DPP – 4 (SHM)

Video Solution on Website:- https://physicsaholics.com/home/courseDetails/90

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Q 1. Vertical displacement of a plank with a body of mass m on it is varying according to law y = sin ωt + $\sqrt{3}$cos ωt. The minimum value of ω for which the mass just breaks off the plank and the moment it occurs first after t = 0, are given by:(y is positive vertically upwards)

(a) $\sqrt{\frac{g}{2}}, \frac{\sqrt{2}}{6}\frac{\pi}{\sqrt{g}}$ (b) $\frac{g}{\sqrt{2}}, \frac{2}{3}\sqrt{\frac{\pi}{g}}$ (c) $\sqrt{\frac{g}{2}}, \frac{\pi}{3}\sqrt{\frac{2}{g}}$ (d) $\sqrt{2g}, \sqrt{\frac{2\pi}{3g}}$

Q 2. Four simple harmonic vibrations x_1 = 8 sin ωt, x_2 = 6 sin (ωt + π/2), x_3 = 4 sin (ωt + π)andx_4 = 2 sin (ωt + 3π/2) are superimposed on each other. The resulting amplitude and its phase difference with x_1 are respectively:

(a) 20 $\tan^{-1}\left(\frac{1}{2}\right)$ (b) $4\sqrt{2}, \frac{\pi}{2}$ (c) 20 $\tan^{-1}(2)$ (d) $4\sqrt{2}, \frac{\pi}{4}$

Q 3. Two linear simple harmonic motions of equal amplitude and frequency are impressed on a particle along x and y axis respectively. The initial phase difference between them is π/2. The resultant path followed by the particle is:

(a) a circle (b) a straight line (c) an ellipse (d) a parabola

Q 4. A simple pendulum (whose length is less than that of a second's pendulum) and a second's pendulum starts swinging in phase. They again swing in phase after an interval of 18 second from the start. The period of the simple pendulum is –

(a) 0.9 sec (b) 1.8 sec (c) 2.7 sec (d) 3.6 sec

Q 5. A pendulum has time period T for small oscillations. An obstacle P is situated below the point of suspension O at a distance 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:

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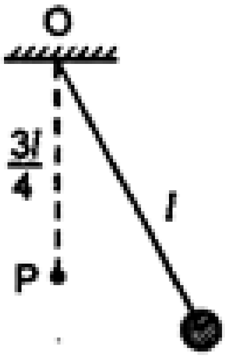


(a) T (b) $\frac{3T}{4}$ (c) $\frac{3T}{5}$ (d) $\frac{4T}{5}$

Q 6. Time period of a simple pendulum of length L is T_1 and Time period of a uniform rod of the same length L pivoted about one end and oscillating in a vertical plane is T_2. Amplitude of oscillations in both the cases is small. Then T_1 / T_2 is

(a) $\sqrt{\frac{4}{3}}$ (b) 1 (c) $\sqrt{\frac{3}{2}}$ (d) $\sqrt{\frac{1}{3}}$

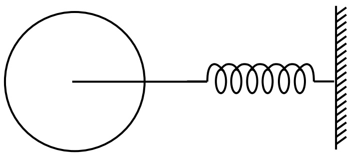
Q 7. The period of oscillation of simple pendulum of length L suspended from the roof of the vehicle which moves without friction, down an inclined plane of inclination α, is given by:

(a) $2\pi\sqrt{\frac{L}{g\cos\alpha}}$ (b) $2\pi\sqrt{\frac{L}{g\sin\alpha}}$ (c) $2\pi\sqrt{\frac{L}{g}}$ (d) $2\pi\sqrt{\frac{L}{g\tan\alpha}}$

Q 8. A ball is suspended by an inextensible thread of length l from a point on a vertical wall. The ball is displaced away from the wall such that the thread makes a very small angle with it and then left free. Assuming the collision of the ball with the wall to be perfectly elastic, the time period of the resulting oscillations is

(a) $T = 2\pi\sqrt{\frac{\ell}{g}}$ (b) $T = \pi\sqrt{\frac{\ell}{g}}$ (c) $T = 2\pi\sqrt{\frac{\ell}{2g}}$ (d) T = 0

Q 9. A solid sphere (M) attached to a massless spring (K) can roll without slipping along a horizontal surface. If the system is released after an initial stretch, the time period will be–



(a) $2\pi\sqrt{\frac{3M}{2K}}$ (b) $2\pi\sqrt{\frac{3M}{5K}}$ (c) $2\pi\sqrt{\frac{7M}{5K}}$ (d) $2\pi\sqrt{\frac{M}{K}}$

Q 10. The pulley shown in figure has a MOI I about its axis and mass M. Find the time period of vertical oscillations of its COM. The spring has a spring constant k and the string does not slip over the pulley

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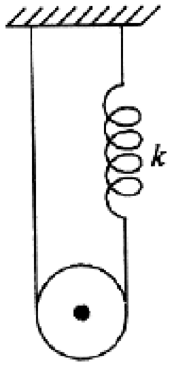
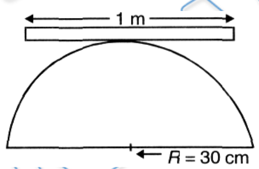


(a) $2\pi\sqrt{\frac{3M}{8K}}$ (b) $2\pi\sqrt{\frac{3M}{5K}}$ (c) $2\pi\sqrt{\frac{7M}{5K}}$ (d) $2\pi\sqrt{\frac{M}{K}}$

Q 11. In y = A sin ωt + A $\sin\left(\omega t + \frac{2\pi}{3}\right)$ match the following table:

Column-I	Column-II
(A) Motion	(P) is periodic but not SHM
(B) Amplitude	(Q) is SHM
(C) Initial phase	(R) A
(D) Maximum velocity	(S) $\pi/3$
	(T) ω A/2
	(U) None

Q 12 A uniform meter scale is balanced on fixed semicircular cylinder of radius 30 cm as shown. One end of scale is slightly depressed and released. Time period of oscillation is



(a) π (b) π/2 (c) π/3 (d) π/4

Q 13. A uniform rod of mass m = 1.5 kg suspended by two identical threads 90 cm as in figure. Then find time period of oscillation of rod

(a) 2 s (b) 2.1 s (c) 2.4 s (d) 1.9 s

Q 14. A compound pendulum of mass 1kg is made to oscillate at distances 20 cms and 40cms on both sides of the center of gravity. The time period is 1.5 sec in both cases. Its M.I. about the axis through the center of gravity in kg × m^2 units is-

(a) 2×10^{-2} (b) 4×10^{-2} (c) 8×10^{-2} (d) 800

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Q 15. A hollow metal sphere is filled with water and hung by a long thread. A small hole is drilled at the bottom through which water slowly flows out. Now the sphere is made to oscillate, the period of oscillation of the pendulum –

(a) Remains constant
(b) Continuously decreases
(c) Continuously increases
(d) First increases and then decreases

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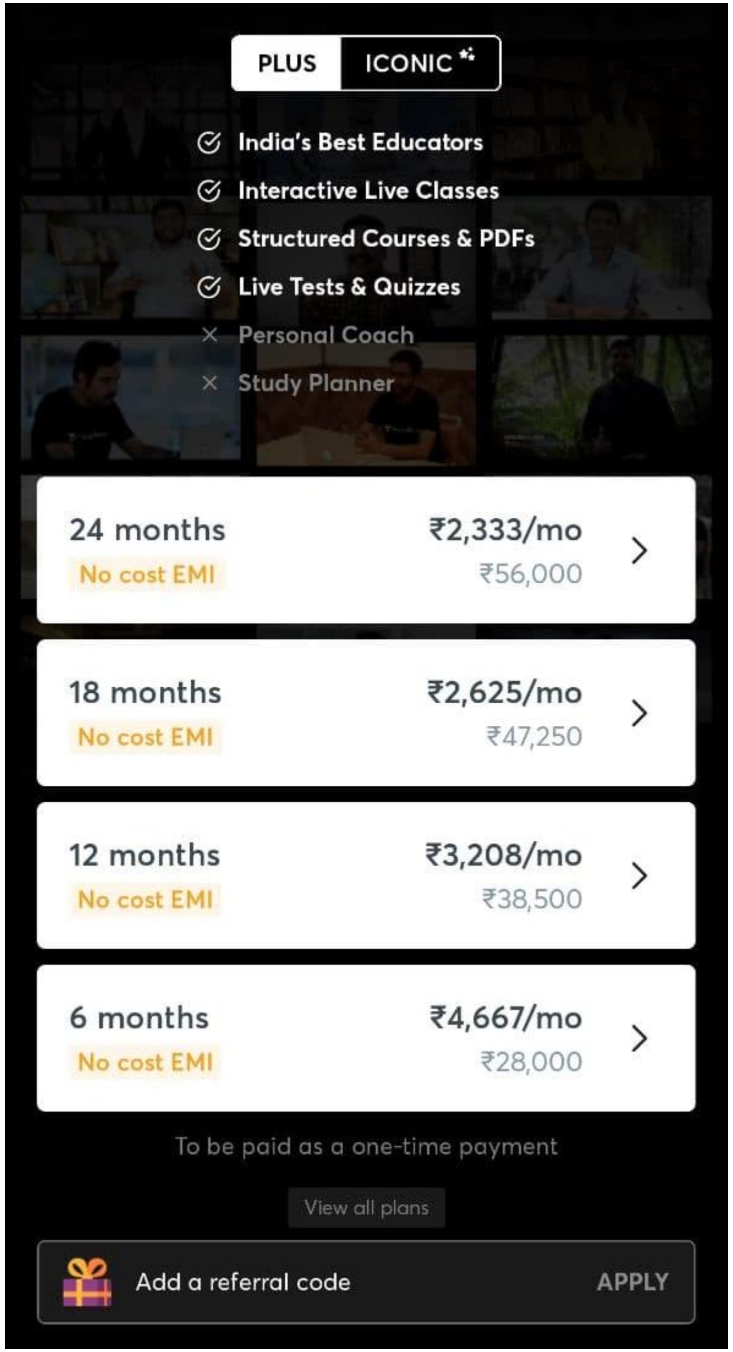
Answer Key

Q.1 a	**Q.2 d**	**Q.3 a**	**Q.4 b**	**Q.5 b**
Q.6 c	**Q.7 a**	**Q.8 b**	**Q.9 c**	**Q.10 a**
Q.11 A(Q), B(R), C(S), D(U)		**Q.12 c**	**Q.13 d**	**Q.14 c**
Q.15 d				



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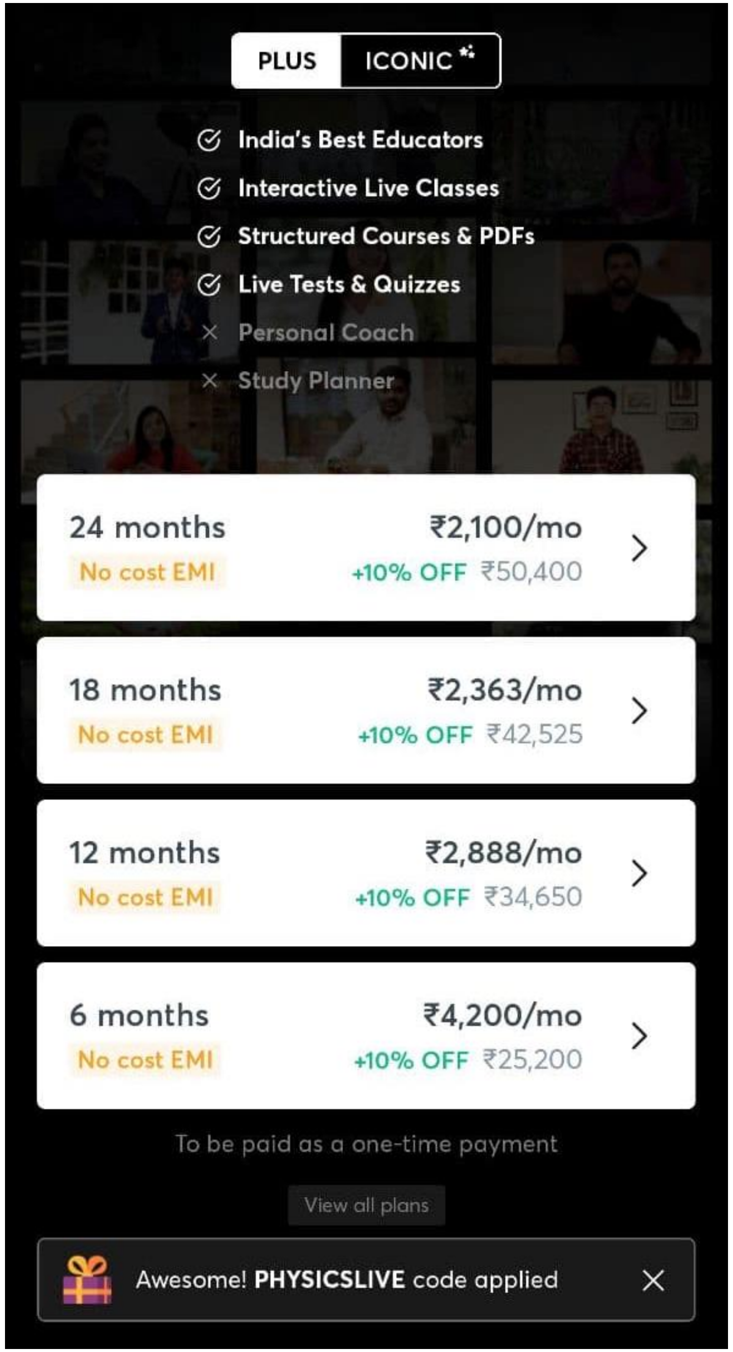

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Physics DPP- Solution

DPP- 4 S.H.M. : Angular S.H.M. ,Simple and compound Pendulum,Superposition of S.H.M.

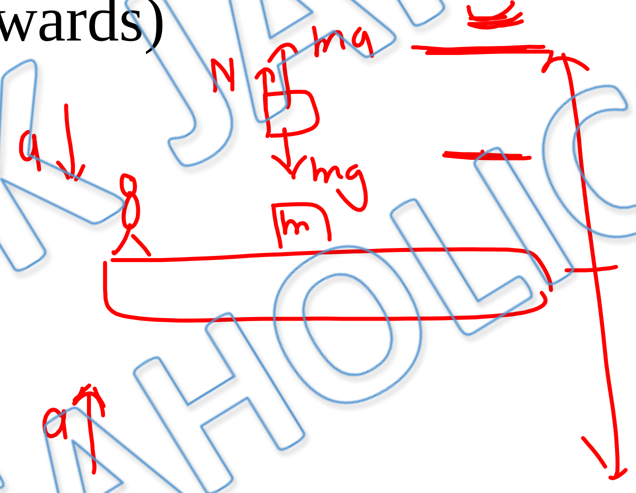
By Physicsaholics Team

Q1) Vertical displacement of a plank with a body of mass m on it is varying according to law $y = \sin \omega t + \sqrt{3}\cos \omega t$. The minimum value of ω for which the mass just breaks off the plank and the moment it occurs first after $t = 0$, are given by:(y is positive vertically upwards)

$y = \sin \omega t + \sqrt{3} \cos \omega t$

$= 1 \sin \omega t + \sqrt{3} \sin(\omega t + \pi/2)$

$= 2 \sin(\omega t + \pi/3)$



a is maximum at extreme

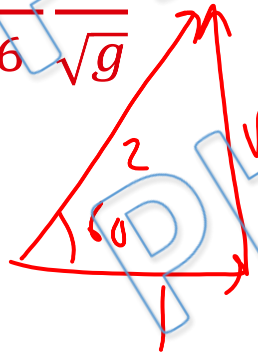
⇒ block will loose contact at extreme.

$ma = mg$

$\omega^2 A = g$

$\omega^2 = g/2 \Rightarrow \omega = \sqrt{g/2}$

(a) $\sqrt{\frac{g}{2}}, \frac{\sqrt{2}}{6}\frac{\pi}{\sqrt{g}}$ (b) $\frac{g}{\sqrt{2}}, \frac{2}{3}\sqrt{\frac{\pi}{g}}$ (c) $\sqrt{\frac{g}{2}}, \frac{\pi}{3}\sqrt{\frac{2}{g}}$ (d) $\sqrt{2g}, \sqrt{\frac{2\pi}{3g}}$



At +ve extreme

$\omega t + \pi/3 = \pi/2$

$\omega t = \pi/6 \Rightarrow t = \frac{\pi}{6\omega} = \frac{\pi}{6}\sqrt{\frac{2}{g}}$

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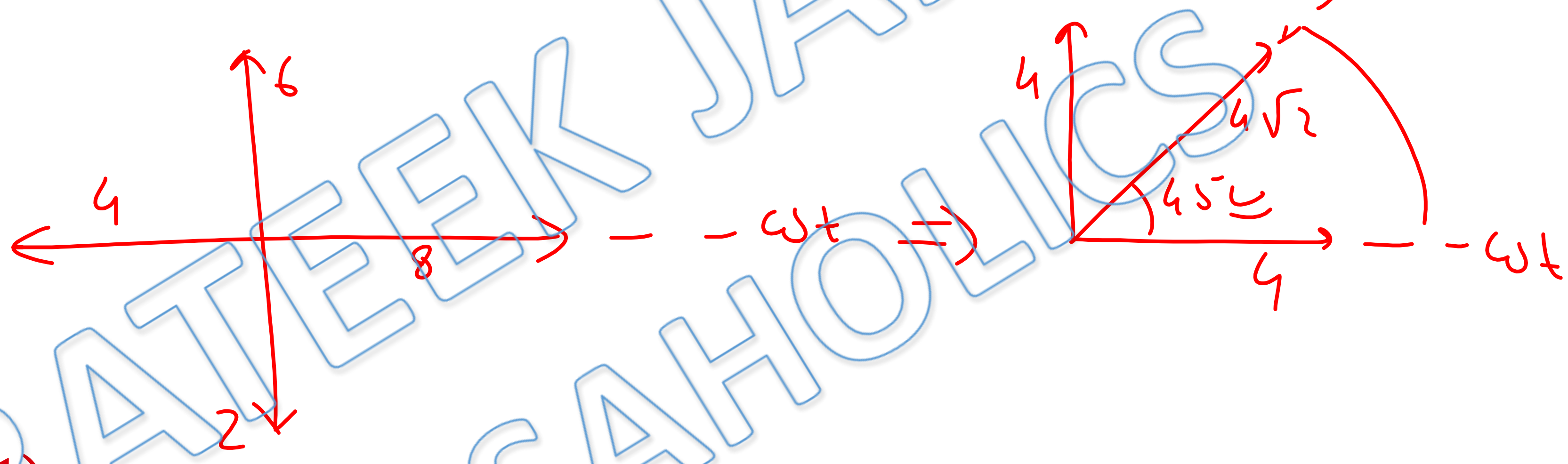
Q2) Four simple harmonic vibrations $x_1 = 8 \sin \omega t$, $x_2 = 6 \sin(\omega t + \pi/2)$, $x_3 = 4 \sin(\omega t + \pi)$ and $x_4 = 2 \sin(\omega t + 3\pi/2)$ are superimposed on each other. The resulting amplitude and its phase difference with x_1 are respectively:



(a) $20 \tan^{-1}\left(\frac{1}{2}\right)$

(b) $4\sqrt{2}, \frac{\pi}{2}$

(c) $20 \tan^{-1}(2)$

(d) $4\sqrt{2}, \frac{\pi}{4}$

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Q3) Two linear simple harmonic motions of equal amplitude and frequency are impressed on a particle along x and y axis respectively. The initial phase difference between them is π/2. The resultant path followed by the particle is:

$x = A \sin \omega t$

$y = A \sin(\omega t + \pi/2)$

$y = A \cos \omega t$

(a) a circle (b) a straight line (c) an ellipse (d) a parabola

$\sin^2 \omega t + \cos^2 \omega t = 1$

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

$x^2 + y^2 = A^2$

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$T < 2$ Sec
$\omega_1 > \omega_2$

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

ω_2

Q4) A simple pendulum (whose length is less than that of a second's pendulum) and a second's pendulum starts swinging in phase. They again swing in phase after an interval of 18 second from the start. The period of the simple pendulum is -

for Simple pendulum $\psi_1 = \omega_1 t + \phi$

" Second " $\psi_2 = \omega_2 t + \phi$

$\Delta\psi = (\omega_1 - \omega_2)t$

When they will be again in same phase

(a) 0.9 sec (b) 1.8 sec
(c) 2.7 sec (d) 3.6 sec

$(\omega_1 - \omega_2)t = 2\pi$

$\left(\frac{2\pi}{T_1} - \frac{2\pi}{2}\right)18 = 2\pi$

$\Rightarrow \frac{1}{T_1} - \frac{1}{2} = \frac{1}{18}$

$\Rightarrow \frac{1}{T_1} = \frac{1}{18} + \frac{1}{2} = \frac{1+9}{18}$

$T_1 = 18$ Sec

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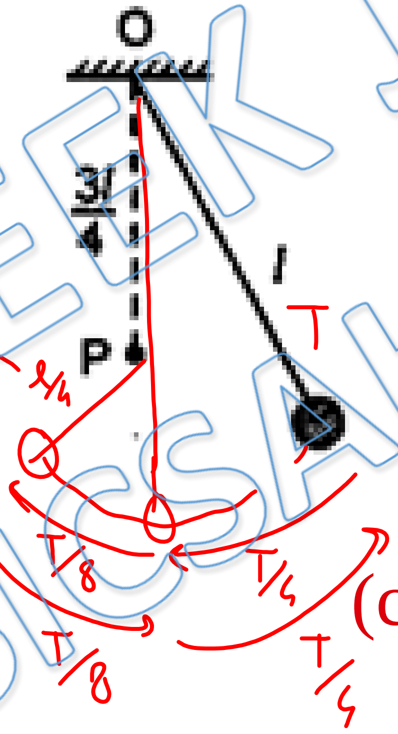
Q5) A pendulum has time period T for small oscillations. An obstacle P is situated below the point of suspension O at a distance 3ℓ/4. The pendulum is released from rest. Throughout the motion the moving string makes small angle with vertical. Time after which the pendulum returns back to its initial position is:



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

(a) T (b) $\frac{3T}{4}$ (c) $\frac{3T}{5}$ (d) $\frac{4T}{5}$

Total time in one round $= T/4 + T/4 + T/8 + T/8$

$= T/2 + T/4 = 3T/4$

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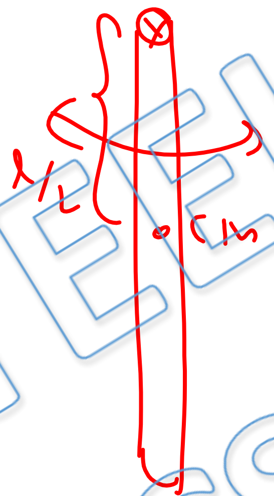
Q6) Time period of a simple pendulum of length L is T_1 and Time period of a uniform rod of the same length L pivoted about one end and oscillating in a vertical plane is T_2. Amplitude of oscillations in both the cases is small. Then T_1 / T_2 is

$$T_1 = 2\pi\sqrt{\frac{l}{g}}$$



$$T_2 = 2\pi\sqrt{\frac{I}{mgl}} = 2\pi\sqrt{\frac{ml^2}{3mg\,l/2}}$$

$$= 2\pi\sqrt{\frac{2l}{3g}}$$

(a) $\sqrt{\frac{4}{3}}$ (b) 1 (c) $\sqrt{\frac{3}{2}}$ (d) $\sqrt{\frac{1}{3}}$

$$T_2 = \sqrt{\frac{2}{3}}\,T_1$$

$$\frac{T_1}{T_2} = \sqrt{3/2}$$

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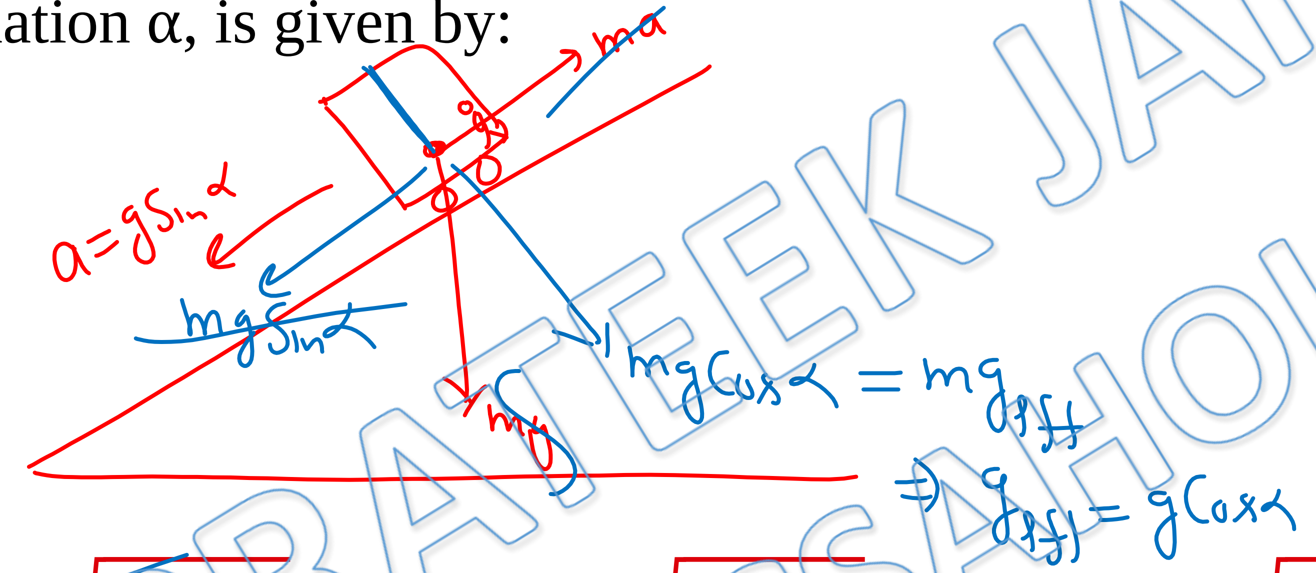
Q7) The period of oscillation of simple pendulum of length L suspended from the roof of the vehicle which moves without friction, down an inclined plane of inclination α, is given by:



(a) $2\pi\sqrt{\dfrac{L}{g\cos\alpha}}$ (b) $2\pi\sqrt{\dfrac{L}{g\sin\alpha}}$ (c) $2\pi\sqrt{\dfrac{L}{g}}$ (d) $2\pi\sqrt{\dfrac{L}{g\tan\alpha}}$

$$T = 2\pi\sqrt{\frac{l}{g_{eff}}} = 2\pi\sqrt{\frac{l}{g\cos\alpha}}$$

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Q8) A ball is suspended by an inextensible thread of length ℓ from a point on a vertical wall. The ball is displaced away from the wall such that the thread makes a very small angle with it and then left free. Assuming the collision of the ball with the wall to be perfectly elastic, the time period of the resulting oscillations is

$T_0 = 2\pi\sqrt{\frac{\ell}{g}}$ → time period in the absence of wall

$T = 2T_0 = \pi\sqrt{\ell/g}$

(a) $T = 2\pi\sqrt{\frac{\ell}{g}}$ (b) $T = \pi\sqrt{\frac{\ell}{g}}$ (c) $T = 2\pi\sqrt{\frac{\ell}{2g}}$ (d) $T = 0$

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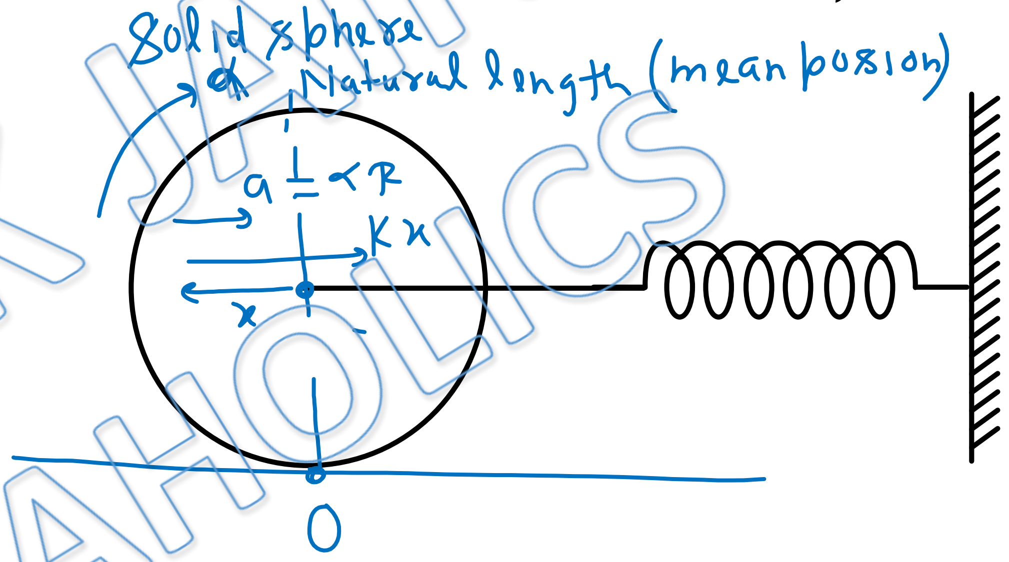
Q9) A solid sphere (M) attached to a massless spring (K) can roll without slipping along a horizontal surface. If the system is released after an initial stretch, the time period will be–



$$\tau_0 = I_0 \alpha$$

$$Kx R = \left(\frac{2}{5} mR^2 + mR^2\right)\alpha$$

$$Kx R = \frac{7}{5} mR^2 \alpha$$

$$a = \frac{5K}{7m} x$$

$$T = 2\pi\sqrt{\frac{7m}{5K}}$$

(a) $2\pi\sqrt{\frac{3M}{2K}}$

(b) $2\pi\sqrt{\frac{3M}{5K}}$

(c) $2\pi\sqrt{\frac{7M}{5K}}$ ✓

(d) $2\pi\sqrt{\frac{M}{K}}$

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Q10) The pulley shown in figure has a MOI I about its axis and mass M. Find the time period of vertical oscillations of its COM. The spring has a spring constant k and the string does not slip over the pulley

Velocity of point O = 0

Pulley is rolling on left string

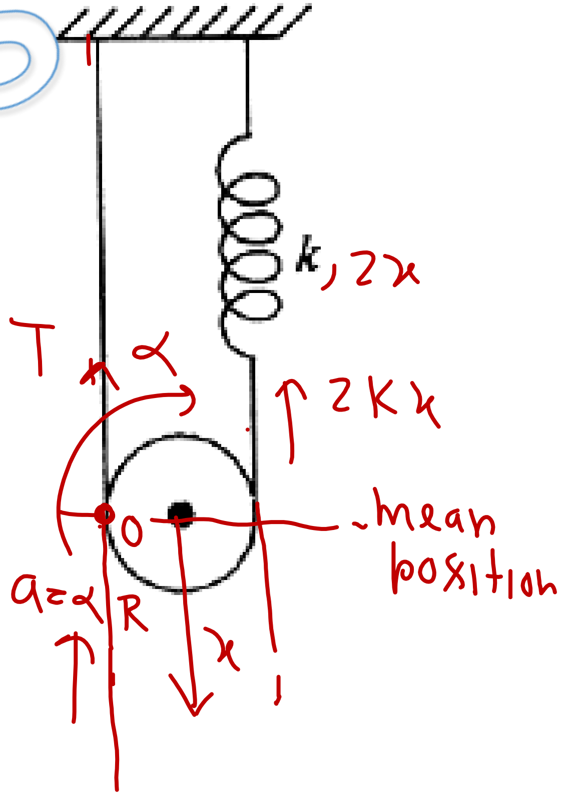
(a) $2\pi\sqrt{\frac{3M}{8K}}$ (b) $2\pi\sqrt{\frac{3M}{5K}}$

(c) $2\pi\sqrt{\frac{7M}{5K}}$ (d) $2\pi\sqrt{\frac{M}{K}}$

$\tau_0 = I_0 \alpha$

$\Rightarrow 2kx \times 2R = \frac{3}{2} mR^2 \alpha$

$a = \frac{8kx}{3m}$



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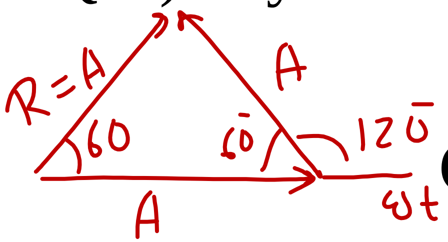
Q11) In y = A sin ωt + A sin$\left(\omega t + \frac{2\pi}{3}\right)$match the following table:



$y = A\sin(\omega t + \pi/3)$

Column-I	Column-II
(A)Motion	(P) is periodic but not SHM
(B) Amplitude	(Q) is SHM
(C) Initial phase	(R) A
(D) Maximum velocity	(S) π /3
	(T) ω A/2
	(U) None

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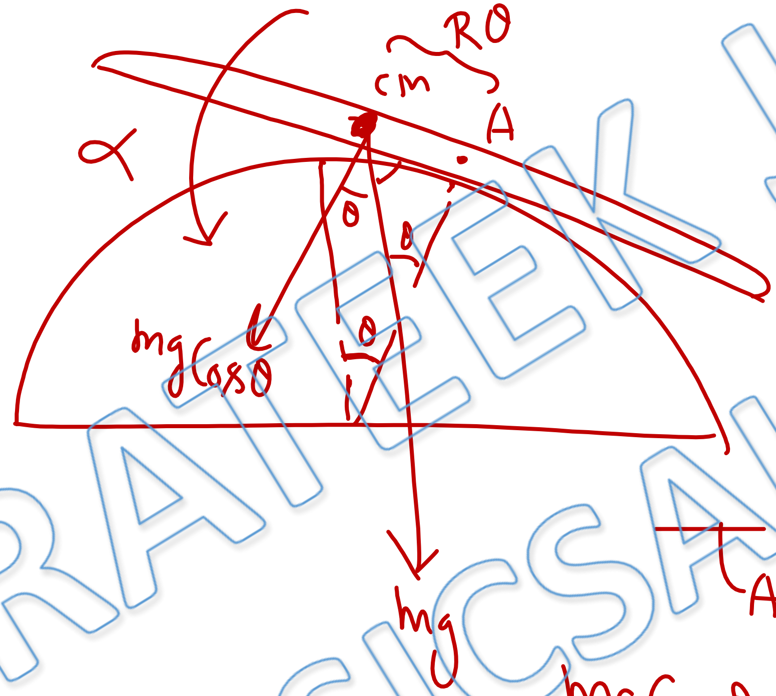
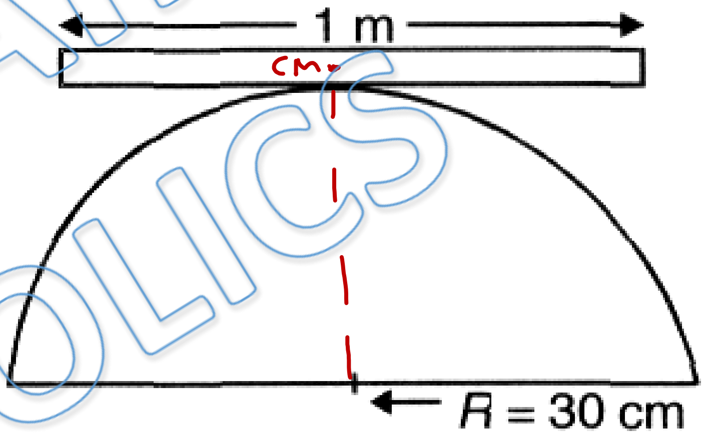
Q12) A uniform meter scale is balanced on fixed semicircular cylinder of radius 30 cm as shown. One end of scale is slightly depressed and released. Time period of oscillation is





(a) π

(b) π/2

(c) π/3

(d) π/4

$\tau_A = I_A \alpha$

$mg\cos\theta \cdot R\theta = \left(\frac{ml^2}{12} + mR^2\theta^2\right)\alpha$ ($mR^2\theta^2$ → very small)

$mgR\theta = \frac{ml^2}{12}\alpha$

$\alpha = \frac{12gR}{l^2}\theta = \frac{12 \times 10 \times .3}{1^2} = 36\,\theta$

$\omega^2 = 36$

$\omega = 6$

$T = \frac{2\pi}{6} = \frac{\pi}{3}$

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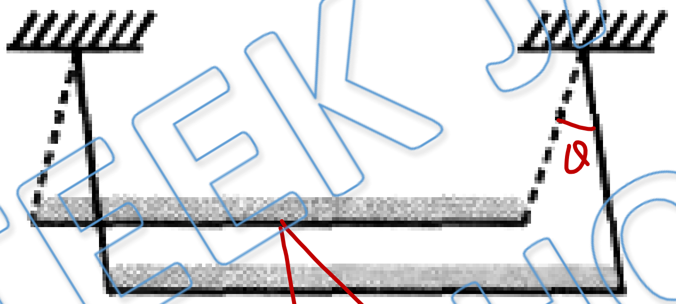
Q13) A uniform rod of mass m = 1.5 kg suspended by two identical threads 90 cm as in figure. Then find time period of oscillation of rod



(a) 2 s

(b) 2.1 s

(c) 2.4 s

(d) 1.9 s

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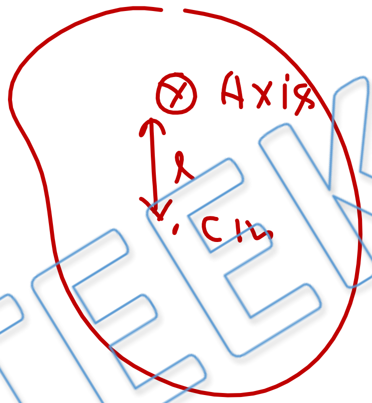
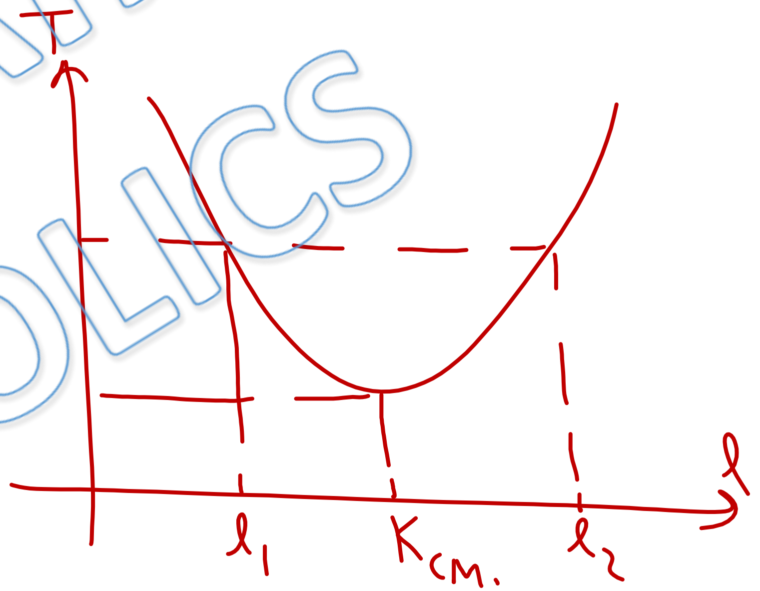
Q14) A compound pendulum of mass 1kg is made to oscillate at distances 20 cms and 40cms on both sides of the center of gravity. The time period is 1.5 sec in both cases. Its M.I. about the axis through the center of gravity in kg × m^2units is-





(a) 2×10^{-2} (b) 4×10^{-2}

(c) 8×10^{-2} (d) 800

$l_1 l_2 = K_{CM}^2$

$.2 \times .4 = K_{CM}^2$

$K_{CM}^2 = .08$

$I_{CM} = mK_{CM}^2$

$= 1 \times .08 = 8 \times 10^{-2}$

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Q15) A hollow metal sphere is filled with water and hung by a long thread. A small hole is drilled at the bottom through which water slowly flows out. Now the sphere is made to oscillate, the period of oscillation of the pendulum -

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

(a) Remains constant

(b) Continuously decreases

(c) Continuously increases

(d) First increases and then decreases

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