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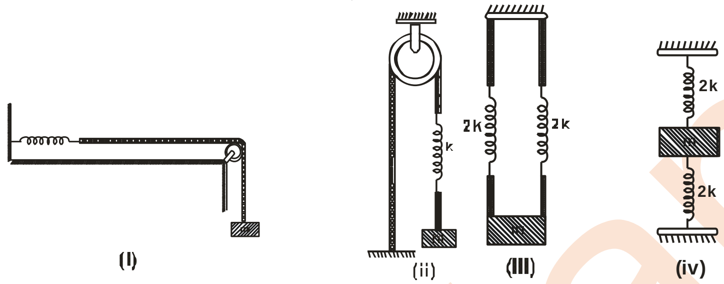
Class: 11
Subject: Physics
Topic: ASK15E11UT07
No. of Questions: 30

Q1. A block of mass m is suspended by different springs of force constant shown in figure. Let time period of oscillation in these four positions be T_1, T_2, T_3 and T_4. Then



(A) $T_1 = T_2 = T_4$ (B) $T_1 = T_2$ and $T_3 = T_4$
(C) $T_1 = T_2 = T_3$ (D) $T_1 = T_3$ and $T_2 = T_4$

Solution: (B) Effective force constant in case (iii) and (iv) is

$k_{eff} = 2k + 2k = 4k$

Therefore, $T_1 = T_2 = 2\pi\sqrt{\frac{m}{k}} = \pi\sqrt{\frac{m}{k}}$

Q2. A particle moves such that its acceleration is given by : $a = -ß(x-2)$ Here ß is a positive constant and x the position from origin. Time period of oscillations is

(A) $2\pi\sqrt{ß}$ (B) $2\pi\sqrt{\frac{1}{ß}}$
(C) $2\pi\sqrt{ß+2}$ (D) $2\pi\sqrt{\frac{1}{ß+2}}$

Solution: (B) a = o at x = 2 i.e. x = 2 is the mean position.

Assuming $x - 2 = X$

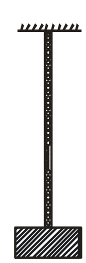
$a = -\beta X$

i.e. $a \propto -X$

oscillations are simple harmonic. Time period of which will be given by :

$$\therefore \quad T = 2\pi\sqrt{\left|\frac{X}{a}\right|} = 2\pi\sqrt{\frac{ml}{YA}}$$

Q3. A wire of length l, area of cross section A and Young's modulus of elasticity Y is suspended from the roof of a building. A block of mass m is attached at lower end of



the wire. If the block is displaced from its mean position and then released the block starts oscillating. Time period of these oscillations will be

(A) $2\pi\sqrt{\frac{AI}{mY}}$ (B) $2\pi\sqrt{\frac{AY}{ml}}$

(C) $2\pi\sqrt{\frac{ml}{YA}}$ (D) $2\pi\sqrt{\frac{m}{YAI}}$

Solution: (C) Force constant of a wire is : k =$\frac{YA}{l}$

$\therefore\ T = 2\pi\sqrt{\frac{m}{k}} \quad = 2\pi\sqrt{\frac{ml}{YA}}$

Q4. Let T_1 and T_2 be the time periods of two springs A and B when a mass m is suspended from them separately. Now both the springs are connected in parallel and same mass m is suspended with them. Now let T be the time period in this position. Then

(A) $T = T_1 + T_2$ (B) $T = \frac{T_1T_2}{T_1+T_2}$

(C) $T^2 = T_1^2 + T_2^2$ (D) $\frac{1}{T^2} = \frac{1}{T_1^2} = \frac{1}{T_2^2}$

Solution: (D) $T_1 = 2\pi\sqrt{\frac{m}{k_1}}$ or $k_1 = \frac{4\pi^2 m}{T_1^2}$

$T_2 = 2\pi\sqrt{\frac{m}{k_2}}$ or $k_2 = \frac{4\pi^2 m}{T_2^2}$

Now $T = 2\pi\sqrt{\frac{m}{k_2}}$ or $k = \frac{4\pi^2 m}{T_2^2}$

In parallel $k = k_1 + k_2$

Substituting the values of k, k_1 and k_2 we get :

$$\frac{1}{T^2} = \frac{1}{T_1^2} + \frac{1}{T_2^2}$$

Q5. A wave disturbance in a medium is described by y(x, t) = 0.02 cos $\left(50\pi t + \frac{\pi}{2}\right)$ cos(10πx) where x and y are in metre and t is in second:

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

(C) The speed wave is 5 ms^{-1} (D) The wave length is 0.3 m

Solution: (C)

Comparing it with y(x, t) = A cos(ωt + π/2)cos kx.

If kx = π/2, a node occurs; ∴ 10πx = π/2 ⇒ x = 0.05m

If kx = π, an antinode occurs ⇒ 10πx = x ⇒ x = 0.1 m

Also speed of wave = ω/k = $\frac{50\pi}{10\pi} = 5m/s$ and λ = 2π/k = 2π/10π= 0.2

Q6. The extension in a string, obeying Hooke's law, is x. The speed of sound in the stretched string is v. If the extension in the string is increased to 1.5x, the speed of sound will be

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

Solution: (A)

According to Hooke's law $F_R \propto x$ [Restoring Force F_R =T, tension of ring]

Velocity of sound by a stretched string

$v = \sqrt{\frac{T}{m}}$ where m is the mass per unit length

$$\therefore \quad \frac{v}{v} = \sqrt{\frac{T}{T'}} \Rightarrow v' = v\sqrt{\frac{T}{T'}} = v\sqrt{\frac{1.5x}{x}} = 1.22v$$

Q7. A whistle giving out 450 Hz approaches a stationary observer at a speed of 33 m/s. The frequency heard by the observer in Hz is

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

Solution: (D)

$33 m/s$ $\qquad$ $V_0 = 0$

$\bullet \longrightarrow$ $\qquad$ $\bullet$

V_S $\qquad$ 0

(Source) (Observer)

$$\nu' = \nu\left[\frac{v}{v - v_s}\right] = 450\left[\frac{330}{330 - 33}\right] = 500Hz$$

Q8. A travelling wave in a stretched string is described by the equation y = A sin (kx – ωt). The maximum particle velocity is

(A) Aω (B) ω/k
(C) dω/dk (D) x/t

Solution: (A)

$$V = \frac{dy}{dt} = -A\omega\cos(kx - \omega t)$$

$\therefore$ $V_{max} = A\omega$

Q9. A siren placed at a railway platform is emitting sound of frequency 5kHz. A passenger sitting in a moving train A records a frequency of 5.5 kHz while the train approaches the

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siren. During his return journey in a different train B he records a frequency of 6.0 kHz while approaching the same siren. The ratio of the velocity of train B to that train A is

(A) 242/252 (B) 2
(C) 5/6 (D) 11/6

Solution: (B)

$$\frac{V_A + V}{V} = \frac{5.5}{5} \text{ and } \frac{V_B + V}{V} = \frac{6}{5} \Rightarrow \frac{V_B}{V_A} = 2$$

Q10. A pendulum clock that keeps correct time on the Earth is taken to the Moon. It will run

(A) at correct rate (B) 6 times faster
(C) √6 times faster (D) √6 times slower.

Solution: (D) g decreases by a factor of 6. T increases by a factor of√6. So, the clock is √6 times slower.

Q11. A horizontal platform with an object placed on it is executing SHM in the vertical direction. The amplitude of oscillation is 2.5 cm. What must be the least period of these oscillation so that the object is not detached ? (Given : g = 10 m s^{-2})

(A) π s (B) $\frac{\pi}{5}$ s
(C) $\frac{\pi}{10}$ s (D) $\frac{\pi}{15}$ s

Solution:(C) $m\omega^2 a = mg \text{ or } \omega = \sqrt{\frac{g}{a}}$

$$\text{or } \frac{T}{2\pi} = \sqrt{\frac{a}{g}} \text{ or } T = 2\pi\sqrt{\frac{a}{g}} = 2\pi\sqrt{\frac{2.5}{1000}} = \frac{\pi}{10} s$$

Q12. A forced oscillator is acted upon by a force $F = F_0 \sin \omega t$. The amplitude of the oscillator is given by $\frac{55}{\sqrt{2\omega^2 - 36\omega + 9}}$. What is the resonant angular frequency ?

(A) 2 units (B) 9 units
(C) 18 units (D) 36 units

Solution:(B) At resonance, amplitude should be maximum.
This is possible if $2\omega^2 - 36\omega + 9$ is minimum.

$$\therefore \frac{d}{d\omega}[2\omega^2 - 36\omega + 9] = 0$$

or $\quad 4\omega - 36 = 0$ or $\omega = 9$ units

Q13. Two simple harmonic motions are represented by :

$y_1 = 10\sin\left(4\pi t + \frac{\pi}{4}\right)$ and $y_2 = 5\left(\sin 4\pi t + \sqrt{3}\cos 4\pi t\right)$. The ratio of the amplitudes of two SHM is

(A) 1 : 1 (B) 1 : 2

(C) 2 : 1 (D) $1 : \sqrt{3}$

Solution:(A) In the second case, amplitude is $\sqrt{5^2 + (5\sqrt{3})^2}$

i.e. $\sqrt{25+75}$ i.e. $\sqrt{100}$ or 10 units.

So, the ratio of amplitudes is 1 : 1.

Q14. The vertical extension in a light spring by a weight of 1 kg is 9.8 cm. The period of oscillation is

(A) $\frac{\pi}{5}$ second (B) $\frac{2\pi}{5}$ second

(C) $\frac{\pi}{10}$ second (D) $\frac{5}{\pi}$ second

Solution:(A) $T = 2\pi\sqrt{\frac{1}{g}} = 2\pi\sqrt{\frac{9.8}{980}}s = \frac{2\pi}{10}s = \frac{\pi}{5}s$

Q15. The period of a simple pendulum, whose bob is a hollow metallic sphere, is T. The period is T_1 when the bob is filled with sand, T_2 when it is filled with mercury and T_3 when it is half filled with sand. Which of the following is true?

(A) $T = T_1 = T_2 > T_2$ (B) $T_1 = T_2 > T_3 > T$

(C) $T > T_3 > T_1 = T_2$ (D) $T = T_1 = T_2 < T_3$

Solution: (D) In the following cases, the location of centre of gravity is same.

(i) hollow sphere

(ii) sphere filled with sand

(iii) sphere filled with mercury.

So, effective value of l is same and hence T is same. In the case of half-filled sphere, the C.G. is below the geometrical centre. So, l and hence T increases.

Q16. What is the spring constant for the combination of springs shown in Fig.9?

(A) k (B) 2k

(C) 4k (D) $\frac{5k}{2}$

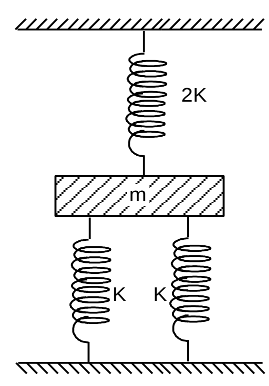

Fig.9

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Solution:(C) Treat the given system as a parallel combination of springs.

Q17. A particle executes simple harmonic motion under the restoring force provided by a spring. The time period is T. If the spring is divided in two equal parts and one part is used to continue the simple harmonic motion, the time period will

(A) remain T
(B) become 2T
(C) become T/2
(D) become T/√2

Solution:(D) k si doubled.

$$T = 2\pi\sqrt{\frac{m}{k}};\ T' = 2\pi\sqrt{\frac{m}{2k}}$$

$$\frac{T'}{T} = \frac{1}{\sqrt{2}} \text{ or } T' = \frac{T}{\sqrt{2}}$$

Q18. A cylindrical tube, open at both ends has a fundamental frequency 'f' in air. The tube is vertically dipped in water so that half of it is in water, the fundamental frequency of the air column is

(A) f/2
(B) 3f/4
(C) f
(D) 2f

Solution: (C) For open tube f = f = v/2λ. On dipping the tube in water, it becomes a closed tube.

For closed tube $f' = \frac{v}{2\lambda'} = v \Big/ 4\left(\frac{\lambda}{2}\right) = \frac{v}{2\lambda} = f$

Q19. The amplitude of a wave disturbance propagating in the positive x-direction is given by $y = 1/(1 + x^2)$ at time t = 0 and by $y = 1/[1 + (x - 1)^2$ at t = 2 seconds, where x and y are in metres. The shape of the wave disturbance does not change during the propagation. The velocity of the wave is

(A) 1 ms^{-1} (B)
0.5 ms^{-1}
(C) 1.5 ms^{-1}
(D) 2 ms^{-1}

Solution: (B) Writing the general expression for y in terms of x as

$y = \frac{1}{1+(x - vt)^2}$ at t = 0, $y = 1/(1 + x)^2$

At t = 2 s, $y = \frac{1}{1+[x - v(2)]^2}$

Comparing with the given equation we get 2v = 1 and v = 0.5 m/s.

Q20. A train has just completed a U-curve in a track which is a semicircle. The engine is at forward end of the semicircular part of the track while the last carriage is at the rear end of the semi-circular track. The driver blows a whistle of frequency 200Hz. Velocity of sound is 340 m/s. Then the apparent frequency as observed by a passenger in the middle of the train, when the need of the train is 30 m/s is

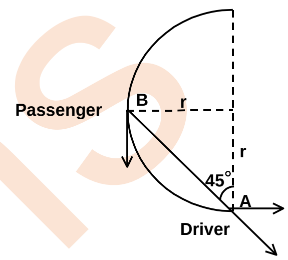
(A) 219Hz (B) 288 Hz
(C) 200Hz (D) 181Hz

Solution: (C) Velocity component of the source in the direction of motion of sound = 30 cos45° along BA.

Velocity component of observer in the direction

BA = 30 cos45°.

∴ There is no relative motion between the source and the observer, hence no change in real frequency is observed.



Q21. Two waves represented by y_1 =10 sin(2000 πt+2x) and y_2=10 sin (2000 π t +2x+π/2) are superposed at any point at a particular instant. The resultant amplitude is:

(A) 10 units (B) 20 units
(C) 14.1 units (D) zero

Solution: (C) The resultant amplitude A of two waves of amplitudes a_1 and a_2 at a phase difference ϕ is $((a_1^2 + a_2^2 + 2a_1a_2\cos\phi)^{1/2}$

Substituting

$a_1 = 10$, $a_2 = 10$ and $\phi = 90^0$, we get A = 14.1.

Q22. A transverse wave is described by the equation $y = y_0 \sin 2\pi\,(ft - x/a)$. The maximum particle velocity is equal to four times the wave velocity if a is equal to

(A) $\pi y_0 / 4$ (B) $\pi y_0/2$
(C) πy_0 (D) $2\pi y_0$

Solution: (B) The maximum particle velocity of a SHM of amplitude Y_0 and frequency f is $2\pi f Y_0$. The wave velocity is $f\lambda$. For $2\pi fY_0$ to be equal to $4f\lambda$, λ has to be $\pi Y_0 / 2$

(Here λ = a).

Q23. When a particle oscillates simple harmonically, its kinetic energy varies periodically. If frequency of the particle is 'n', the frequency of the kinetic energy is

(A) n/2 (B) n
(C) 2n (D) 4n

Solution: K.E. $= \frac{m\omega^2}{2}(A^2 - y^2) = \frac{m\omega^2}{2}[A^2 - (A\sin(\omega t + \phi))^2]$

$= \frac{m\omega^2}{2}[A^2 - A^2\sin^2(\omega t + \phi)]$

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$$= \frac{m\omega^2 A^2}{2}[\cos^2(\omega t + \phi)]$$

$$= \frac{m\omega^2 A^2}{4}[1 + \cos(2\omega t + 2\phi)]$$

$\therefore$ Frequency $= \frac{2\omega}{2\pi} = 2n$

Q24. An accurate pendulum clock is mounted on the ground floor of high building. How much time will it lose or gain in one day if it is transferred to top storey of a building which is h = 200m higher than the ground floor. Radius of earth is 6.4×10^6m.

(A) it will lose 6.2s
(B) it will lose 2.7s
(C) it will gain 5.2s
(D) it will gain 1.6s

Solution: (B) $T = 2\pi\sqrt{\frac{l}{g}}$ or $T \propto \frac{1}{\sqrt{g}}$

$\therefore$ $$\frac{T'}{T} = \sqrt{\frac{g}{g'}}$$

But $$g' = \frac{g}{\left(1+\frac{h}{R}\right)^2}$$

Or $$\frac{g'}{g} = \frac{1}{\left(1+\frac{h}{R}\right)^2}$$

$\therefore$ $$\frac{T'}{T} = \left(1+\frac{h}{R}\right)$$

or $$T' = T\left(1+\frac{h}{R}\right)$$

Since T'>T, the clock will lose the time.

$\therefore$ $$\Delta T = T' - T = T\left(\frac{h}{R}\right)$$

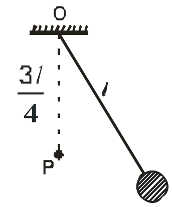
$\therefore$ Time lost in t = 1 day is

$$\Delta t = \left(\frac{\Delta t}{T'}\right)t$$

$$= \frac{t(h/R)}{(1+h/R)} \approx t\left(\frac{h}{R}\right)$$

$$= \frac{(24\times 3600)(200)}{6.4\times 10^6}\text{ s} = 2.7\text{ s}$$

25. A pendulum has time period T for small oscillations. An obstacle P is situated below the point of suspension O at a distance $\frac{3l}{4}$. The pendulum is released from rest. Throughout the motion the moving string makes small angle with vertical. Time after which the pendulum returns back to its initial position is



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

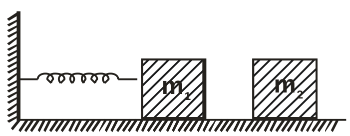
(C) $\frac{3T}{5}$ (D) $\frac{4T}{5}$

Solution: (B) After P length of pendulum becomes $\frac{l}{4}$

Now as T α $\sqrt{l}$, so after P time period will become T' = T/2, Therefore, the desired time will be :

$$t = \frac{T}{2} + \frac{T'}{2} = \frac{T}{2} + \frac{T}{4} = \frac{3T}{4}$$

Q26. The two block of mass m_1 and m_2 are kept on a smooth horizontal table as shown in figure. Block of mass m_1 but not m_2 is fastened to the spring. If now both the blocks are pushed to the left so that the spring is compressed a distance d. The amplitude of oscillation of block of mass m_1, after the system is released is



(A) $b\sqrt{\frac{m_1}{m_1+m_2}}$

(B) $d\sqrt{\frac{m_2}{m_1+m_2}}$

(C) $d\sqrt{\frac{2m_2}{m_1+m_2}}$

(D) $d\sqrt{\frac{2m_1}{m_1+m_2}}$

Solution: (A)

Block of mass m_2 shoots off carrying some kinetic energy away from the system. To find its speed. Potential energy of spring = maximum kinetic energy of blocks.

$$\therefore \qquad \frac{kd^2}{2} = (m_1 + m_2)\frac{v^2}{4}$$

(k = force constant of spring)

or $$v^2 = \frac{kd^2}{m_1 + m_2}$$

with m_1 alone on the spring :

maximum potential energy = maximum kinetic energy of m_1.

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or $\frac{1}{2}kA^2 = \frac{1}{2}m_1v^2$

or $KA^2 = \frac{km_1d^2}{m_1 + m_2}$

or $A = d\sqrt{\frac{m_1}{m_2 + m_2}}$

27. A source of sound emitting a note of frequency 200Hz moves towards an observer with a velocity v equal to the velocity of sound. If the observer also moves away from the source with the same velocity v, the apparent frequency heard by the observer is

(A) 50Hz (B) 100Hz

(C) 150Hz (D) 200Hz

Solution: (D) No relative motion between source and observers.

CMP : A small here of radius R is arranged to pulsate so that its radius varies in simple harmonic motion between a minimum of R – ΔR and a maximum of R + ΔR with frequency f. This produces sound waves in the surrounding air of density ρ and bulk modulus B (The amplitude of oscillation of the here is the same as that of the air at the surface of the here).

Q27. Find the intensity of sound waves at the surface of the here

(A) $\sqrt{\rho B}\,\pi^2 f^2 (\Delta R)^2$ (B) $2\sqrt{\rho B}\,\pi^2 f^2 (\Delta R)^2$

(C) $4\sqrt{\rho B}\,\pi^2 f^2 (\Delta R)^2$ (D) $8\sqrt{\rho B}\,\pi^2 f^2 R^2$

Solution: (B) The density is (by definition) the time average value of P (x, t)v_y (x, t). For any value of x the average value of function $\cos^2 (Kx - \omega t)$ over one period\

$T = \frac{2\pi}{\omega}$ is half $\therefore\ I = \frac{1}{2}B\omega KA^2$

By using the relation $\omega = vk$ and $v^2 = \frac{B}{\rho}$

So we get $I = \frac{1}{2}\sqrt{\rho B}\omega^2 A^2$ (intensity of sinusoidal wave)

The amplitude of oscillation is ΔR.

Hence, $I = \frac{1}{2}\sqrt{\rho B}\,(2\pi f)^2 (\Delta R)^2 \Rightarrow 2\pi^2 f^2 \sqrt{(\rho B)}(\Delta R)^2$

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Q28. The total acoustic power radiated by the here will be

(A) $\sqrt{\rho B}\,\pi^3 f^2 R^2 (\Delta R)^2$ (B) $2\sqrt{\rho B}\,\pi^3 f^2 R^2 (\Delta R)^2$

(C) $4\sqrt{\rho B}\,\pi^2 f^2 R^2 (\Delta R)^2$ (D) $8\pi^3 \sqrt{\rho B}\, f^2 R^2 (\Delta R)^2$

Solution: (D) $P = I \times (\text{Area}) = I \times 4\pi R^2 = 8\pi^3 f^2 \sqrt{\rho B}\, R^2 (\Delta R)^2$

Q29. At a distance d > > R from the centre of the here, find the amplitude.

(A) $\left(\frac{R}{d}\right)(\Delta R)$ (B) $2.\left(\frac{Rf}{d}\right)^2 \pi^2 \sqrt{\rho B}\,(\Delta R)^2$

(C) $4.\left(\frac{Rf}{d}\right)^2 \pi^2 \sqrt{\rho B}\,(\Delta R)^2$ (D) $\left(\frac{Rf}{d}\right)\pi^2 \sqrt{\rho B}\,(\Delta R)^2$

Solution: (A)

$$A = \frac{P_{max}}{BK} = \frac{P_{max}\lambda}{2\pi B} = \frac{P_{max} v}{2\pi f B} = v\sqrt{\rho B}\left(\frac{R}{d}\right)\Delta R$$

But $v = \sqrt{\frac{B}{\rho}}$ $\therefore$ $v\sqrt{\frac{\rho}{B}} = 1$

Hence $A = \left(\frac{R}{d}\right)\Delta R$

Q30. At a distance d > > R from the centre of the here, find pressure amplitude

(A) $\pi\sqrt{\rho B}\left(\frac{Rf}{d}\right)\Delta R$ (B) $2\pi^2\sqrt{\rho B}\left(\frac{Rf}{d}\right)^2 (\Delta R)^2$

(C) $2\pi\sqrt{\rho B}\left(\frac{Rf}{d}\right)(\Delta R)$ (D) $4\pi\sqrt{\rho B}\left(\frac{Rf}{d}\right)^2 (\Delta R)^2$

Solution: (C) $I = \frac{P_{max}^2}{2\sqrt{\rho B}}$

Hence, $P_{max} = 2\pi\sqrt{\rho B}.\left(\frac{Rf}{d}\right)\Delta R$