Oscillations and Superposition of Waves **Marks: 60**

ANSWER KEY

Physics

Q.1 A	Q.2 D	Q.3 B	Q.4 B	Q.5 D	Q.6 B	Q.7 B	Q.8 A
Q.9 C	Q.10 C	Q.11 C	Q.12 C	Q.13 B	Q.14 A	Q.15 C	Q.16 D
Q.17 C	Q.18 D	Q.19 B	Q.20 A	Q.21 C	Q.22 A	Q.23 B	Q.24 B
Q.25 A	Q.26 C	Q.27 B	Q.28 D	Q.29 D	Q.30 D	Q.31 A	Q.32 D
Q.33 C	Q.34 C	Q.35 C	Q.36 D	Q.37 C	Q.38 B	Q.39 C	Q.40 C
Q.41 A	Q.42 C	Q.43 C	Q.44 A	Q.45 A	Q.46 B	Q.47 D	Q.48 B
Q.49 A	Q.50 D	Q.51 A	Q.52 B	Q.53 C	Q.54 D	Q.55 A	Q.56 D
Q.57 A	Q.58 B	Q.59 B	Q.60 A				

SOLUTION

Physics

Q.1 The end correction for a pipe closed at one end is 'e_1' and for an open pipe it is 'e_2'. The ratio $\frac{e_1}{e_2}$ is

Correct option: (A)

For a closed pipe,

$e_1 = \frac{n_2 l_2 - n_1 l_1}{n_1 - n_2}$

For an open pipe,

$e_2 = \frac{n_2 l_2 - n_1 l_1}{2(n_1 - n_2)}$

$\therefore \frac{e_1}{e_2} = 2$

Q.2 A shot put iron ball of mass 3 kg is rolling on a frictionless horizontal surface with velocity 4 m/s. It collides on the free end of an ideal horizontal spring whose other end is fixed to a rigid support. If the spring constant is 32 N / m, the maximum compression produced in the spring will be

Correct option: (D)

Gain in P.E. of spring = loss in K.E. of iron ball

$\therefore \frac{1}{2}kx^2 = \frac{1}{2}mv^2 + \frac{1}{2}Iw^2$

$= \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)w^2$

$= \frac{1}{2}mv^2 + \frac{1}{5}mv^2$ ....($\because$ v = rw)

$= \frac{7}{10}mv^2$

$\therefore x^2 = \frac{14mv^2}{10k}$

$= \frac{14 \times 3 \times (4)^2}{10 \times 32} = 2.1$

i.e., $x = \sqrt{2.1}$ m

Q.3 A progressive wave is given by, Y = 12 sin (5t – 4x). On this wave, how far away are the two points having a phase difference of 90°?

Correct option: (B)

Given, y = 12 sin (5t – 4x) cm

$\therefore y = 12 \sin 2\pi \left(\frac{5t}{2\pi} - \frac{4x}{2\pi}\right)$

Comparing above eq. with,

$y = A \sin 2\pi\left(\frac{x}{\lambda} - \frac{t}{T}\right)$

We get, $\lambda = \frac{2\pi}{4}$ cm

Relation between phase difference and path difference is

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

$\therefore \frac{\pi}{2} = \frac{2\pi}{\left(\frac{2\pi}{4}\right)}\Delta x$

$\therefore \Delta x = \frac{\pi}{8}$ cm

Q.4 A pendulum is performing simple harmonic motion. The acceleration of the bob is 20 cm s^{-2} at a distance of 5 cm from mean position. The time period of oscillation is

Correct option: (B)

Acceleration, $a = \omega^2 x$

$\omega = \sqrt{\frac{a}{x}} = \sqrt{\frac{20}{5}}$ ....($\because$ a = 20 cm/s^2, x = 5 cm)

ω = 2 rad/s

Period, $T = \frac{2\pi}{\omega} = \pi$ s

Q.5 A body of mass 40 g is executing linear S.H.M. It experiences a force of 0.1 N when it is at a point 2.5 cm from mean position. The period and acceleration of the particle at that point is respectively.

Correct option: (D)

Acceleration a = $\frac{F}{m} = \frac{0.1}{40 \times 10^{-3}}$ = 2.5 ms^{-2}

The direction of acceleration is opposite to the direction of displacement.

∴ a = –2.5 ms^{-1}

Force constant, k = $\frac{F}{x} = \frac{0.1}{2.5 \times 10^{-2}}$ = 4 N/m

Period T = 2π

$$\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{40 \times 10^{-3}}{4}} = \frac{2\pi}{10} = \frac{\pi}{5}s$$

Thinking Hatke

In case of S.H.M., displacement and acceleration are always out of phase. Hence, the acceleration of the body will be negative. This condition is satisfied by option (D) only.

Q.6 A transverse wave is moving along a string. The linear density of a vibrating string is 2 × 10^{-3} kg/m. The wave equation is y = 0.02 sin (2x + 10t) m. The tension in the string is

Correct option: (B)

y = 0.02 sin $[2\pi(2x + 10t)]$

Using, v = $\sqrt{\frac{T}{\mu}} = \frac{\omega}{k}$

$$\Rightarrow \sqrt{\frac{T}{2 \times 10^{-3}}} = \frac{10}{2}$$

∴ T = $(5)^2 \times 2 \times 10^{-3}$ = 25 × 2 × 10^{-3}

∴ T = 5 × 10^{-2} N

Q.7 In Melde's experiment, in parallel position when mass m_1 is kept in the pan, then the number of loops obtained is p_1 and when mass m_2 is kept the number of loops is p_2; then the mass of pan m_0 is

Correct option: (B)

For both the positions in Melde's experiment, Tp^2 = constant.

$\therefore T_1p_1^2 = T_2p_2^2$

$(m_0 + m_1)gp_1^2 = (m_0 + m_2)gp_2^2$

$\therefore m_0p_1^2 + m_1p_1^2 = m_0p_2^2 + m_2p_2^2$

$\therefore m_0\left(p_1^2 - p_2^2\right) = m_2p_2^2 - m_1p_1^2$

$\therefore m_0 = \frac{m_2p_2^2 - m_1p_1^2}{p_1^2 - p_2^2}$

Q.8 In a pipe closed at one end, air column is vibrating in its second overtone. The column has

Correct option: (A)

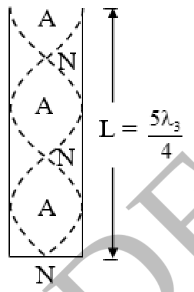
For a pipe closed at one end,

p^{th} mode of vibration: n_p = (2p – 1) $\frac{v}{4L}$

3^{rd} mode of vibration will be second overtone.

3^{rd} mode of vibration: $n_3 = \frac{5v}{4L}$

∴ Second overtone will be fifth harmonics.



∴ The column has 3 nodes and 3 anti-nodes.

Q.9 A particle executes a linear S.H.M. of amplitude 3 cm. When it is at 1 cm from the mean position, the magnitudes of its velocity and acceleration are equal. The maximum velocity is

Correct option: (C)

Velocity, v = $\omega\sqrt{A^2 - x^2}$ and

acceleration = ω^2x

Now given that, $\omega^2x = \omega\sqrt{A^2 - x^2}$

∴ $\omega^2.1 = \omega\sqrt{3^2 - 1^2} \Rightarrow \omega = \sqrt{8} = 2\sqrt{2}$

$v_{max} = A\,\omega = 3 \times 2\sqrt{2} = 6\sqrt{2}$

Q.10 A string of length 2 m is fixed at both ends. If this string vibrates in its fourth normal mode with a frequency of 500 Hz, then the waves would travel on it with a velocity of

Correct option: (C)

For a vibrating string, λ = $\frac{2L}{p}$

where p = Number of loops = Order of vibration or mode

∴ For fourth mode p = 4, λ = $\frac{2(2)}{4}$ = 1 m

$\therefore$ v = n λ = 500 × 1 = 500 m/s

Q.11 What is the change in phase, when longitudinal wave is reflected from denser medium?
Correct option: (C)

when longitudinal wave is reflected from denser medium, the phase changes by π^c.

Q.12 The total energy of a simple harmonic oscillator is 3×10^{-5} J and maximum force acting on the body is 1.5×10^{-3} N. If the period of the motion is 2 s and initial phase is 30°, then the equation of motion will be
Correct option: (C)

$\alpha = 30° = \frac{\pi}{6}$

Using F = –kx, we get

$|F_{max}| = kA = m\omega^2 A$

$\therefore \quad E = \frac{1}{2}m\omega^2 A^2 = \frac{1}{2}|F_{max}| \times A$

$\therefore \quad A = \frac{2E}{|F_{\max}|} = \frac{2\times3\times10^{-5}}{1.5\times10^{-3}} = 4 \times 10^{-2} = 0.04$ m

$\therefore \quad \omega = \frac{2\pi}{T} = \frac{2\pi}{2} = \pi$ rad/s

$\therefore$ The equation of motion is,

$x = A \sin(\omega t + \alpha) = 0.04 \sin\left(\pi t + \frac{\pi}{6}\right)$

Q.13 Fundamental frequency of pipe is 100 Hz and other two frequencies are 300 Hz and 500 Hz, then
Correct option: (B)

For a closed organ pipe, we have

$n_1 : n_2 : n_3$ ….. = 1 : 3 : 5 : …..

Q.14 A ball is released from height 'h' which makes perfectly elastic collision with ground.
The frequency of periodic vibratory motion is
(g = acceleration due to gravity)
Correct option: (A)

If t is the time to reach the ground then

$h = \frac{1}{2} gt^2 \quad \Rightarrow t = \sqrt{\frac{2h}{g}}$

The time taken will be the same to bounce back to height h.

$\therefore$ Period of oscillation $T = 2t = 2\sqrt{\frac{2h}{g}}$

Frequency $f = \frac{1}{T} = \frac{1}{2}\sqrt{\frac{g}{2h}}$

Q.15 Two tuning forks have frequencies 380 Hz and 384 Hz respectively. When they are sounded together, they produce maximum sound. How long will it take to hear the minimum sound?
Correct option: (C)

Time interval between a maxima and consecutive minima is

$\Delta t = \frac{1}{2(n_1 - n_2)} = \frac{1}{2 \times 4} = \frac{1}{8}$ s

Q.16 Equation of a simple harmonic progressive wave is y = 0.03 sin 8π $\left(\frac{t}{0.016} - \frac{x}{1.6}\right)$, where all the quantities are in S.I. units. The velocity of wave is
Correct option: (D)

Given equation is,

$y = 0.03 \sin 8\pi \left(\frac{t}{0.016} - \frac{x}{1.6}\right)$

$= 0.03 \sin 2\pi \left(\frac{t}{0.004} - \frac{x}{0.4}\right)$

$\therefore$ Comparing with the standard form,

$y = A \sin 2\pi \left(\frac{t}{T} - \frac{x}{\lambda}\right)$ we get,

$T = 0.004 \text{ s} = n = \frac{1}{T} = \frac{1}{0.004} = \frac{1000}{4} = 250$ Hz,

$\lambda = 0.4$ m

$\therefore$ Using, $v = n\lambda = 250 \times 0.4 = 100$ m/s

Q.17 For a particle performing S.H.M., the total energy is 'n' times the kinetic energy, when the displacement of a particle from mean position is $\frac{\sqrt{3}}{2}$A, where A is the amplitude of S.H.M.
The value of 'n' is
Correct option: (C)

We know

K.E. = $\frac{1}{2}m\omega^2 (A^2 - x^2)$ and T.E. = $\frac{1}{2}m\omega^2 A^2$

Given: T.E. = n × K.E.

$\frac{1}{2}$ mω^2 A^2 = n × $\frac{1}{2}$ mω^2 (A^2 – x^2)

$\frac{1}{2}$ mω^2 A^2 = n × $\frac{1}{2}$ mω^2 A^2 $\left(1 - \frac{3}{4}\right)$…(given

x = $\frac{\sqrt{3}}{2}A$)

⇒ 1 = n$\left(1 - \frac{3}{4}\right)$

∴ n = 4

Q.18 Two identical straight wires are stretched so as to produce 6 beats per second when vibrating simultaneously with tensions 'T_1' and 'T_2' respectively. On changing the tension slightly in one of them, the beat frequency remains unchanged. This will happen when (Given → $T_1 > T_2$)

Correct option: (D)

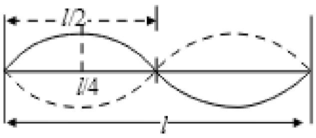
Using, $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$ ⇒ n ∝ $\sqrt{T}$

Beat frequency = $\left|\sqrt{T_1} - \sqrt{T_2}\right| = 6$

To keep beat frequency same:
If T_1 is decreased or T_2 is increased,
$\left|\sqrt{T_1} - \sqrt{T_2}\right|$ remains 6.

Q.19 A second harmonic has to be generated in a string of length and stretched between two rigid supports. The points where the string has to be plucked and touched from one end are

Correct option: (B)



String vibrates with two loops. (Second Harmonic)
The point where we touch the string becomes a node and where we pluck it becomes an antinode.

Q.20 A small body of mass 0.10 kg is executing S.H.M. of amplitude 1.0 m and period 0.20 s. The maximum force acting on it is

Correct option: (A)

a_{max} = Aω^2 = $\frac{A \times 4\pi^2}{T^2} = \frac{1 \times 4 \times (3.14)^2}{0.2 \times 0.2}$

F_{max} = m × a_{max} = $\frac{0.1 \times 4 \times (3.14)^2}{0.2 \times 0.2}$

∴ F_{max} = 98.596 N

Q.21 What is nature of waves on stretched sonometer wire?

Correct option: (C)

The waves on a stretched sonometer wire are *transverse* in nature, meaning the oscillations of the particles in the wire are perpendicular to the direction of wave propagation. The wire is fixed at both ends, which leads to the formation of *stationary waves*, also known as standing waves. These waves are formed by the superposition of two waves travelling in opposite directions. The points where the amplitude is always zero are called nodes, and the points with maximum amplitude are called antinodes. The waves are also *polarized* because the oscillations of the particles are confined to a single plane.
Therefore, the correct answer is *Transverse stationary polarized*.

Q.22 The periodic time of a simple pendulum inside a stationary lift is 'T'. When the lift moves upwards with an acceleration '$\frac{g}{3}$', the periodic time of the simple pendulum will be [g = acceleration due to gravity]

Correct option: (A)

We know,

T = 2π $\sqrt{\frac{l}{g}}$

g_2 = g + $\sqrt{\frac{g}{3}} = \frac{4g}{3}$ …(lift accelerating upwards)

∴ T_2 = 2π $\sqrt{\frac{3l}{4g}}$ = $\sqrt{3}\frac{T}{2}$ …(∵ g_2 = 4g/3)

Q.23 The distance of the body from mean position, where the kinetic energy of a particle performing S.H.M. of amplitude 8 mm, is three times its potential energy is

Correct option: (B)

K.E. = 3 × P.E.

K.E. = $\frac{1}{2}m\omega^2 (A^2 - x^2) = 3 \times \frac{1}{2} m\omega^2 x^2$

$\therefore A^2 = 4x^2 \Rightarrow A = 2x$

$\therefore x = \frac{8}{2} = 4$ mm

Q.24 The maximum velocity and maximum acceleration of a body moving in a simple harmonic oscillator are 2 m/s and 4 m/s^2. The angular velocity is

Correct option: (B)

$v_{max} = A\omega$ and $a_{max} = A\omega^2$

$\therefore \omega = \frac{a_{max}}{v_{max}} = \frac{4}{2} = 2$ rad/s

Q.25 Given equation of S.H.M. is y = 10sin(20t + 0.5). The initial phase is

Correct option: (A)

y = 10 sin (20 t + 0.5)

Comparing with equation y = A sin (ωt + α) we get,

initial phase α = 0.5 rad

Q.26 A small sphere oscillates simple harmonically in a watch glass whose radius of curvature is 90 cm. The period of oscillations of the sphere is (g = 10 ms^{-2})

Correct option: (C)

$T = 2\pi\sqrt{\frac{l}{g}}$

$T = 2\pi\sqrt{\frac{90 \times 10^{-2}}{10}}$

$T = 2\pi \times 0.3$

$T = 0.6\,\pi$

Q.27 Two waves represented by the following equations are travelling in the same medium $y_1 = 5 \sin 2\pi (75t - 0.25x)$, $y_2 = 10 \sin 2\pi (150t - 0.50x)$. The intensity ratio I_1/I_2 of the two waves is

Correct option: (B)

$\frac{I_1}{I_2} = \frac{A_1^2}{A_2^2} \Rightarrow \frac{I_1}{I_2} = \frac{25}{100} = \frac{1}{4}$

Q.28 A carriage is sliding down an inclined plane at an angle of 60° with a simple pendulum of length 1 m, its period of oscillation will be

Correct option: (D)

$T' = 2\pi\sqrt{\frac{l}{g\cos\theta}}$

$= 2\pi\sqrt{\frac{1}{9.8 \times \cos 60^\circ}} = 2\pi\sqrt{\frac{1}{9.8 \times 1/2}}$

$= \sqrt{\frac{2}{9.8}} = \sqrt{\frac{1}{4.9}} = \sqrt{\frac{10}{49}}$

$= \frac{1}{7} \times 3.16 = 0.45$ s

Q.29 The total energy of a particle executing S.H.M. is 80 J. What is the potential energy when the particle is at a distance of 3/4 of amplitude from the mean position?

Correct option: (D)

$x = \frac{3}{4}A \Rightarrow \frac{A^2}{x^2} = \frac{16}{9}$ ….(i)

$\therefore \frac{T.E.}{P.E.} = \frac{\frac{1}{2}m\omega^2 A^2}{\frac{1}{2}m\omega^2 x^2} = \frac{A^2}{x^2} = \frac{16}{9}$ ….[From (i)]

$\therefore \frac{80}{P.E.} = \frac{16}{9} \Rightarrow$ P.E. = 45 J

Q.30 The kinetic energy of a particle performing S.H.M. is $\frac{1}{n}$ times its potential energy. If the amplitude of S.H.M. is 'A' then the displacement of the particle will be

Correct option: (D)

We know,

K.E. = $\frac{1}{2}m\omega^2 (A^2 - x^2)$ and P.E. = $\frac{1}{2}m\omega^2 x^2$

n K.E. = P.E. …(given)

$\Rightarrow n(A^2 - x^2) = x^2$

$nA^2 - nx^2 = x^2$

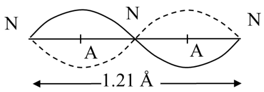
$x^2(1 + n) = nA^2$

$x^2 = \frac{n}{1+n} A^2$

$\therefore\quad x = \sqrt{\frac{n}{1+n}}\,A = \sqrt{\frac{nA^2}{n+1}}$

Q.31 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

Correct option: (A)



Q.32 The lengths of a given open end pipe and a closed end pipe are ‘L_o’ and ‘L_c’ respectively. If both the pipes emit same fundamental notes, then the ratio L_o:L_c is

Correct option: (D)

We know

$n_c = \frac{v}{4l_c}$ and $n_o = \frac{v}{2l_o}$

$n_c = n_o$ …(given)

$\therefore\quad \frac{v}{4l_c} = \frac{v}{2l_o}$

$2l_c = l_o$

$\therefore\quad \frac{l_o}{l_c} = 2$

Q.33 The equation of simple harmonic progressive wave is given by y = a sin 2π $\left(10t - \frac{x}{6.28}\right)$. The maximum particle velocity will be twice the wave velocity if a = [Take π = 3.14]

Correct option: (C)

Equation of the simple harmonic wave is

$y = a \sin 2\pi\left(10t - \frac{x}{6.28}\right)$ ….(i)

Standard equation of a simple harmonic wave is

y = A sin (ωt + kx) ….(ii)

Comparing (i) and (ii)

ω = 2π × 10 = 20π

$k = \frac{2\pi}{6.28} = 1$

Maximum particle velocity $(V_{P_{max}})$ = ω.a

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

Given $(v_P)_{max}$ = 2v

$\omega a = \frac{2\omega}{k}$

$\therefore\quad a = \frac{2}{k}$

but k = 1,

$\therefore$ a = 2

Q.34 A progressive wave of frequency 500 Hz is travelling with a speed of 350 m/s. A compressional maximum appears at a given instant. The minimum time interval after which a rarefactional maximum occurs at the same point is

Correct option: (C)

T = 0.2 s ⇒ n = $\frac{1}{T}$ = 5 Hz

Time interval between two consecutive compressional maxima, T = $\frac{1}{n} = \frac{1}{500}$ s

Time interval between compressional maxima and rarefactional maxima, $\frac{T}{2} = \frac{1}{2n} = \frac{1}{1000}$ s

Q.35 If the length and diameter of a wire are decreased, then for the same tension the natural frequency of stretched wire will

Correct option: (C)

Frequency $n = \frac{1}{2lr}\sqrt{\frac{T}{\pi\rho}}$

$\therefore$ If l and r decreases, the frequency will increase.

Q.36 In a string, stationary waves are produced by

Correct option: (D)

Stationary waves are formed when two waves of the same frequency and amplitude travelling in opposite directions interfere. This interference can be constructive or destructive, resulting in points of maximum displacement (antinodes) and points of zero displacement (nodes). The superposition principle states that when two or more waves meet, the resultant displacement at any point is the vector sum of the displacements of the individual waves. In the case of stationary waves, the superposition of the two waves leads to the formation of a wave pattern that appears to be standing still, hence the name "stationary waves."

Q.37 The length of seconds pendulum at a place where g = 4.9 m/s² is

Correct option: (C)

For seconds pendulum, T = 2 s

$$\therefore 2 = 2\pi\sqrt{\frac{l}{g}}$$

$$\therefore l = \frac{g}{\pi^2} = \frac{4.9}{\pi^2} \approx 50 \text{ cm}$$

Q.38 When two tuning forks are sounded together, 6 beats per second are heard. One of the fork is in unison with 0.70 m length of sonometer wire and another fork is in unison with 0.69 m length of the same sonometer wire. The frequencies of the two tuning forks are

Correct option: (B)

Given number of beats = 6, $l_1 = 0.70\ m,$

$$l_2 = 0.69\ m$$

The frequencies of the given sonometer are as follows:

$$f_1 = \frac{1}{2l_1}\sqrt{\frac{T}{m}}$$

$$f_2 = \frac{1}{2l_2}\sqrt{\frac{T}{m}}$$

$$f_2 - f_1 = 6$$

$$\frac{1}{2l_2}\sqrt{\frac{T}{m}} - \frac{1}{2l_1}\sqrt{\frac{T}{m}} = 6$$

$$\left(\frac{1}{2(0.69)} - \frac{1}{2(0.70)}\right)\sqrt{\frac{T}{m}} = 6$$

$$\sqrt{\frac{T}{m}} = 579.6$$

$$\therefore \quad f_1 = 414\ Hz \text{ and } f_2 = 420\ Hz$$

Q.39 A particle performs S.H.M. Its potential energies are 'U_1' and 'U_2' at displacements 'x_1' and 'x_2' respectively. At displacement ($x_1 + x_2$), its potential energy 'U' is

Correct option: (C)

Potential energy of particle performing SHM is U $= \frac{1}{2}kx^2$

$$\Rightarrow U_1 = \frac{1}{2}kx_1^2$$

$$\therefore \quad x_1 = \sqrt{\frac{2U_1}{k}}$$

$$\Rightarrow U_2 = \frac{1}{2}kx_2^2$$

$$\therefore \quad x_2 = \sqrt{\frac{2U_2}{k}}$$

$$\therefore \quad U = \frac{1}{2}k(x_1 + x_2)^2$$

$$\therefore \quad x_1 + x_2 = \sqrt{\frac{2U}{k}}$$

$$\sqrt{\frac{2U_1}{k}} + \sqrt{\frac{2U_2}{k}} = \sqrt{\frac{2U}{k}}$$

$$\therefore \quad \sqrt{U} = \sqrt{U_1} + \sqrt{U_2}$$

Q.40 The force constant of a wire is k and that of another wire of the same material is 2k. When both the wires are stretched, then work done are related as

Correct option: (C)

$$W_1 = \frac{1}{2}kx^2$$

$$W_2 = \frac{1}{2}(2k)x^2 = 2.\left(\frac{1}{2}kx^2\right)$$

$$\Rightarrow W_2 = 2W_1$$

Q.41 A tuning fork of frequency 340 Hz is held vibrating at the open end of an empty measuring cylinder of length 100 cm. Water is then poured in it slowly. What is the minimum height of water in cylinder, for which resonance will be obtained? Velocity of sound in air = 340 m/s, Neglect end correction.

Correct option: (A)

For a resonance tube,

In the first mode, we have

n = $\frac{V}{4L_1}$ or L_1 =

$$\frac{V}{4n} = \frac{340}{4 \times 340} = 0.25m = 25cm$$

In this case L_1 = $\frac{\lambda}{4} = 25cm$ ⇒ λ = 100 cm

Resonance can also be obtained when the length of the air column is $\frac{3\lambda}{4}$ = 75 cm

Hence the minimum height of water = 100 – 75 = 25 cm

Q.42 If the displacement (x) and velocity (v) of a particle executing simple harmonic motion are related through the expression $4v^2 = 25 - x^2$, then its time period is given by [Assam CEE 2015]

Correct option: (C) 4π

The given equation can be written as,

$v^2 = \frac{1}{4}\,(25 - x^2)$

Comparing with general equation,

$v^2 = \omega^2 (A^2 - x^2)$

∴ $\omega = \frac{1}{2} \Rightarrow T = \frac{2\pi}{\omega} = 4\pi$

Q.43 If stationary waves are being generated, then particles of medium

Correct option: (C)

In stationary waves, the particles of the medium execute **simple harmonic motion** but with varying amplitude. The amplitude is maximum at antinodes and minimum or zero at nodes. So, particles at antinodes oscillate with maximum amplitude, while those at nodes remain stationary.

Q.44 A 1.00 × 10^{-12} kg particle is performing S.H.M with a period of $4\pi^2 \times 10^{-6}$ s and with maximum velocity $\frac{6}{\pi} \times 10^3$ m/s. The maximum displacement from the mean position is

Correct option: (A)

$\omega = \frac{2\pi}{T} = \frac{2\pi}{4\pi^2 \times 10^{-6}} = \frac{1}{2\pi} \times 10^6$

$v_{max} = \omega A$

$\Rightarrow A = \frac{v_{max}}{\omega} = \frac{\frac{6}{\pi} \times 10^3}{\frac{1}{2\pi} \times 10^6} = 12 \times 10^{-3} = 12$ mm

Q.45 Two waves Y_1 = 0.25 sin 316t and Y_2 = 0.25 sin 310t are propagating in same direction. The number of beats produced per second are

Correct option: (A)

From the equations of progressive waves,

$\omega_1 = 2\pi n_1 = 316$ and $\omega_2 = 2\pi n_2 = 310$

∴ $n_1 = \frac{316}{2\pi} = \frac{158}{\pi}$

$n_2 = \frac{310}{2\pi} = \frac{155}{\pi}$

∴ Beat frequency = $n_1 - n_2$

$= \frac{158}{\pi} - \frac{155}{\pi} = \frac{3}{\pi}$

Q.46 A sonometer wire is in unison with a tuning fork. When its length increases by 4%, it gives 8 beats per second with the same fork. The frequency of the fork is

Correct option: (B)

When the length of sonometer wire increases by 4%, the new length,

$l_2 = 1.04\, l_1$

Now, nl = constant

∴ $n_1 l_1 = n_2 (1.04\, l_1) \Rightarrow n_1 = 1.04\, n_2$

∴ $n_2 = n_1 - 8$ …(∵ $n_2 < n_1$)

∴ $n_2 = 1.04\, n_2 - 8$

∴ $0.04\, n_2 = 8 \Rightarrow n_2 = 200$ Hz

Q.47 To make the angular frequency of an oscillator double, we have to

Correct option: (D)

$\omega = \sqrt{\frac{k}{m}} \Rightarrow \frac{\omega_2}{\omega_1} = \sqrt{\frac{m_1}{m_2}}$

∴ $2 = \sqrt{\frac{m_1}{m_2}} \Rightarrow m_2 = \frac{m_1}{4}$

Q.48 y = 6 sin $\frac{\pi x}{6}$ cos 8πt represents a stationary wave. The frequency of the stationary wave in cycles/s is

Correct option: (B)

Comparing given equation with the standard form,

y = A sin $\left(\frac{2\pi x}{\lambda}\right)$.cos (2πnt) we get,

2πtn = 8πt ⇒ n = $\frac{8}{2}$ = 4 cycles / s

Q.49 Two strings X and Y of a sitar produce a beat frequency 4 Hz. When the tension of the string Y is slightly increased the beat frequency is found to be 2 Hz. If the frequency of X is 300 Hz, then the original frequency of Y was

Correct option: (A)

n_x = 300 Hz

x = beat frequency = 4 Hz, which is decreasing after increasing the tension of the string Y.

Also, ∵ $n \propto \sqrt{T}$, tension of wire Y increases so

n_y increases

Hence, if $n_y > n_x$

beat frequency increases, which contradicts the data.

∴ $n_y < n_x$

∴ $n_x - n_y = x$

$n_y = n_x - x = 300 - 4 = 296\ Hz$

Q.50 The equation of motion of a body in S.H.M. is x = 4 sin $\left(\pi t + \frac{\pi}{3}\right)$. The acceleration, in cm/s^2, at the end of 4 s will be

Correct option: (D)

a = $\frac{dv}{dt}$ = – 4π^2 sin$\left(4\pi + \frac{\pi}{3}\right)$

= – 4π^2 sin $\frac{\pi}{3}$ = – 4π^2× $\frac{\sqrt{3}}{2}$ = – $2\sqrt{3}$π^2

cm/s^2

Q.51 The average velocity of a particle performing S.H.M. in one complete vibration is

(A = amplitude of S.H.M., ω = angular velocity)

Correct option: (A)

In one complete vibration, displacement is zero.

∴ Average velocity, v_{avg} = 0

Q.52 Two particles P and Q start from the origin and execute simple harmonic motion along x-axis with the same amplitude and time periods 3 s and 6 s respectively. The ratio of the velocities of P and Q when they meet is

Correct option: (B)

Since the particle start from x = 0 and have the same amplitude but different time periods, they will meet again at x = 0 where their velocities are maximum equal to Aω_1 and Aω_2, i.e.

$\frac{v_1}{v_2} = \frac{\omega_1}{\omega_2} = \frac{2\pi}{T_1} \times \frac{T_2}{2\pi} = \frac{6}{3} = 2$

Q.53 When the potential energy of a particle executing S.H.M. is one-fourth of its maximum value during the oscillation, its displacement from the equilibrium in terms of amplitude 'A' is

Correct option: (C)

The potential energy is $P = \frac{1}{2}\text{kx}^2$

The maximum value of potential energy is

$P_{\max} = \frac{1}{2}\text{kA}^2$

According to the given condition

$\frac{1}{2}\text{kx}^2 = \frac{1}{4}\left(\frac{1}{2}\text{kA}^2\right)$

$\therefore\ x^2 = \frac{A^2}{4}$

$\therefore\ x = \pm\frac{A}{2}$

Q.54 Two particles execute S.H.M. of same amplitude and frequency along the same straight line path. They pass each other when going in opposite directions, each time their displacement is half the amplitude. The phase difference between them is $(\sin 30^\circ = 0 \cdot 5)$

Correct option: (D)

Equation of simple harmonic wave,

y = A sin (ωt + ϕ)

y = $\frac{A}{2}$ …(given)

∴ A sin (ωt + ϕ) = $\frac{A}{2}$

⇒ δ = ωt + ϕ = $\frac{\pi}{6}$ or $\frac{5\pi}{6}$

The phase difference of the two particles when they are crossing each other at y = $\frac{A}{2}$ in opposite directions is given by

$\delta = \delta_1 - \delta_2 = \frac{5\pi}{6} - \frac{\pi}{6} = \frac{2\pi}{3}$

Q.55 It is possible to recognize a person by hearing his voice even if he is hidden behind a solid wall. This is due to the fact that his voice [BCECE 2015]

Correct option: (A) has definite pitch.

Self Explanatory

Q.56 In a resonance tube experiment, a vibrating tuning fork is held above the open end & water level is gradually pushed down. The first & the second resonances occur when the water level is 24.1 cm & 74.1 cm respectively below the open end. The diameter of the tube is

Correct option: (D)

$e = \frac{l_2 - 3l_1}{2}$

$= \frac{74.1 - 3 \times 24.1}{2}$

e = 0.9

But e = 0.3d

$\therefore d = \frac{e}{0.3} = \frac{0.9}{0.3} = 3$ cm

Q.57 Node is that point in longitudinal stationary waves where pressure

Correct option: (A)

At a node, particles do not move, but adjacent particles on either side are moving in opposite directions. This creates the greatest compression and rarefaction around the node, resulting in the maximum pressure variation. Hence, the pressure difference is maximum where displacement is zero.

Q.58 The frequency of vibration of open organ pipe is

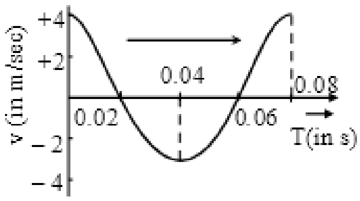
Correct option: (B)

Q.59 If 'v' is velocity and 'a' is acceleration of a particle executing linear simple harmonic motion. Which one of the following statements is correct?

Correct option: (B)

In linear SHM, when velocity v of particle is zero and acceleration a is maximum.

Q.60 The velocity-time diagram of a harmonic oscillator is shown in the adjoining figure. The frequency of oscillation is



Correct option: (A)

From the graph, T = 0.08 s

$\therefore f = \frac{1}{T} = \frac{1}{0.08} = 12.5$ Hz