (4) 2.94 Hz

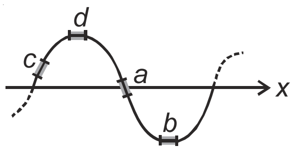
**Sol.** Answer (3)

Time period from maximum displacement $T_0$ zero displacement is $\dfrac{T}{4} = 0.170$ s

$\therefore$ Total time = 4 × 0.17 = 0.688

Frequency = $\dfrac{1}{T}$ = 1.47 Hz

7. Figure shows a snapshot for a travelling sine wave along a string. Four elemental portions $a$, $b$, $c$ and $d$ are indicated on the string. The elemental portion which has maximum potential energy is/are




(1) $a$ (2) $b$ (3) $c$ (4) $b$ and $d$

**Sol.** Answer (1)

Maximum potential energy is stored where kinetic energy, *i.e.*, velocity is zero as the total energy of an element of a wave is constant in its oscillating direction. All the energy is stored as potential energy of the wire at points *b* and *d*.

**(Displacement Relation for a Progressive Wave)**

8. Which one of the following represents a wave?

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

(2) $y = A \cos^2(at - bx + c) + A \sin^2(at - bx + c)$

(3) $y = A \sin kx$

(4) $y = A \sin \omega t$

**Sol.** Answer (1)

$\frac{d^2y}{dx^2} = -\frac{1}{v^2}\frac{d^2y}{dt^2}$ is satisfied only by functions of the form $f(kx - \omega t)$

The only equation in the option which satisfies the above equation.

9. Which of the following functions for $y$ can never represent a travelling wave?

(a) $(x^2 - vt)^2$ (b) $\log\left[\frac{(x+vt)}{x_0}\right]$ (c) $e^{\left\{-\frac{(x+vt)}{x_0}\right\}^2}$ (d) $\frac{1}{x+vt}$

(1) Only (a) (2) (b) & (c) (3) (c) & (d) (4) Only (c)

**Sol.** Answer (1)

The only function in the given function which is not of the form $f(kx - \omega t)$ is the first one (a)

Hence option (1) is correct.

10. A sinusoidal wave of frequency 500 Hz has a speed of 350 m/s. The phase difference between two displacements at a certain point at times 1 m apart is

(1) $\frac{\pi}{4}$ (2) $\frac{\pi}{2}$ (3) $\pi$ (4) $\frac{3\pi}{2}$

**Sol.** Answer (3)

$v = 350$ m/s $f = 500$ Hz

$$v = \frac{\omega}{k}$$

$$k = \frac{2\pi f}{v}$$

$$k = \frac{2\pi \times 500}{350}$$

$$k = \frac{2\pi}{0.7}$$

$\therefore \lambda = 0.7$ m

Let equation of wave be

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

Let $x_1 = 0$ $\qquad x_2 = 1$ m

$y_1 = A \sin (\omega t)$

$y_2 = A \sin \left(\frac{2\pi}{0.7} \times 1 + \omega t\right)$

Hence phase difference = $\frac{20\pi}{7}$ or approximately

Phase difference $\approx 3\pi$

Which is same as $\Delta\phi = \pi$

11. The equation of travelling wave is $y = a\sin 2\pi\left(pt - \frac{x}{5}\right)$. Then the ratio of maximum particle velocity to wave velocity is

(1) $\frac{\pi a}{5}$ (2) $2\sqrt{5\pi a}$ (3) $\frac{2\pi a}{5}$ (4) $\frac{2\pi a}{\sqrt{5}}$

**Sol.** Answer (3)

Equation of travelling wave

$y = a \sin 2\pi\left(pt - \frac{x}{5}\right)$

Maximum particle velocity ($v_y$) = $A\omega$ or $v_y = a \times 2\pi p$

Wave velocity ($v$) = $\frac{\omega}{k} = \frac{2\pi p}{2\pi / 5} = 5p$

$\therefore \quad \frac{v_y}{v} = \frac{2\pi a}{5}$

12. A travelling wave pulse is given by $y = \frac{4}{3x^2 + 48t^2 + 24xt + 2}$ where $x$ and $y$ are in metre and $t$ is in second. The velocity of wave is

(1) 4 m/s (2) 2 m/s (3) 8 m/s (4) 12 m/s

**Sol.** Answer (1)

$y = \frac{4}{3x^2 + 48t^2 + 24xt + 2}$

We need to convert it into the form of $f(kx - \omega t)$

$y = \frac{4}{3(x^2 + 16t^2 + 8x) + 2}$

$y = \frac{4}{3(x + 4t)^2 + 2}$

$v = \frac{\omega}{k}$

Hence $v = \frac{4}{1}$ = 4 m/s

13. The ratio of maximum particle velocity to wave velocity is [where symbols have their usual meanings]

(1) $kA$ (2) $A\omega$ (3) $k\omega$ (4) $\frac{\omega}{k}$

**Sol.** Answer (1)

Maximum particle velocity ($v_y$) = $A\omega$

Wave velocity (v) = $\frac{\omega}{k}$

$\therefore \quad \frac{v_y}{v} = A_k$

14. What is the phase difference between the displacement wave and pressure wave in sound wave?

(1) Zero (2) $\frac{\pi}{2}$ (3) $\pi$ (4) $\frac{\pi}{4}$

**Sol.** Answer (2)

Phase difference between the pressure and displacement wave will always be $\frac{\pi}{2}$.

15. The ratio of intensities between two coherent sound sources is 4 : 1. The difference of loudness in dB between maximum and minimum intensities when they interfere in the space is

(1) $20 \log_{10}(3)$ (2) $10 \log_{10}(2)$

(3) $20 \log_{10}(2)$ (4) $10 \log_{10}(3)$

**Sol.** Answer (1)

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

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

$$= 9:1$$

$$SL_2 - SL_1 = 10 \log_{10}\frac{I_{max}}{I_{min}} = 20 \log_{10} 3$$

16. The intensity of sound reduces by 20% on passing through a glass slab. If sound of intensity $I$ is made to cross through two such slabs, then the intensity of emergent sound will be

(1) 0.36 $I$ (2) 0.64 $I$ (3) 0.4 $I$ (4) 0.8 $I$

**Sol.** Answer (2)

Let intensity of sound initially be = $I_0$

After passing through glass slab intensity is = $\frac{80}{100} I_0 = 0.8 I_0$

After passing through 2nd slab it further reduces by 20% and only 80% is left.

Hence final intensity = $\frac{80}{100} \times 0.8 I_0 = 0.64 I_0$

17. Two periodic waves of intensities $I_1$ and $I_2$ pass through a region at the same time in the same direction. The sum of the maximum and minimum intensities is

(1) $2(I_1 + I_2)$ (2) $I_1 + I_2$ (3) $(\sqrt{I_1}+\sqrt{I_2})^2$ (4) $(\sqrt{I_1}-\sqrt{I_2})^2$

**Sol.** Answer (1)

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

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

$$I_{max} + I_{min} = 2(I_1 + I_2)$$

**(The Principle of Superposition of Waves)**

18. A stationary wave is represented by $y = A \sin (100t) \cos (0.01x)$, where $y$ and $A$ are in millimetres, $t$ is in second and $x$ is in metre. The velocity of the constituent wave is

(1) $10^4$ m/s (2) Not derivable (3) 1 m/s (4) $10^2$ m/s

**Sol.** Answer (1)

$$y = A \sin 100t \cos 0.01x$$

$$\omega = 100 \qquad k = 0.01$$

$$v = \frac{\omega}{k}$$

or $v = 10^4$ m/s

19. The length of a sonometer wire $AB$ is 110 cm. Where should the two bridges be placed from $A$ to divide the wire in 3 segments whose fundamental frequencies are in the ratio of 1 : 2 : 3?

(1) 60 cm and 90 cm (2) 30 cm and 60 cm (3) 30 cm and 90 cm (4) 40 cm and 80 cm

**Sol.** Answer (1)

$$L_{AB} = 110 \text{ cm}$$

Fundamental frequencies = $\frac{v}{2l_1} : \frac{v}{2l_2} : \frac{v}{2l_3}$ are given as 1 : 2 : 3

Hence, $l_2 = \frac{l_1}{2}$ and $l_3 = \frac{l_1}{3}$

Also $l_1 + l_2 + l_3 = 110$

$$l_1 + \frac{l}{2} + \frac{l_1}{3} = 110$$

$$6l_1 + 3l_1 + 2l_1 = 660$$

$$l_1 = \frac{660}{11}$$

$\therefore$ $l_1 = 60$ cm

$\therefore$ $l_2 = 30$ cm

$\therefore$ $l_3 = 20$ cm

Hence answer is (1)

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

(1) 5 Hz (2) 10 Hz (3) 2 Hz (4) 4 Hz

**Sol.** Answer (1)

The question refers to the 5th harmonic of a vibrating wave.

Frequency of 5th harmonic is = $\frac{nv}{2l} = \frac{5\times20}{2\times10} = 5$ Hz

21. If the tension and diameter of a sonometer wire of fundamental frequency $n$ is doubled and density is halved then its fundamental frequency will become

(1) $\frac{n}{4}$ (2) $\sqrt{2n}$ (3) $n$ (4) $\frac{n}{\sqrt{2}}$

**Sol.** Answer (3)

Fundamental frequency ($n$) = $\frac{v}{2l}$

or $n = \sqrt{\frac{T}{\mu}}\times\frac{1}{2l}$ ... (i)

Tension becomes $2T$ ... (ii)

$v' = A\rho$ per metre

or $v' = \pi r^2\rho$

Now, $\mu' = \pi(2r)^2\frac{\rho}{2}$

or $\mu' = 2\pi r^2\rho$

or $\mu' = 2\mu$ ... (iii)

Putting (ii) and (iii) in equation (i),

$n' = n$

22. Two waves have equations $x_1 = a\sin(\omega t + \phi_1)$ and $x_2 = a\sin(\omega t + \phi_2)$. If in the resultant wave the frequency and amplitude remain equal to amplitude of superimposing waves, the phase difference between them is

(1) $\frac{\pi}{6}$ (2) $\frac{2\pi}{3}$ (3) $\frac{\pi}{4}$ (4) $\frac{\pi}{3}$

**Sol.** Answer (2)

$x_1 = a\sin(\omega t + \phi_1)$

$x_2 = a\sin(\omega t + \phi_2)$

$x' = x_1 + x_2$

$= a[\sin(\omega t + \phi_1) + \sin(\omega t + \phi_2)]$

$= 2a\sin\left(\omega t + \frac{\phi_1+\phi_2}{2}\right)\cos\left(\frac{\phi_1-\phi_2}{2}\right)$

Now as given in question

$$2a\cos\frac{\phi_1-\phi_2}{2}=a$$

$$\cos\left(\frac{\phi_1-\phi_2}{2}\right)=\frac{1}{2}$$

$$\frac{\phi_1-\phi_2}{2}=\frac{\pi}{3}$$

$$\phi_1-\phi_2=\frac{2\pi}{3}$$

23. The standing wave in a medium is expressed as $y = 0.2 \sin (0.8x) \cos (3000t)$ m. The distance between any two consecutive points of minimum or maximum displacement is

(1) $\frac{\pi}{2}$m (2) $\frac{\pi}{4}$m (3) $\frac{\pi}{6}$m (4) None of these

**Sol.** Answer (4)

$y = 0.2 \sin 0.8x \cos 3000t$

The distance between any two points of minimum or maximum displacement is simply wavelength $\left(\frac{\lambda}{4}\right)$ of the wave.

$$k = \frac{2\pi}{\lambda} = 0.8$$

or $\lambda = \dfrac{2\pi}{0.8}$

$\therefore\ \lambda = \dfrac{5\pi}{2}\text{m} \Rightarrow \dfrac{\lambda}{4}=\dfrac{5\pi}{8}\text{m}$

Hence answer must be (4).

24. The equation of a standing wave in a string fixed at both ends is given as $y = 2A \sin kx \cos \omega t$

The amplitude and frequency of a particle vibrating at the mid of an antinode and a node are respectively

(1) $A,\frac{\omega}{2\pi}$ (2) $\frac{A}{\sqrt{2}},\frac{\omega}{2\pi}$ (3) $A,\frac{\omega}{\pi}$ (4) $\sqrt{2}A,\frac{\omega}{2\pi}$

**Sol.** Answer (4)

$y = 2A \sin kx \,.\, \cos \omega t$

In a standing waves the function of amplitude ($A_y$) is given by

$A_y = 2A \sin kx$

At mid-point of node and antinode $x = \dfrac{\lambda}{8}$

$$A_y = 2A\sin\frac{2\pi}{\lambda}\times\frac{\lambda}{8}\quad\left[k=\frac{2\pi}{\lambda}\right]$$

or $A_y = \frac{2A}{\sqrt{2}}$

$\therefore$ $A_y = \sqrt{2}A$

Frequency is same at all points = $\frac{\omega}{2\pi}$

25. Two sinusoidal waves given below are superposed

$y_1 = A\sin(kx - \omega t + \frac{\pi}{6})$ , $y_2 = A\sin(kx - \omega t - \frac{\pi}{6})$

The equation of resultant wave is

(1) $y = \frac{A}{\sqrt{3}}\sin(kx - \omega t)$
(2) $y = A\sqrt{3}\sin(kx - \omega t)$
(3) $y = A\sqrt{3}\sin(kx - \omega t - \frac{\pi}{3})$
(4) $y = \frac{A}{\sqrt{3}}\sin(kx - \omega t - \frac{\pi}{3})$

**Sol.** Answer (2)

$y' = y_1 + y_2$

or $y' = A\sin(kx - \omega t + \frac{\pi}{6}) + A\sin(kx - \omega t - \frac{\pi}{6})$

or $y' = 2A\sin(kx - \omega t) \cdot \cos\left(\frac{\left(\frac{\pi}{6}+\frac{\pi}{6}\right)}{2}\right)$

or $y' = 2A\frac{\sqrt{3}}{2}\sin(kx - \omega t)$

$\therefore$ $y' = A\sqrt{3}\sin(kx - \omega t)$

26. For a particular resonance tube, following are four of the six harmonics below 1000 Hz;

300, 600, 750 and 900 Hz

The two missing harmonics are

(1) 75, 150
(2) 150, 450
(3) 400, 800
(4) 250, 400

**Sol.** Answer (2)

The 6$^{th}$ harmonic ($f_6$) = $\frac{6v}{2l} = 900$

or $\frac{v}{2l} = 150$

Hence fundamental frequency of string $\frac{v}{2l}$ or 150 Hz is missing.

3$^{rd}$ multiple of 150 which is 450 is also missing.

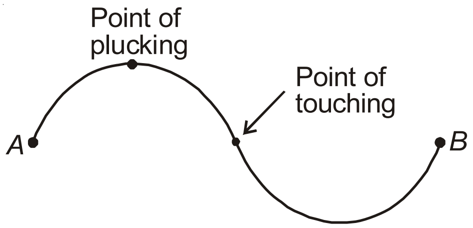
Hence required frequencies are 150, 450.

27. A second harmonic has to be generated in a string of length $l$ stretched between two rigid supports. The points where the string has to be plucked and touched are respectively

(1) $\frac{l}{4}, \frac{l}{2}$ (2) $\frac{l}{4}, \frac{3l}{4}$ (3) $\frac{l}{2}, \frac{l}{2}$ (4) $\frac{l}{2}, \frac{3l}{4}$

**Sol.** Answer (1)

In the $2^{nd}$ harmonic the shape of wave looks like.




The point of touching forms a node point of plucking forms an antinode. Hence, for $2^{nd}$ harmonic, we need to need wire touched at $\frac{l}{2}$ and pluck it at $\frac{l}{4}$.

28. In a standing wave, all particles of the medium cross the mean position with

(1) Different speeds at different instants (2) Different speeds at same instant

(3) Same speed at different instants (4) Same speed at same instant

**Sol.** Answer (2)

In a standing waves all particles of same wave have same $v$ and hence vibrate in phase passing the mean point at same time. The amplitude of the waves is different at different points hence the speed is different.

29. Two waves are represented by

$y_1 = 5 \sin 2\pi(75t - 0.25x)$

$y_2 = 10 \sin 2\pi(150t - 0.50x)$

The intensity ratio $\frac{I_1}{I_2}$ of the two waves is

(1) 1 : 2 (2) 1 : 4 (3) 1 : 8 (4) 1 : 16

**Sol.** Answer (4)

$A_1 = 5,$ $A_2 = 10$

$$\frac{I_1}{I_2} = \frac{kA_1^2}{kA_2^2} = \left(\frac{5}{10}\right)^2 = 1 : 4$$

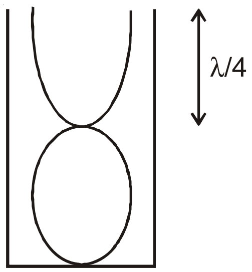
30. In a closed organ pipe of length 105 cm, standing waves are set up corresponding to third overtone. What distance from the closed end, a pressure node is formed?

(1) 5 cm (2) 15 cm (3) 25 cm (4) 30 cm

**Sol.** Answer (2)

In a closed pipe $f = \frac{(2P+1)}{4l}v$

For third overtone $(f) = \frac{7v}{4l}$




$$\lambda = \frac{v}{f} = \frac{v}{7v} \times 4l$$

$$\lambda = \frac{4l}{7}$$

$$\lambda = \frac{4 \times 105}{7}$$

$$\lambda = 60 \text{ cm}$$

First pressure node will be formed $\frac{\lambda}{4}$

31. A uniform string resonates with a tuning fork, at a maximum tension of 32 N. If it is divided into two segments by placing a wedge at a distance one-fourth of length from one end, then to resonance with same frequency the maximum value of tension for string will be

(1) 2 N (2) 4 N (3) 8 N (4) 16 N

**Sol.** Answer (1)

Let length be $l$.

$$f = \sqrt{\frac{T}{\mu}} \times \frac{1}{2l} \text{ ... (i)} \qquad f = \sqrt{\frac{T}{\mu}} \times \frac{4}{2l} \text{ ... (ii)} \qquad \text{or } f = \sqrt{\frac{T}{\mu}} \times \frac{4}{6l} \text{ ... (iii)}$$

Equating (i) & (ii) and (i) & (iii)

$$\sqrt{\frac{T}{T_1}} = 4 \quad \& \quad \sqrt{\frac{T}{T_2}} = \frac{4}{3}$$

Put $T$ = 32 N

$$\frac{32}{16} = T_1 \qquad \frac{9}{16} \times 32 = T_2$$

$$T_1 = 2 \text{ N} \qquad T_2 = 18 \text{ N}$$

of the options on $T_1$ is right.

32. If in a stationary wave the amplitude corresponding to antinode is 4 cm, then the amplitude corresponding to a particle of medium located exactly midway between a node and an antinode is

(1) 2 cm (2) $2\sqrt{2}$ cm (3) $\sqrt{2}$ cm (4) 1.5 cm

**Sol.** Answer (2)

$$y = A_0 \sin (kx) \cos \omega t$$

Mid way between a node and antinode is $\frac{\lambda}{8}$ from origin.

Function for amplitude is $A = A_0 \sin (kx)$

$$A = 4 \sin \left(\frac{2\pi}{\lambda} \times \frac{\lambda}{8}\right)$$

$$A = 2\sqrt{2} \text{ cm}$$

33. A uniform string of fundamental frequency of vibration $f$ is divided into two segments by means of a bridge. If $f_1$ and $f_2$ are fundamental frequencies of these segments then

(1) $f_1 f_2 = f[f_1 + f_2]$ (2) $2f = f_1 + f_2$ (3) $\sqrt{f} = \sqrt{f_1} + \sqrt{f_2}$ (4) $\sqrt{f_1 f_2} = 2f$

**Sol.** Answer (1)

$$l = l_1 + l_2$$

$$f_1 = \frac{v}{2l_1}$$

or $l_1 = \frac{v}{2f_1}$

Similarly,

$$l_2 = \frac{v}{2f_2} \qquad l = \frac{v}{2f}$$

$$\frac{v}{2f} = \frac{v}{2f_1} + \frac{v}{2f_2}$$

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$f = \frac{f_1 f_2}{f_1 + f_2}$$

$$f[f_1 + f_2] = f_1 f_2$$

34. Two sound waves of intensity 2 W/m$^2$ and 3 W/m$^2$ meet at a point to produce a resultant intensity 5 W/m$^2$. The phase difference between two waves is

(1) $\pi$ (2) $\frac{\pi}{4}$ (3) $\frac{\pi}{2}$ (4) Zero

**Sol.** Answer (3)

$$I = I_1 + I_2 + 2\sqrt{T_1}\sqrt{T_2} \cos \phi$$

$$5 = 3 + 2 + 2\sqrt{6} \cos \phi$$

$\therefore$ $\cos \phi = 0$

or $\phi = \frac{\pi}{2}$

**(Beats)**

35. The two waves of the same frequency moving in the same direction give rise to

(1) Beats (2) Interference (3) Stationary waves (4) None of these

**Sol.** Answer (2)

The two waves of same frequency moving in the same direction give rise to interference.

36. The string of a violin emits a note of 205 Hz at its correct tension. The string is tightened slightly and then it produces six beats in two second**s** with a tuning fork of frequency 205 Hz. The frequency of the note emitted by the taut string is

(1) 211 Hz (2) 199 Hz (3) 208 Hz (4) 202 Hz

**Sol.** Answer (3)

Initial frequency = 205 Hz

String tightned so frequency is increased = 205 + $f$

Final frequency of string – frequency of tuning fork = 3 beats

$205 + f - 205 = 3$

$\therefore \quad f = 3$

$\therefore$ Final frequency = 205 + 3 = 208 Hz

37. When two tuning forks (fork 1 and fork 2) are sounded together, 4 beats per second are heard. Now some tape is attached on the prong of the fork 2. When the tuning forks are sounded again, 6 beats per second are heard. If the frequency of fork 1 is 200 Hz, then what was the original frequency of fork 2?

(1) 204 Hz (2) 196 Hz (3) 202 Hz (4) 200 Hz

**Sol.** Answer (2)

Frequency of fork 1 = 200 Hz

Frequency of fork 2 = 200 ± 4

When tape is added frequency of fork 2 decreases.

When frequency of fork 2 decreases number of beats increases.

Hence we know frequency of fork 2 is

$f_2 = 200 - 4 = 196$ Hz

**(Doppler Effect)**

38. The driver of a car travelling with speed 30 m/s towards a hill sounds a horn of frequency 600 Hz. If the velocity of sound in air is 330 m/s, the frequency of reflected sound as heard by driver is

(1) 500 Hz (2) 550 Hz (3) 555.5 Hz (4) 720 Hz

**Sol.** Answer (4)

Velocity of sound = 330 m/s

Frequency of incident sound on wall ($f_1$) = $\dfrac{v}{v - v_s} \times f$

Frequency of sound observed by driver $(f_2) = \dfrac{v + v_s}{v} \times f_1$

or $f_2 = \dfrac{v + v_s}{v - v_s} \times 600$

or $f_2 = \dfrac{360}{300} \times 600$

or $f_2$ = 720 Hz

39. A train moving at a speed of 220 ms$^{-1}$ towards a stationary object, emits a sound of frequency 1000 Hz. Some of the sound reaching the object gets reflected back to the train as echo. The frequency of the echo as detected by the driver of the train is (Speed of sound in air is 330 ms$^{-1}$)

(1) 3500 Hz (2) 4000 Hz (3) 5000 Hz (4) 3000 Hz

**Sol.** Answer (3)

$v$ = 220 ms$^{-1}$

$f$ = 1000 Hz

Frequency of echo = $\dfrac{300+220}{330-220} \times f$

$f_e = \dfrac{550}{110} \times f$

or $f_e = 5\ f$

or $f_e$ = 5000 Hz

40. A source of frequency ν gives 5 beats/second when sounded with a source of frequency 200 Hz. The second harmonic of frequency 2ν of source gives 10 beats/second when sounded with a source of frequency 420 Hz. The value of ν is

(1) 205 Hz (2) 195 Hz (3) 200 Hz (4) 210 Hz

**Sol.** Answer (1)

$\nu = 200 \pm 5$ ... (i)

$2\nu = 420 \pm 10$

$\nu = 210 \pm 5$ ... (ii)

Common value for (i) & (ii) is 205 Hz.

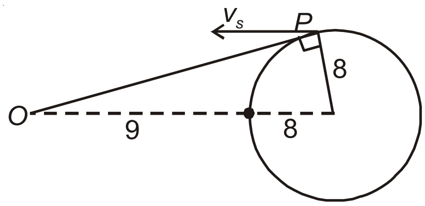
Hence ν = 205 Hz

41. A vibrating tuning fork is moving slowly and uniformly in a horizontal circular path of radius 8 m. The shortest distance of an observer in same plane from the tuning fork is 9 m. The distance between the tuning fork and observer at the instant when apparent frequency becomes maximum is

(1) 9 m (2) 25 m (3) 15 m (4) $\sqrt{353}$ m

**Sol.** Answer (3)

The apparent frequency is maximum when relative velocity of approach of tuning fork with respect to observer is maximum.




$OP = \sqrt{17^2 - 8^2}$ = 15 m

42. The frequency changes by 10% as a sound source approaches a stationary observer with constant speed $v_s$. What would be percentage change in the frequency as the source recedes the observer with same speed ($v_s < v$)?

(1) 10.5% (2) 8.5% (3) 4.5% (4) 1.5%

**Sol.** Answer (2)

$$f' = \frac{v}{v - v_s} f_0$$

$f$ is such that $f = \frac{110}{100} f_0$

When $\frac{v}{v - v_s} = \frac{110}{100}$

$100\ v = 110\ v - 110\ v_s$

$v = 11\ v_s$

When source is received

$$\frac{v}{v + v_s} f_0 = \frac{x}{100} f_0$$

Putting $v = 11\ v_s$

$$\frac{11}{12} \times 100 = x$$

$x = 91.66\%$

% change = 100 – 91.66 ≈ 8.5%

43. A train blowing its whistle moves with constant speed on a straight track towards observer and then crosses him. If the ratio of difference between the actual and apparent frequencies be 3 : 2 in the two cases, then the speed of train is [$v$ is speed of sound]

(1) $\frac{2v}{3}$ (2) $\frac{v}{5}$ (3) $\frac{v}{3}$ (4) $\frac{3v}{2}$

**Sol.** Answer (2)

$f_A = \frac{v}{v - v_s} f_0$ (Frequency of approach)

$f_R = \frac{v}{v + v_s} f_0$ (Frequency of departing)

$$\Delta f_A = \left(\frac{v}{v - v_s} - 1\right) f_0$$

$$\Delta f_A = \frac{v}{v - v_s} f_0$$

$$\Delta f_R = \left(1 - \frac{v}{v + v_s}\right) f_0$$

$$\Delta f_R = \frac{v}{v + v_s} f_0$$

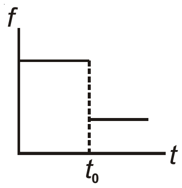
$$\frac{\Delta f_A}{\Delta f_R} = \frac{v + v_s}{v - v_s} = \frac{3}{2}$$

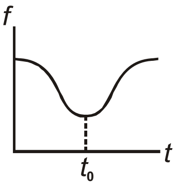
$2\ v = 2\ v_s = 3\ v - 3\ v_s$

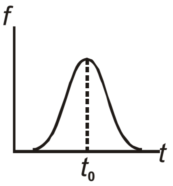
$5\ v_s = v$

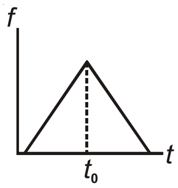
$$v_s = \frac{v}{5}$$

44. A man is standing on a railway platform listening to the whistle of an engine that passes the man at constant speed without stopping. If the engine passes the man at time instant $t_0$, how does the frequency $f$ of the whistle as heard by the man changes with time?

(1) 


(2) 


(3) 


(4) 

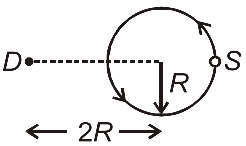

**Sol.** Answer (1)

When the train is approaching with speed $v_s$. The apparent frequency is constant and $f_A = \frac{v}{v - v_s} f_0$

When it is departing it is again constant, suddenly changing after $t_0$ to $f_0 = \frac{v}{v + v_s} f_0$.

Hence graph will be that of option (1).

45. A whistle '$S$' of frequency $f$ revolves in a circle of radius $R$ at a constant speed $v$. What is the ratio of maximum and minimum frequency detected by a detector $D$ at rest at a distance $2R$ from the center of circle as shown in figure? (take '$c$' as speed of sound)




(1) $\left(\frac{c+v}{c-v}\right)$ (2) $\sqrt{2}\left(\frac{c+v}{c-v}\right)$ (3) $\sqrt{2}$ (4) $\frac{(c+v)}{c\sqrt{2}}$

**Sol.** Answer (1)

$c$ = Speed of sound

At maximum frequency sources directly approaches observes with speed $v_s$.

$$\therefore \quad f_A = \frac{c}{c-v} f_0$$

At minimum frequency sources recedes with $v_s$

$$f_R = \frac{c}{c+v} f_0$$

$$\frac{f_A}{f_R} = \frac{c+v}{c-v}$$

## SECTION - C

### Previous Years Questions

1. A tuning fork is used to produce resonance in a glass tube. The length of the air column in this tube can be adjusted by a variable piston. At room temperature of 27ºC two successive resonances are produced at 20 cm and 73 cm of column length. If the frequency of the tuning fork is 320 Hz, the velocity of sound in air at 27ºC is **[NEET-2018]**

(1) 330 m/s (2) 339 m/s (3) 300 m/s (4) 350 m/s

**Sol.** Answer (2)

$v = 2\,(\nu)\,[L_2 - L_1]$

$= 2 \times 320\,[73 - 20] \times 10^{-2}$

$= 339.2\ \text{ms}^{-1}$

$= 339$ m/s

2. The fundamental frequency in an open organ pipe is equal to the third harmonic of a closed organ pipe. If the length of the closed organ pipe is 20 cm, the length of the open organ pipe is **[NEET-2018]**

(1) 13.2 cm (2) 8 cm (3) 16 cm (4) 12.5 cm

**Sol.** Answer (1)

For closed organ pipe, third harmonic

$$= \frac{3v}{4l}$$

For open organ pipe, fundamental frequency

$$= \frac{v}{2l'}$$

Given,

$$\frac{3v}{4l} = \frac{v}{2l'}$$

$$\Rightarrow \quad l' = \frac{4l}{3 \times 2} = \frac{2l}{3}$$

$$= \frac{2 \times 20}{3} = 13.33 \text{ cm}$$

3. Two cars moving in opposite directions approach each other with speed of 22 m/s and 16.5 m/s respectively. The driver of the first car blows a horn having a frequency 400 Hz. The frequency heard by the driver of the second car is [velocity of sound 340 m/s] **[NEET-2017]**

(1) 350 Hz (2) 361 Hz (3) 411 Hz (4) 448 Hz

**Sol.** Answer (4)

$$f_A = f\left[\frac{v+v_o}{v-v_s}\right]$$

$$= 400\left[\frac{340+16.5}{340-22}\right]$$

$f_A$ = 448 Hz

4. The two nearest harmonics of a tube closed at one end and open at other end are 220 Hz and 260 Hz. What is the fundamental frequency of the system? **[NEET-2017]**

(1) 10 Hz (2) 20 Hz (3) 30 Hz (4) 40 Hz

**Sol.** Answer (2)

Two successive frequencies of closed pipe

$$\frac{nv}{4l} = 220 \qquad \text{...(i)}$$

$$\frac{(n+2)v}{4l} = 260 \qquad \text{...(ii)}$$

Dividing (ii) by (i), we get

$$\frac{n+2}{n} = \frac{260}{220} = \frac{13}{11}$$

$11n + 22 = 13n$

$n = 11$

So, $11\frac{v}{4l} = 220$

$$\frac{v}{4l} = 20$$

So fundamental frequency is 20 Hz.

5. The second overtone of an open organ pipe has the same frequency as the first overtone of a closed pipe $L$ metre long. The length of the open pipe will be **[NEET(Phase-2)-2016]**

(1) $L$ (2) $2L$ (3) $\frac{L}{2}$ (4) $4L$

**Sol.** Answer (2)

$$\frac{3V}{2L_1} = \frac{3V}{4L} \Rightarrow L_1 = 2L$$

6. Three sound waves of equal amplitudes have frequencies $(n – 1)$, $n$, $(n + 1)$. They superimpose to give beats. The number of beats produced per second will be **[NEET(Phase-2)-2016]**

(1) 1 (2) 4

(3) 3 (4) 2

**Sol.** Answer (4)

($n$ – 1) and ($n$ + 1) suppose to form frequency $n$

$n$ and $n$ will be at resonance

$n$ – 1 and $n \rightarrow$ produce 1 beat

$n$ + 1 and $n \rightarrow$ produce 1 beat

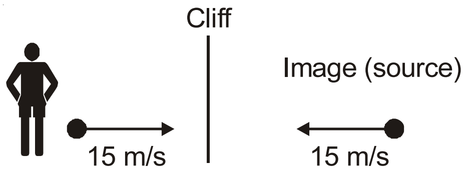
Number of beats formed are '2'.

7. A siren emitting a sound of frequency 800 Hz moves away from an observer towards a cliff at a speed of 15 ms$^{-1}$. Then, the frequency of sound that the observer hears in the echo reflected from the cliff is (Take velocity of sound in air = 330 ms$^{-1}$) **[NEET-2016]**

(1) 885 Hz (2) 765 Hz

(3) 800 Hz (4) 838 Hz

**Sol.** Answer (4)




$$f' = \left(\frac{v}{v - v_s}\right) f = \left(\frac{330}{330 - 15}\right) 800 = 838 \text{ Hz}$$

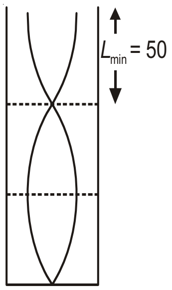
8. An air column, closed at one end and open at the other, resonates with a tuning fork when the smallest length of the column is 50 cm. The next larger length of the column resonating with the same tuning fork is

**[NEET-2016]**

(1) 200 cm (2) 66.7 cm

(3) 100 cm (4) 150 cm

**Sol.** Answer (4)




$L_{min}$ = 50 cm

So other lengths for resonance are $3L_{min}$, $5L_{min}$, $7L_{min}$, etc.

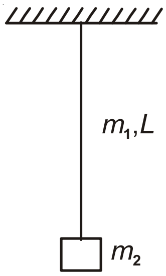
$\Rightarrow$ 150 cm, 250 cm, 350 cm, etc.

9. A uniform rope of length $L$ and mass $m_1$ hangs vertically from a rigid support. A block of mass $m_2$ is attached to the free end of the rope. A transverse pulse of wavelength $\lambda_1$ is produced at the lower end of the rope. The wavelength of the pulse when it reaches the top of the rope is $\lambda_2$. The ratio $\lambda_2/\lambda_1$ is **[NEET-2016]**

(1) $\sqrt{\frac{m_1 + m_2}{m_1}}$ (2) $\sqrt{\frac{m_1}{m_2}}$ (3) $\sqrt{\frac{m_1 + m_2}{m_2}}$ (4) $\sqrt{\frac{m_2}{m_1}}$

**Sol.** Answer (3)

$$\lambda = \frac{v}{f} \qquad \left(v = \sqrt{\frac{T}{\mu}}\right)$$




$$\frac{\lambda_2}{\lambda_1} = \frac{v_2}{v_1}$$

$$= \sqrt{\frac{T_2}{T_1}}$$

$$= \sqrt{\frac{(m_1 + m_2)}{m_2}}$$

10. A string is stretched between fixed points separated by 75.0 cm. It is observed to have resonant frequencies of 420 Hz and 315 Hz. There are no other resonant frequencies between these two. The lowest resonant frequency for this string is **[Re-AIPMT-2015]**

(1) 105 Hz (2) 155 Hz

(3) 205 Hz (4) 10.5 Hz

**Sol.** Answer (1)

$$\frac{(n+1)}{n} = \frac{420}{315}$$

$$\frac{n+1}{n} = \frac{84}{63}$$

$63\, n + 63 = 84\, n$

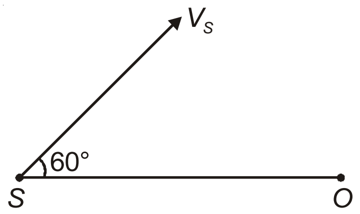
$63 = 21\, n$

$n = 3$

$\frac{1}{3}$ of 315 is fundamental.

$f = 105$

11. A source of sound $S$ emitting waves of frequency 100 Hz and an observer $O$ are located at some distance from each other. The source is moving with a speed of 19.4 ms$^{-1}$ at an angle of 60° with the source observer line as shown in the figure. The observer is at rest. The apparent frequency observed by the observer (velocity of sound in air 330 ms$^{-1}$), is **[Re-AIPMT-2015]**




(1) 97 Hz (2) 100 Hz (3) 103 Hz (4) 106 Hz

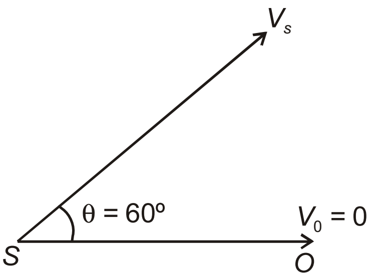
**Sol.** Answer (3)

$$\eta' = \eta\left(\frac{V}{V - V_s\cos\theta}\right)$$

$$= 100\times\left(\frac{330}{330 - 15.4\times\frac{1}{2}}\right)$$

$$= 100\times\left(\frac{330}{330-9.7}\right)$$

$$= \frac{33000}{3\cdot 20\cdot 3} = 103 \text{ Hz}$$




12. The fundamental frequency of a closed organ pipe of length 20 cm is equal to the second overtone of an organ pipe open at both the ends. The length of organ pipe open at both the ends is **[AIPMT-2015]**

(1) 140 cm (2) 80 cm (3) 100 cm (4) 120 cm

**Sol.** Answer (4)

$$\eta_c = \frac{V}{4l_c}$$

$$\eta_c = 3\left(\frac{V}{2l_0}\right) = 2^{nd} \text{ overtone}$$

$$\frac{2V}{2l_0} = \frac{V}{4l_c} \quad \Rightarrow \quad 6l_c = l_0$$

$$6 \times 20 = l_0$$

$$120 = l_0$$

13. If $n_1$, $n_2$ and $n_3$ are the fundamental frequencies of three segments into which a string is divided, then the original fundamental frequency $n$ of the string is given by **[AIPMT-2014]**

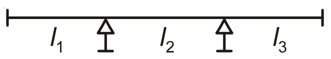
(1) $\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}$

(2) $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}} + \frac{1}{\sqrt{n_3}}$

(3) $\sqrt{n} = \sqrt{n_1} + \sqrt{n_2} + \sqrt{n_3}$

(4) $n = n_1 + n_2 + n_3$

**Sol.** Answer (1)




$$l = l_1 + l_2 + l_3$$

$$\frac{1}{2n}\sqrt{\frac{T}{\mu}} = \frac{1}{2n_1}\sqrt{\frac{T}{\mu}} + \frac{1}{2n_2}\sqrt{\frac{T}{\mu}} + \frac{1}{2n_3}\sqrt{\frac{T}{\mu}}$$

$$\boxed{\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}}$$

$$n_1 = \frac{1}{nl_1}\sqrt{\frac{T}{\mu}} \Rightarrow l_1 = \frac{1}{2n_1}\sqrt{\frac{T}{\mu}}$$

$$n_2 = \frac{1}{2l_2}\sqrt{\frac{T}{\mu}} \Rightarrow l_2 = \frac{1}{2n_2}\sqrt{\frac{T}{\mu}}$$

$$n_3 = \frac{1}{2l_3}\sqrt{\frac{T}{\mu}} \Rightarrow l_3 = \frac{1}{2n_3}\sqrt{\frac{T}{\mu}}$$

14. The number of possible natural oscillations of air column in a pipe closed at one end of length 85 cm whose frequencies lie below 1250 Hz are (velocity of sound = 340 $ms^{-1}$) **[AIPMT-2014]**

(1) 4 (2) 5

(3) 7 (4) 6

**Sol.** Answer (4)

The frequency which is integral multiple of fundamental frequency is called overtones

Now, $n_0 = \frac{v}{4l_0} = \frac{340}{4 \times 0.85} = 100$

Now, combintation of frequencies = 100, 300, 500, 700, 900, 1200

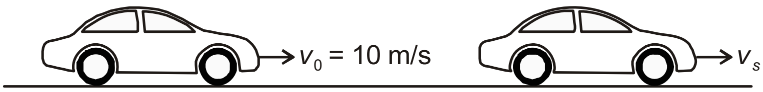
*i.e.*, 6 frequencies.

15. A speeding motorcyclist sees traffic jam ahead of him. He slows down to 36 km/hour. He finds that traffic has eased and a car moving ahead of him at 18 km/hour is honking at a frequency of 1392 Hz. If the speed of sound is 343 m/s, the frequency of the honk as heard by him will be **[AIPMT-2014]**

(1) 1332 Hz (2) 1372 Hz

(3) 1412 Hz (4) 1454 Hz

**Sol.** Answer (3)




$$N' = N_0\left(\frac{v+v_0}{v+v_s}\right) = 1392 \times \left(\frac{343+10}{343-5}\right) = 1412 \text{ Hz}$$

16. If we study the vibration of a pipe open at both ends, then the following statement is not true: **[NEET-2013]**

(1) Odd harmonics of the fundamental frequency will be generated

(2) All harmonics of he fundamental frequency will be generated

(3) Pressure change will be maximum at both ends

(4) Open end will be antinode

**Sol.** Answer (3)

17. A source of unknown frequency gives 4 beats/s, when sounded with a source of known frequency 250 Hz. The second harmonic of the source of unknown frequency gives five beats per second, when sounded with a source of frequency 513 Hz. The unknown frequency is **[NEET-2013]**

(1) 246 Hz (2) 240 Hz (3) 260 Hz (4) 254 Hz

**Sol.** Answer (4)

18. A wave travelling in the positive *x*-direction having displacement along y-direction as 1 m, wavelength 2πm and frequency of $\frac{1}{\pi}$ Hz is represented by **[NEET-2013]**

(1) $y = \sin(2\pi x - 2\pi t)$ (2) $y = \sin(10\pi x - 20\pi t)$

(3) $y = \sin(2\pi x + 2\pi t)$ (4) $y = \sin(x - 2t)$

**Sol.** Answer (4)

19. Two sources of sound placed close to each other, are emitting progressive waves given by $y_1 = 4 \sin 600\pi t$ and $y_2 = 5 \sin 608\pi t$. An observer located near these two sources of sound will hear **[AIPMT (Prelims)-2012]**

(1) 8 beats per second with intensity ratio 81 : 1 between waxing and waning

(2) 4 beats per second with intensity ratio 81 : 1 between waxing and waning

(3) 4 beats per second with intensity ratio 25 : 16 between waxing and waning

(4) 8 beats per second with intensity ratio 25 : 16 between waxing and waning

**Sol.** Answer (2)

$\omega_1 = 600\,\pi = 2\pi f_1$

$\omega_2 = 608\,\pi = 2\pi f_2$

$f_1 = 300$ Hz

$f_2 = 304$ Hz

$\therefore$ Beats heard will be 304 – 300 = 4 beats / s

$$\frac{I_{\max}}{I_{\min}} = \frac{(A_1 + A_2)^2}{(A_1 - A_2)^2} \text{ or } \frac{I_{\max}}{I_{\min}} = \frac{81}{1}$$

20. When a string is divided into three segments of length $l_1$, $l_2$ and $l_3$, the fundamental frequencies of these three segments are $v_1$, $v_2$ and $v_3$ respectively. The original fundamental frequency ($v$) of the string is

**[AIPMT (Prelims)-2012]**

(1) $\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2} + \frac{1}{v_3}$

(2) $\frac{1}{\sqrt{v}} = \frac{1}{\sqrt{v_1}} + \frac{1}{\sqrt{v_2}} + \frac{1}{\sqrt{v_3}}$

(3) $\sqrt{v} = \sqrt{v_1} + \sqrt{v_2} + \sqrt{v_3}$

(4) $v = v_1 + v_2 + v_3$

**Sol.** Answer (1)

Let original fundamental frequency be = $\frac{v}{2l}$

$l = l_1 + l_2 + l_3$ ... (i)

$f_1 = \frac{\nu}{2l_1}$ or $l_1 = \frac{\nu}{2f_1}$

Similarly, $l_2 = \frac{v}{2f_2}$ $l_3 = \frac{v}{2f_3}$ $l = \frac{v}{2f}$

Putting values for $l$, $l_1$, $l_2$, $l_3$ in (i)

$$\frac{v}{2f} = \frac{v}{2f_1} + \frac{v}{2f_2} + \frac{v}{2f_3}$$

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$$

21. The equation of a simple harmonic wave is given by $y = 3\sin\frac{\pi}{2}(50t - x)$, where $x$ and $y$ are in metres and $t$ is in seconds. The ratio of maximum particle velocity to the wave velocity is **[AIPMT (Mains)-2012]**

(1) $2\pi$ (2) $\frac{3}{2}\pi$ (3) $3\pi$ (4) $\frac{2}{3}\pi$

**Sol.** Answer (2)

22. A train moving at a speed of 220 $ms^{-1}$ towards a stationary object, emits a sound of frequency 1000 Hz. Some of the sound reaching the object gets reflected back to the train as echo. The frequency of the echo as detected by the driver of the train is: (Speed of sound in air is 330 $ms^{-1}$) **[AIPMT (Mains)-2012]**

(1) 3500 Hz (2) 4000 Hz (3) 5000 Hz (4) 3000 Hz

**Sol.** Answer (3)

23. Two waves are represented by the equations

$y_1 = a \sin(\omega t + kx + 0.57)$ m and

$y_2 = a \cos(\omega t + kx)$ m

where $x$ is in meter and $t$ in sec. The phase difference between them is **[AIPMT (Prelims)-2011]**

(1) 0.57 radian (2) 1.0 radian (3) 1.25 radian (4) 1.57 radian

**Sol.** Answer (2)

Phase difference is simply difference in the argument in sine function.

We can write $y_2 = a \sin[\omega t + kx + \pi/2]$

$\therefore \quad \Delta\phi = \omega t + kx + \pi/2 - (\omega t + kx + 0.57)$

$= 1.57 - 0.57 = 1$ radian

24. Sound waves travel at 350 m/s through a warm air and at 3500 m/s through brass. The wavelength of a 700 Hz acoustic wave as it enters brass from warm air **[AIPMT (Prelims)-2011]**

(1) Decreases by a factor 20 (2) Decreases by a factor 10

(3) Increases by a factor 20 (4) Increases by a factor 10

**Sol.** Answer (4)

Frequency will remain constant

$v_a$ = Velocity in air

$v_b$ = Velocity in brass

$v_a = 700 \times \lambda_a$

$v_b = 700 \times \lambda_b$

$\lambda_a = \dfrac{350}{700}$ $\qquad \lambda_b = \dfrac{3500}{700}$

$\lambda_a = 0.5$ m/s $\qquad \lambda_b = 50$ m

$\therefore \quad \lambda_b = 10\,\lambda_a$

25. Two identical piano wires, kept under the same tension $T$ have a fundamental frequency of 600 Hz. The fractional increase in the tension of one of the wires which will lead to occurrence of 6 beats/s when both the wires oscillate together would be **[AIPMT (Mains)-2011]**

(1) 0.04 (2) 0.01 (3) 0.02 (4) 0.03

**Sol.** Answer (3)

Beats = 6 Hz

New frequency of one of the wires = 600 + 6 = 606

$$f = \frac{v}{2l} = \sqrt{\frac{T}{\mu}} \times \frac{1}{2l}$$

$$\left(\frac{606}{600}\right)^2 = \frac{T + \Delta T}{T} \text{ or } \frac{\Delta T}{T} = 0.0201 \simeq 0.02$$

26. A transverse wave is represented by $y = A\sin(\omega t - kx)$. For what value of the wavelength is the wave velocity equal to the maximum particle velocity? **[AIPMT (Prelims)-2010]**

(1) $\frac{\pi A}{2}$ (2) $\pi A$ (3) $2\pi A$ (4) $A$

**Sol.** Answer (3)

27. A tuning fork of frequency 512 Hz makes 4 beats per second with the vibrating string of a piano. The beat frequency decreases to 2 beats per sec when the tension in the piano string is slightly increased. The frequency of the piano string before increasing the tension was **[AIPMT (Prelims)-2010]**

(1) 508 Hz (2) 510 Hz (3) 514 Hz (4) 516 Hz

**Sol.** Answer (1)

Tuning fork of frequency = 512 Hz

Frequency of wire = 512 ± 4

Since frequency beats decrease when tension is increased, frequency of tuning fork must be greater than string initially.

$\therefore$ Frequency of piano = 508 Hz

28. Each of the two strings of length 51.6 cm and 49.1 cm are tensioned separately by 20 N force. Mass per unit length of both the strings is same and equal to 1 g/m. When both strings vibrate simultaneously the number of beats is **[AIPMT (Prelims)-2009]**

(1) 7 (2) 8 (3) 3 (4) 5

**Sol.** Answer (1)

$l_1 = 51.6$ cm $\quad l_2 = 49.1$ cm $\quad T = 20$ N

$\mu = 1$ g/m = 0.001 kg/m

$$\frac{v}{2l_1} = \sqrt{\frac{20}{0.001}} \times \frac{1}{2\times 0.516} \quad \left[v = \sqrt{\frac{T}{\mu}}\right]$$

$\approx 137$ Hz

Similarly,

$$\frac{v}{2l_2} = 144\,\text{Hz}$$

Number of beats = 144 – 137 = 7 Hz]

29. The driver of a car travelling with speed 30 m/sec towards a hill sounds a horn of frequency 600 Hz. If the velocity of sound in air is 330 m/s, the frequency of reflected sound as heard by driver is:

**[AIPMT (Prelims)-2009]**

(1) 555.5 Hz (2) 720 Hz

(3) 500 Hz (4) 550 Hz

**Sol.** Answer (2)

30. A wave in a string has an amplitude of 2 cm. The wave travels in the positive direction of x axis with a speed of 128 m/s and it is noted that 5 complete waves fit in 4 m length of the string. The equation describing the wave is **[AIPMT (Prelims)-2009]**

(1) $y = (0.02)$ m $\sin(15.7x - 2010t)$ (2) $y = (0.02)$ m $\sin(15.7x + 2010t)$

(3) $y = (0.02)$ m $\sin(7.85x - 1005t)$ (4) $y = (0.02)$ m $\sin(7.85x + 1005t)$

**Sol.** Answer (3)

$$\lambda = \frac{4}{5} = 0.8 \text{ m}$$

Velocity = 128 m/s

$$\omega = \frac{2\pi v}{\lambda} = \frac{2\pi \times 128}{0.8} = 320\,\pi = 1005$$

$$k = \frac{2\pi}{0.8} = 7.85$$

$\therefore$ Equation of the form $y = A \sin(kx - \omega t)$ is the first option.

31. The wave described by $y = 0.25 \sin(10\pi x - 2\pi t)$, where $x$ and $y$ are in meters and $t$ in seconds, is a wave travelling along the **[AIPMT (Prelims)-2008]**

(1) –x-direction with amplitude 0.25 m and wavelength $\lambda = 0.2$ m

(2) –x-direction with frequency 1 Hz

(3) +$x$-direction with frequency $\pi$ Hz and wavelength $\lambda = 0.2$ m

(4) +$x$-direction with frequency 1 Hz and wavelength $\lambda = 0.2$ m

**Sol.** Answer (4)

$y = 0.25 \sin(10\,\pi x - 2\,\pi t)$ ... (i)

Frequency ($f$) = $\dfrac{\omega}{2\pi}$ = 1 Hz

Wavelength ($\lambda$) = $\dfrac{2\pi}{k} = \dfrac{1}{5}$ m

Equation (i) is the equation of wave travelling in +ve $x$-direction.

Hence answer is (0.2) option (4)

32. Two points are located at a distance of 10 m and 15 m from the source of oscillation. The period of oscillation is 0.05 sec and the velocity of the wave is 300 m/sec. What is the phase difference between the oscillations of two points? **[AIPMT (Prelims)-2008]**

(1) $\dfrac{\pi}{6}$ (2) $\dfrac{\pi}{3}$ (3) $\dfrac{2\pi}{3}$ (4) $\pi$

**Sol.** Answer (3)

$T = 0.05$ s Velocity ($v$) = 300 m/s

$\therefore$ $f = \dfrac{1}{T}$ = 20 Hz

$\omega = 2\pi f = 40\,\pi$

Since velocity = $\dfrac{\omega}{k}$

$$300 = \frac{40\pi}{k}$$

$$k = \frac{2\pi}{15}$$

$\lambda = 15$ m

Put $x = 10$ and $x = 15$ in equation

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

$= A\sin\left(\frac{2\pi}{15}x - 40\pi t\right)$

Time ($t$) is same.

$y_1 = A\sin\left(\frac{2\pi}{15}10 - \omega t\right)$

$y_2 = A\sin(2\pi - \omega t)$

$\Delta\phi = (2\pi - \omega t) - \left(\frac{4\pi}{3} - \omega t\right)$

or $\Delta\phi = 2\pi - \frac{4\pi}{3}$

or $\Delta\phi = \frac{2\pi}{3}$

33. Two sound waves with wavelengths 5 m and 5.5 m respectively, each propagate in a gas with velocity 330 m/s. We expect the following number of beats per second **[AIPMT (Prelims)-2006]**

(1) 12 (2) 0

(3) 1 (4) 6

**Sol.** Answer (4)

$f_1 = \frac{v}{\lambda_1} = \frac{330}{5} = 66\text{Hz}$

$f_2 = \frac{v}{\lambda_2} = \frac{330}{5.5} = 60\text{Hz}$

Beats = $f_2 - f_1 = 6$ beats/s

34. A transverse wave propagating along x-axis is represented by: $y(x, t) = 8\sin(0.5\pi x - 4\pi t - \frac{\pi}{4})$

where $x$ is in metres and $t$ is in seconds. The speed of the wave is **[AIPMT (Prelims)-2006]**

(1) $4\pi$ m/s (2) $0.5\pi$ m/s (3) $\frac{\pi}{4}$ m/s (4) 8 m/s

**Sol.** Answer (4)

$v = \frac{\omega}{k}$

$v = \frac{4\pi}{\pi/2}$

$v = 8$ m/s

35. The time of reverberation of a room-A is one second. What will be the time (in seconds) of reverberation of a room, having all the dimensions double of those of room-A? **[AIPMT (Prelims)-2006]**

(1) 2 (2) 4 (3) $\frac{1}{2}$ (4) 1

**Sol.** Answer (1)

Sabini's formula for reverberation time is

$$T = \frac{0.16V}{\Sigma as}$$

Where $V$ is volume of hall in $m^3$

$$\frac{T'}{T} = \frac{V'}{s'} \times \frac{s}{V}$$

$$\frac{T'}{T} = \frac{2^3}{2^2} \text{ or } T = 2 \text{ s}$$

36. Which one of the following statements is true? **[AIPMT (Prelims)-2006]**

(1) Both light and sound waves in air are transverse

(2) The sound waves in air are longitudinal while the light waves are transverse

(3) Both light and sound waves in air are longitudinal

(4) Both light and sound waves can travel in vacuum

**Sol.** Answer (2)

37. A point source emits sound equally in all directions in a non-absorbing medium. Two points $P$ and $Q$ are at distance of 2 m and 3 m respectively from the source. The ratio of the intensities of the waves at $P$ and $Q$ is

**[AIPMT (Prelims)-2005]**

(1) 9 : 4 (2) 2 : 3 (3) 3 : 2 (4) 4 : 9

**Sol.** Answer (1)

$$I \propto \frac{1}{r^2}$$

$$I_P = \frac{k}{2^2} \qquad I_Q = \frac{k}{3^2}$$

$$I_P = I_Q = 9 : 4$$

38. Two vibrating tuning forks produce progressive waves given by $y_1 = 4\sin 500\pi t$ and $y_2 = 2\sin 506\pi t$. Number of beats produced per minute is **[AIPMT (Prelims)-2005]**

(1) 360 (2) 180

(3) 3 (4) 60

**Sol.** Answer (2)

$$y_1 = 4 \sin 500\, \pi t \text{ and } y_2 = 2 \sin 506\, \pi t$$

$$\omega_1 = 2\pi f_1 = 500\, \pi$$

$$f_1 = 250 \text{ Hz}$$

Similarly, $2\pi f_2 = 506\, \pi$

$f_2 = 253$ Hz

Beats = $f_2 - f_1 = 3$ Hz

3 beats in 1 second then number of beats in 1 minute = 3 × 60 = 180

39. Two waves are represented by the equations

$y_1 = a\sin(\omega t + kx + 0.57)$m and

$y_2 = a\cos(\omega t + kx)$ m,

where $x$ is in metre and $t$ in second. The phase difference between them is

(1) 0.57 radian (2) 1.0 radian (3) 1.25 radian (4) 1.57 radian

**Sol.** Answer (2)

40. A hospital uses an ultrasonic scanner to locate tumours in a tissue. The operating frequency of the scanner is 4.2 MHz. The speed of sound in a tissue is 1.7 km/s. The wavelength of sound in the tissue is close to

(1) $4 \times 10^{-3}$ m (2) $8 \times 10^{-3}$ m (3) $4 \times 10^{-4}$ m (4) $8 \times 10^{-4}$ m

**Sol.** Answer (3)

$f = 4.2 \times 10^6$ Hz

$v = 1700$ m/s

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

$$= \frac{1700}{42\times10^5} = 0.404 \times 10^{-3}$$

$$= 4 \times 10^{-4}$$

41. Two sound waves having a phase difference of 60° have path difference of

(1) $\frac{\lambda}{6}$ (2) $\frac{\lambda}{3}$ (3) $2\lambda$ (4) $\frac{\lambda}{2}$

**Sol.** Answer (1)

Path difference = $\frac{\lambda}{2\pi}$ × Phase difference.

$\therefore$ Path difference = $\frac{\lambda}{6}$ m

42. A transverse wave is represented by the equation $y = y_0 \sin\frac{2\pi}{\lambda}(vt - x)$. For what value of $\lambda$ the maximum particle velocity is equal to two times the wave velocity?

(1) $\lambda = \frac{\pi y_0}{2}$ (2) $\lambda = \frac{\pi y_0}{3}$ (3) $\lambda = 2\pi y_0$ (4) $\lambda = \pi y_0$

**Sol.** Answer (4)

$$y = y_0 \sin\frac{2\pi}{\lambda}(vt - x)$$

$$\frac{dy}{dt} = y_0\frac{v}{\lambda}2\pi\cos\frac{2\pi}{\lambda}(vt - x)$$

Maximum particle velocity = $y_0\frac{2\pi v}{\lambda}$

Wave velocity = $v$

$$\frac{y_0 2\pi v}{\lambda} = 2\,v$$

$$\pi_{y_0} = \lambda$$

43. A wave travelling in positive x-direction with $A$ = 0.2 m, velocity = 360 m/s and $\lambda$ = 60 m, then correct expression for the wave is

(1) $y = 0.2\sin\left[2\pi\left(6t + \frac{x}{60}\right)\right]$  (2) $y = 0.2\sin\left[\pi\left(6t + \frac{x}{60}\right)\right]$

(3) $y = 0.2\sin\left[2\pi\left(6t - \frac{x}{60}\right)\right]$  (4) $y = 0.2\sin\left[\pi\left(6t - \frac{x}{60}\right)\right]$

**Sol.** Answer (3)

$A$ = 0.2 m  Velocity = 360 m/s and $\lambda$ = 60 m

We are looking for a waves of the form $y = A \sin \omega t - kx$

$$\omega = \frac{2\pi v}{\lambda} = \frac{2\pi \times 360}{60} = 12\pi$$

$$k = \frac{2\pi}{\lambda} = \frac{2\pi}{60}$$

Correct value of $\omega$ and $k$ are found in option (3).

44. The phase difference between two waves, represented by $y_1 = 10^{-6}\sin[100t + (x/50) + 0.5]$ m and $y_2 = 10^{-6}\cos[100t + (x/50]$ m, where $x$ is expressed in metre and $t$ is expressed in second, is approximately

(1) 1.07 radian (2) 2.07 radian (3) 0.5 radian (4) 1.5 radian

**Sol.** Answer (1)

$$y_1 = 10^{-6}\sin\left(100t + \frac{x}{50} + 0.5\right)$$

$$y_2 = 10^{-6}\cos\left(100t + \frac{x}{50}\right)$$

$$y_2 = 10^{-6}\sin\left(100t + \frac{x}{50} + \frac{\pi}{2}\right)$$

Phase differences

$$\left(100t + \frac{x}{50} + \frac{\pi}{2}\right) - \left(100t + \frac{x}{50} + 0.5\right)$$

$$= \frac{3.14}{2} - \frac{1}{2}$$

= 1.07 radian

45. A wave of frequency 100 Hz travels along a string towards its fixed end. When this wave travels back, after reflection, a node is formed at a distance of 10 cm from the fixed end. The speed of the wave (incident and reflected) is

(1) 20 m/s (2) 40 m/s (3) 5 m/s (4) 10 m/s

**Sol.** Answer (1)

Node is formed at 10 cm

$\therefore$ Wavelength = 2 × 10 = 20 cm

$\lambda$ = 0.2 cm

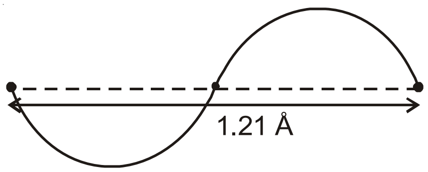
$v = f\lambda$ = 0.2 × 100 = 20 m/s

46. A standing wave having 3 nodes and 2 antinodes is formed between two atoms having a distance 1.21 Å between them. The wavelength of the standing wave is

(1) 6.05 Å (2) 2.42 Å (3) 1.21 Å (4) 3.63 Å

**Sol.** Answer (3)

Total distance 1.21 Å




According to description the wave must like above diagram wavelength ($\lambda$) = 1.21 Å

47. Two waves of wavelengths 50 cm and 51 cm produced 12 beats per second. The velocity of sound is

(1) 340 m/s (2) 331 m/s (3) 306 m/s (4) 360 m/s

**Sol.** Answer (3)

$$f_1 = \frac{v}{\lambda_1} \qquad f_2 = \frac{v}{\lambda_2}$$

$$f_1 - f_2 = 12$$

$$\frac{v}{0.5} - \frac{v}{0.51} = 12$$

Solving for $v$, we get $v$ = 306 m/s.

48. Two stationary sources each emit waves of wavelength $\lambda$. An observer moves from one source to another with velocity $u$. Then number of beats heard by him

(1) $\frac{2u}{\lambda}$ (2) $\frac{u}{\lambda}$ (3) $\sqrt{u\lambda}$ (4) $\frac{u}{2\lambda}$

**Sol.** Answer (1)

Let both have the same frequencies $\rho_0$.

Let the initial source be $s_1$ and the source is approaching be $s_2$.

$$f_0 = \frac{v}{\lambda}$$

$$f_{s_1} = \frac{v - v_0}{v} \times f_0 = \frac{1}{\lambda}(v - v_0)$$

$$f_{s_2} = \frac{v + v_0}{v} \times f_0 = \frac{1}{\lambda}(v + v_0)$$

$v_0 = u$ and $f_{s_2} - f_{s_1} = ?$

$$\left[\frac{(v+u)}{\lambda} - \frac{(v-u)}{\lambda}\right] = \text{number of beats.}$$

$$\left[\frac{v+u-v+u}{\lambda}\right] = \text{number of beats.}$$

$$\frac{2u}{\lambda} = \text{number of beats.}$$

49. Two vibrating tuning forks produce progressive waves given by $y_1$ = 4sin 500 $\pi t$ and $y_2$ = 2sin 506 $\pi t$. Number of beats produced per minute is

(1) 360 (2) 180 (3) 60 (4) 3

**Sol.** Answer (2)

50. A vehicle, with a horn of frequency $n$ is moving with a velocity of 30 m/s in a direction perpendicular to the straight line joining the observer and the vehicle. The observer perceives the sound to have a frequency $n + n_1$. Then (if the sound velocity in air is 300 m/s)

(1) $n_1 = 0.1\ n$ (2) $n_1 = 0$ (3) $n_1 = 10\ n$ (4) $n_1 = -0.1\ n$

**Sol.** Answer (2)

If the object and source are not approaching each other in any direction there is no change in frequency due to Doppler effect.

Length = 50 cm

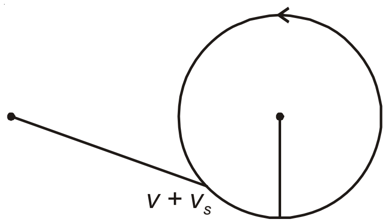
51. A whistle revolves in a circle with angular speed ω = 20 rad/s using a string of length 50 cm. If the frequency of sound from the whistle is 385 Hz, then what is the minimum frequency heard by an observer who is far away from the centre ($v_{sound}$ = 340 m/s)?

(1) 385 Hz (2) 374 Hz (3) 394 Hz (4) 333 Hz

**Sol.** Answer (2)

$v_s = r_\omega = 20 \times 0.5 = 10$ m/s

Observed frequency is minimum when source moves from observer.




Apparent frequency $= \dfrac{v}{v+v_s} \times f_0$

$= \dfrac{340}{340+10} \times 385$

$= \dfrac{340}{350} \times 385$

$= 34 \times 11 = 374$ Hz

52. An observer moves towards a stationary source of sound with a speed 1/5$^{th}$ of the speed of sound. The wavelength and frequency of the source emitted are λ and $f$ respectively. The apparent frequency and wavelength recorded by the observer are respectively

(1) 1.2$f$, 1.2 λ (2) 1.2$f$, λ (3) $f$, 1.2 λ (4) 0.8$f$, 0.8 λ

**Sol.** Answer (2)

Wavelength of wave does not change due to the Doppler effect.

Apparent frequency $= \dfrac{v+v_s}{v} \times f = \dfrac{6}{5} \times f$ or 12 $f$

Wavelength = λ

53. A car is moving towards a high cliff. The driver sounds a horn of frequency $f$. The reflected sound heard by the driver has frequency 2$f$ if $v$ the velocity of sound, then the velocity of the car, in the same velocity units, will be

(1) $\dfrac{v}{\sqrt{2}}$ (2) $\dfrac{v}{3}$ (3) $\dfrac{v}{4}$ (4) $\dfrac{v}{2}$

**Sol.** Answer (2)

Frequency with which sound hits the wall $(f_1) = \dfrac{v}{v - v_c} \times f$

Frequency with which man hears the sound again $(f_2) = \dfrac{v+v_c}{v} \times f_1$

or $f_2 = \dfrac{v+v_c}{v-v_c} \times f$

or $2f = \dfrac{v+v_c}{v-v_c} \times f$ or $2v - 2v_c = v + v_c$

$v_c = \dfrac{v}{3}$

54. The equation of a simple harmonic wave is given by $y = 3\sin\dfrac{\pi}{2}(50t - x)$, where $x$ and $y$ are in metres and $t$ is in seconds. The ratio of maximum particle velocity to the wave velocity is

(1) $2\pi$ (2) $\dfrac{3}{2}\pi$ (3) $3\pi$ (4) $\dfrac{2}{3}\pi$

**Sol.** Answer (2)

$y = 3\sin\dfrac{\pi}{2}(50t - x)$

Maximum particle velocity = $A\omega$

or $3 \times 25\pi = 75\pi$

Wave velocity = $\dfrac{\omega}{k} = \dfrac{50}{1} = 50\,\text{m/s}$

Ratio = $\dfrac{75\pi}{50} = \dfrac{3\pi}{2}$

55. Which one of the following statements is true?

(1) The sound waves in air are longitudinal while the light waves are transverse

(2) Both light and sound waves in air are longitudinal

(3) Both light and sound waves can travel in vacuum

(4) Both light and sound waves in air are transverse

**Sol.** Answer (1)

Sound is a mechanical wave and travels longitudinally in air.

Light being electromagnetic will be all transversely irrespective of the medium.

## SECTION - D

### Assertion-Reason Type Questions

1. A : Doppler's effect in sound is asymmetric but in light, it is symmetric.

R : In sound, change in frequency depends on the individual velocity of both the source as well as the observer. In light, change in frequency depends on the relative velocity between source and observer.

**Sol.** Answer (2)

Doppler's effect in sound is different when the object is moving towards source and when source moves towards observer.

Hence it is asymmetric. Light is symmetric as it just depends on relative motion between the source and the object.

2. A : The propagation of sound in air should be an isothermal process.

   R : As air is bad conductor of heat, its temperature does not change by compression or expansion.

**Sol.** Answer (4)

The propagation of sound in air is an adiabatic process as very little sound energy get dissipated as heat.

Air may be a bad conductor of heat but its temperature does change when work is performed on it.

3. A : Velocity of sound in air increases with increase in humidity.

   R : Velocity of sound doesn't depend upon medium.

**Sol.** Answer (3)

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

The $\rho$ or density reduces because of presence of water vapour as both $N_2$ and $O_2$ are heavier than $H_2O$.

Velocity of sound, thus, depends largely on the medium.

4. A : Intensity of sound wave does not change when the listener moves towards or away from the stationary source.

   R : The motion of listener towards a stationary source causes an apparent change in wavelength of sound.

**Sol.** Answer (4)

Intensity of sound changes when observer moves towards are away from source because of change in frequency.

Motion of observers only causes change in frequency of sound and not the wavelength.

5. A : A vibrating tuning fork sounds louder when its stem is pressed against desk top.

   R : When a wave reaches another denser medium, part of the wave is reflected.

**Sol.** Answer (2)

When a vibrating tuning fork is held in hand only air is set into vibration. When its stem is placed in contact with the labels the entire labels is set into forced vibrations.

6. A : Longitudinal waves do not exhibit the phenomenon of polarisation.

   R : In longitudinal waves medium particle vibrate in direction normal to the wave propagation.

**Sol.** Answer (3)

Polarisation means redirecting a wave to propagate in only one plane.

The molecules in a longitudinal wave vibrate along the direction of propagation of wave and hence cannot be redirected by any material.

7. A : If a wave moving in a rarer medium, gets reflected at the boundary of a denser medium, then it encounters a sudden change in phase of $\pi$.

   R : If a wave propagating in a denser medium, gets reflected from rarer medium, then there will be no abrupt phase change.

**Sol.** Answer (2)

Both the statements are true but (2) does not give the correct explanation for (1).

8. A : Speed of sound in moist air is more than its speed in dry air.

   R : Dry air is denser than moist air at atmospheric pressure.

**Sol.** Answer (1)

Speed of sound in air is $v = \sqrt{\frac{\gamma P}{\rho}}$

When the air is humid, the density of air reduces as $O_2$ and $N_2$ are heavier than $H_2O$.

Hence speed of sound decreases.

9. A : Sound travels faster in solids as compared to liquids and gases.

   R : Solids are more elastic than liquids and gases.

**Sol.** Answer (1)

$$v = \sqrt{\frac{B}{\rho}}$$

Hence since the Bulk molecules of solids is higher the speed of sound is higher in solids.

Since '$B$' is refer to bulk molecule.

Speed depends on elasticity and reason is correct explanation of assertion.

10. A : There is no energy transferred by standing waves.

    R : The total energy of standing waves is twice the energy of each of incident and reflected wave.

**Sol.** Answer (2)

Both statements are true but reason is not the correct explanation of each other.

11. A : In Doppler's effect the value of apparent frequency depends on the relative motion between source and observer.

    R : The change in frequency in Doppler effect is independent from the distance between source and observer.

**Sol.** Answer (2)

Both the statements are true but reason does not explain the cause for assertion.

12. A : The pitch of female voice is higher than the pitch of male voice.

    R : Pitch distinguishes between a shrill and a grave sound.

**Sol.** Answer (2)

The assertion is a true fact and so is the reason. But the reason offers no explanation for the assertion.

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