EXERCISE - O

SINGLE CORRECT TYPE QUESTIONS

General Equation of SHM

1. The equation of motion of a particle is $x = a\cos(\alpha t)^2$. The motion is

(A) Periodic but not oscillatory. (B) Periodic and oscillatory.

(C) Oscillatory but not periodic. (D) Neither periodic nor oscillatory.

PSH084

2. **Statement 1** : Position–time equation of a particle moving along x–axis is $x = 4 + 6\sin\omega t$. Under this situation, motion of particle is not simple harmonic.

and

Statement 2 : $\frac{d^2x}{dt^2}$ for the given equation is not proportional to $-x$.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1.

(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1.

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

PSH085

3. A simple harmonic motion having an amplitude A and time period T is represented by the equation: $y = 5\sin\pi(t + 4)\ m$. Then the values of A (in m) and T (in sec) are :

(A) $A = 5;\ T = 2$ (B) $A = 10;\ T = 1$ (C) $A = 5;\ T = 1$ (D) $A = 10;\ T = 2$

PSH086

4. The angular frequency of motion whose equation is $4\frac{d^2y}{dt^2} + 9y = 0$ is

(y = displacement and t = time)

(A) $\frac{9}{4}$ (B) $\frac{4}{9}$ (C) $\frac{3}{2}$ (D) $\frac{2}{3}$

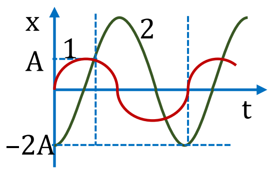
PSH087

5. For a particle acceleration is defined as $\vec{a} = \frac{-5x\hat{i}}{|x|}$ for $x \neq 0$ and $\vec{a} = 0$ for $x = 0$. If the particle is initially at rest at $(a, 0)$, what is period of motion of the particle.

(A) $4\sqrt{2a/5}$ sec. (B) $8\sqrt{2a/5}$ sec. (C) $2\sqrt{2a/5}$ sec. (D) cannot be determined

PSH088

6. The oscillations represented by curve 1 in the graph are expressed by equation $x = A\sin\omega t$. The equation for the oscillations represented by curve 2 is expressed as:

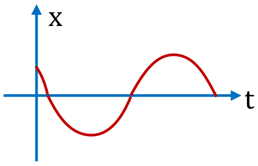


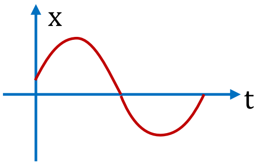
(A) $x = 2A\sin(\omega t - \pi/2)$ (B) $x = 2A\sin(\omega t + \pi/2)$

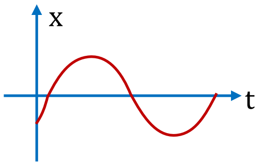
(C) $x = -2A\sin(\omega t - \pi/2)$ (D) $x = A\sin(\omega t - \pi/2)$

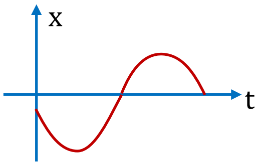
PSH089

7. A particle performing S.H.M. about mean position $x = 0$ and at $t = 0$ it is at position $x = \frac{A}{\sqrt{2}}$ and moving towards the origin. Then which of the following is its possible graph between position (x) and time (t)

(A) 

(B) 

(C) 

(D) 

PSH090

8. A particle is performing S.H.M. and at $t = \frac{3T}{4}$, is at position $\frac{\sqrt{3}A}{2}$ and moving towards the origin. Equilibrium position of the particle is at $x = 0$. Then what was the position and direction of particle at $t = 0$?

(A) $-\frac{A}{2}$, away from mean position (B) $\frac{A}{2}$, away from mean position

(C) $\frac{A}{2}$, towards mean position (D) $-\frac{A}{2}$, towards mean position

PSH091

9. The time taken by a particle performing SHM to pass from point A to B where its velocities are same is 2 seconds. After another 2 seconds it returns to B. The time period of oscillation is (in seconds)

(A) 2 (B) 8 (C) 6 (D) 4

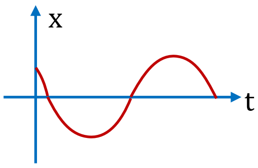
PSH092

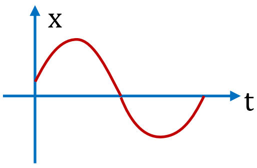
10. A particle moves along the x-axis according to : $x = A\,[1 + \sin \omega t]$. What distance does it travel between $t = 0$ and $t = 2.5\pi/\omega$?

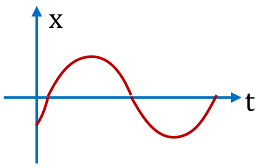
(A) $4A$ (B) $6A$ (C) $5A$ (D) None

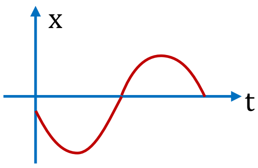
PSH093

11. A particle is performing S.H.M. and at $t = \frac{3T}{4}$, is at position $= \frac{A}{\sqrt{2}}$ and moving towards the origin. Equilibrium position of the particle is at $x = 0$. After $t = \frac{3T}{2}$ what will be the graph of the particle :-

(A) 

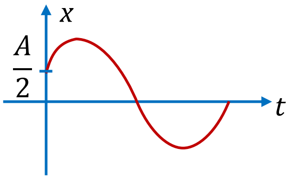
(B) 

(C) 

(D) 

PSH094

12. Following graph shows a particle performing S.H.M. about mean position $x = 0$. The equation of particle if $t = \frac{T}{4}$ is taken as starting time is (Notations have usual meanings)



(A) $A\sin\left(\omega t+\frac{2\pi}{3}\right)$ (B) $A\sin\left(\omega t+\frac{\pi}{3}\right)$ (C) $A\sin\left(\omega t+\frac{\pi}{6}\right)$ (D) $A\cos\left(\omega t+\frac{2\pi}{3}\right)$

PSH095

13. Two particles are in SHM on same straight line with amplitude A and $2A$ and with same angular frequency ω. It is observed that when first particle is at a distance $A/\sqrt{2}$ from origin and going toward mean position, other particle is at extreme position on other side of mean position. Find phase difference between the two particles

(A) 45° (B) 90° (C) 135° (D) 180°

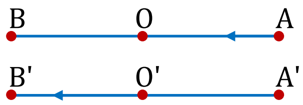
PSH096

14. Two pendulums have time periods T and $5T/4$. They start SHM at the same time from the mean position. After how many oscillations of the smaller pendulum they will be again in the same phase:

(A) 5 (B) 4 (C) 11 (D) 9

PSH097

15. Two particles undergo SHM along parallel lines with the same time period (T) and equal amplitudes. At a particular instant, one particle is at its extreme position while the other is at its mean position. They move in the same direction. They will cross each other after a further time



(A) $T/8$ (B) $3T/8$ (C) $T/6$ (D) $4T/3$

PSH098

16. Two particles are in SHM in a straight line about same equilibrium position. Amplitude A and time period T of both the particles are equal. At time $t = 0$, one particle is at displacement $y_1 = +A$ and the other at $y_2 = -A/2$, and they are approaching towards each other. After what time they cross each other ?

(A) $T/3$ (B) $T/4$ (C) $5T/6$ (D) $T/6$

PSH099

17. Two particles execute SHM of same amplitude of 20 *cm* with same period along the same line about the same equilibrium position. The maximum distance between the two is 20 *cm*. Their phase difference in radians is :-

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

PSH101

18. A particle performing SHM is found at its equilibrium at t = 1 sec. and it is found to have a speed of 0.25 m/s at t = 2 sec. If the period of oscillation is 6 sec. Calculate amplitude of oscillation

(A) $\frac{3}{2\pi}m$ (B) $\frac{3}{4\pi}m$ (C) $\frac{6}{\pi}m$ (D) $\frac{3}{8\pi}$

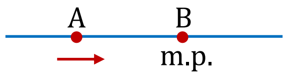
PSH103

19. A particle performs SHM with a period T and amplitude a. The mean velocity of the particle over the time interval during which it travels a distance $a/2$ from the extreme position is

(A) a/T (B) $2a/T$ (C) $3a/T$ (D) $a/2T$

PSH104

20. A particle is oscillating simple harmonically with angular frequency ω and amplitude A. It is at a point (A) at certain instant (shown in figure). At this instant it is moving towards mean position (B). It takes time t to reach mean position (B). If time period of oscillation is T, the average speed between A and B is :-



(A) $\frac{A\sin\omega t}{t}$ (B) $\frac{A\cos\omega t}{t}$ (C) $\frac{A\sin\omega t}{T}$ (D) $\frac{A\cos\omega t}{T}$

PSH105

21. A particle executes SHM on a straight-line path. The amplitude of oscillation is 2 cm. When the displacement of the particle from the mean position is 1 cm, the numerical value of magnitude of acceleration is equal to the numerical value of magnitude of velocity. The frequency of SHM (in second^{-1}) is:

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

PSH107

22. A plank with a small block on top of it is under going vertical SHM. Its period is 2 sec. The minimum amplitude at which the block will separate from plank is :

(A) $\frac{10}{\pi^2}$ (B) $\frac{\pi^2}{10}$ (C) $\frac{20}{\pi^2}$ (D) $\frac{\pi}{10}$

PSH108

23. Speed v of a particle moving along a straight line, when it is at a distance x from a fixed point on the line is given by $v^2 = 108 - 9x^2$ (all quantities in S.I. unit). Then

(A) The motion is uniformly accelerated along the straight line

(B) The magnitude of the acceleration at a distance 3 cm from the fixed point is 0.27 m/s^2.

(C) The motion is simple harmonic about $x = \sqrt{12}\ m$.

(D) The maximum displacement from the fixed point is 4 cm.

PSH109

Energy of Particle in SHM

24. Potential energy of a particle is given as $U(x) = 2x^3 - 9x^2 + 12x$ where U is in joule and x is in metre. If the motion of a particle is S.H.M., then find the potential energy of the particle at mean position :-

(A) – 36 J (B) 4 J (C) 5 J (D) None of these

PSH112

25. If the potential energy of a harmonic oscillator of mass 2 *kg* on its equilibrium position is 5 joules and the total energy is 9 joules. If the amplitude is one meter then period of the oscillator (in sec) is:

(A) 1.5 (B) 3.14 (C) 6.28 (D) 4.67

PSH113

26. Kinetic energy of a particle executing simple harmonic motion in straight line is pv^2 and potential energy is qx^2, where v is speed at distance x from the mean position. It's time period is given by the expression :-

(A) $2\pi\sqrt{\frac{q}{p}}$ (B) $2\pi\sqrt{\frac{p}{q}}$ (C) $2\pi\sqrt{\frac{q}{p+q}}$ (D) $2\pi\sqrt{\frac{p}{p+q}}$

PSH115

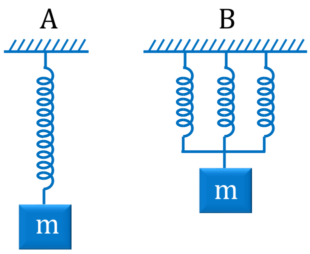
27. Two bodies P and Q of equal mass are suspended from two separate massless springs of force constants k_1 and k_2 respectively. If the maximum velocity of them are equal during their motion, the ratio of amplitude of P to Q is :

(A) $\frac{k_1}{k_2}$ (B) $\sqrt{\frac{k_2}{k_1}}$ (C) $\frac{k_2}{k_1}$ (D) $\sqrt{\frac{k_1}{k_2}}$

PSH116

Linear SHM

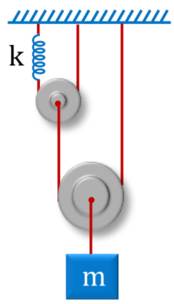
28. The springs in figure A and B are identical but length of spring in A is three times than the length of each spring in B. The ratio of period T_A/T_B is :-



(A) $\sqrt{3}$ (B) 1/3 (C) 3 (D) $1/\sqrt{3}$

PSH121

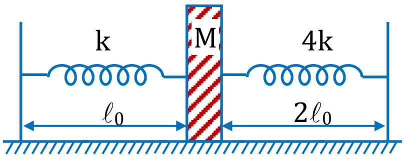
29. What is the period of small oscillations of the block of mass m if the springs are ideal and pulleys are massless ?



(A) $\frac{\pi}{2}\sqrt{\frac{m}{k}}$ (B) $\frac{\pi}{2}\sqrt{\frac{m}{2k}}$ (C) $\frac{\pi}{2}\sqrt{\frac{2m}{k}}$ (D) $\pi\sqrt{\frac{m}{2k}}$

PSH122

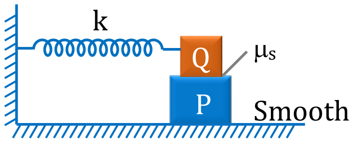
30. A block of mass M is kept in gravity free space and touches the two springs as shown in the figure. Initially springs are in their natural lengths. Now, the block is shifted $(\ell_0/2)$ from the given position in such a way that it compresses a spring and is released. The time-period of oscillation of mass will be



(A) $\frac{\pi}{2}\sqrt{\frac{M}{K}}$ (B) $2\pi\sqrt{\frac{M}{5K}}$ (C) $\frac{3\pi}{2}\sqrt{\frac{M}{K}}$ (D) $\pi\sqrt{\frac{M}{2K}}$

PSH123

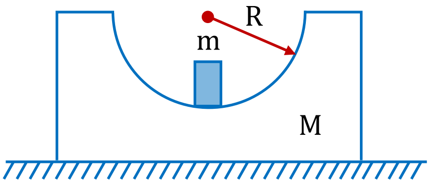
31. A block P of mass m is placed on a frictionless horizontal surface. Another block Q of same mass is kept on P and connected to the wall with the help of a spring of spring constant k as shown in the figure. μ_s is the coefficient of friction between P and Q. The blocks move together performing SHM of amplitude A. The maximum value of the friction force between P and Q is :-



(A) kA (B) $\frac{kA}{2}$ (C) zero (D) $\mu_s mg$

PSH124

32. A symmetrical block of mass M having a notch of hemispherical shape of radius R is placed on a horizontal surface. A small particle of mass m is placed inside the hemispherical notch and can slide without friction. Find the time period of small oscillation of the particle and the block. The acceleration due to gravity is g.



(A) $2\pi\sqrt{\frac{R}{g\left[1+\frac{m}{M}\right]}}$ (B) $2\pi\sqrt{\frac{R}{g\left[1+\frac{M}{m}\right]}}$ (C) $2\pi\sqrt{\frac{R}{g}\left[1+\frac{m}{M}\right]}$ (D) $2\pi\sqrt{\frac{R}{g}\left[1+\frac{M}{m}\right]}$

PSH141

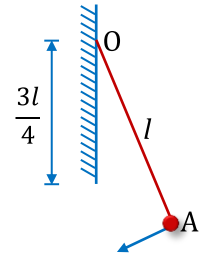
Angular SHM

33. A bob is attached to a long, light string. The string is deflected by 3° initially with respect to vertical. The length of the string is 1 m. The value of θ at any time t after the bob released can be approximately written as (Use : $g = \pi^2$)

(A) $3° \cos \pi t$ (B) $3° \sin \pi t$ (C) $3° \sin\left(\pi t + \frac{\pi}{6}\right)$ (D) $3° \cos\left(\pi t + \frac{\pi}{6}\right)$

PSH117

34. A small bob attached to a light inextensible thread of length l has a periodic time T when allowed to vibrate as a simple pendulum. The thread is now suspended from a fixed end O of a vertical rigid rod of length $\frac{3l}{4}$ (as in figure). If now the pendulum performs periodic oscillations in this arrangement, the periodic time will be



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

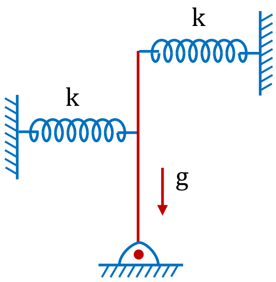
PSH118

35. A simple pendulum has time period $2s$. The point of suspension is now moved upward according to relation $y = (6t - 3.75\, t^2)m$ where t is in second and y is the vertical displacement in upward direction. The new time period of simple pendulum will be

(A) $2s$ (B) $1s$ (C) $4s$ (D) None of these

PSH119

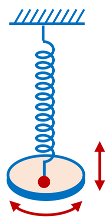
36. In the figure shown, the spring are connected to the rod at one end and at the midpoint. The rod is hinged at its lower end. Rotational SHM of the rod (Mass m, length L) will occur only if



(A) $k > mg/3L$ (B) $k > 2mg/3L$ (C) $k > 2mg/5L$ (D) $k > 0$

PSH127

37. A solid disk of radius R is suspended from a spring of linear spring constant k and torsional constant c, as shown in figure. In terms of k and c, what value of R will give the same period for the vertical and torsional oscillations of this system?



(A) $\sqrt{\frac{2c}{k}}$ (B) $\sqrt{\frac{c}{2k}}$ (C) $2\sqrt{\frac{c}{k}}$ (D) $\frac{1}{2}\sqrt{\frac{c}{k}}$

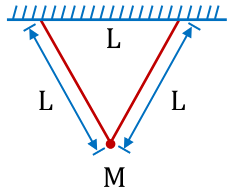
PSH130

38. The time period of a bar pendulum when suspended at distances 30 *cm* and 50 *cm* from its centre of gravity comes out to be the same. If the mass of the body is 2*kg*. Find out its moment of inertia about an axis passing through first point.

(A) 0.24 $kg\text{-}m^2$ (B) 0.72 $kg\text{-}m^2$ (C) 0.48 $kg\text{-}m^2$ (D) Data insufficient

PSH131

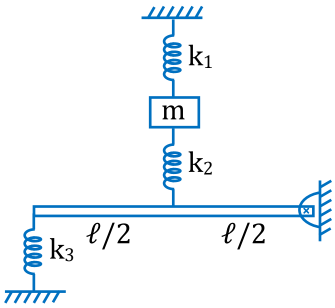
39. A man is swinging on a swing made of 2 ropes of equal length L and in direction perpendicular to the plane of paper. The time period of the small oscillations about the mean position is :-



(A) $2\pi\sqrt{\frac{L}{2g}}$ (B) $2\pi\sqrt{\frac{\sqrt{3}L}{2g}}$ (C) $2\pi\sqrt{\frac{L}{2\sqrt{3}g}}$ (D) $\pi\sqrt{\frac{L}{g}}$

PSH132

40. Find the angular frequency for small oscillation of block of mass m in the arrangement shown in the figure. Neglect the mass of the rod (system is in vertical plane).



(A) $\omega = \sqrt{\frac{1}{m}\left(k_1 + \frac{4k_2k_3}{k_2+4k_3}\right)}$ (B) $\omega = \sqrt{\frac{1}{m}(k_1+k_2+2k_3)}$

(C) $\omega = \sqrt{\frac{1}{m}\left(\frac{k_1k_2}{k_1+k_3} + 4k_3\right)}$ (D) $\omega = \sqrt{\frac{1}{m}\left(k_1 + \frac{k_2k_3}{k_2+k_3}\right)}$

PSH142

Superposition Of SHM

41. The amplitude of the vibrating particle due to superposition of two SHMs,

$y_1 = \sin\left(\omega t + \frac{\pi}{3}\right)$ and $y_2 = \sin\omega t$ is

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

PSH135

42. Two simple harmonic motions $y_1 = A\sin\omega t$ and $y_2 = A\cos\omega t$ are superimposed on a particle of mass m. The total mechanical energy of the particle is:

(A) $\frac{1}{2}m\omega^2A^2$ (B) $m\omega^2A^2$ (C) $\frac{1}{4}m\omega^2A^2$ (D) zero

PSH136

43. The displacement of a particle varies with time according to the relation $y = a \sin \omega t + b \cos \omega t$.
(A) The motion is oscillatory but not S.H.M.
(B) The motion is S.H.M. with amplitude $a + b$.
(C) The motion is S.H.M. with amplitude $a^2 + b^2$.
(D) The motion is S.H.M. with amplitude $\sqrt{a^2+b^2}$

PSH137

44. Equations $y = 2A \cos^2 \omega t$ and $y = A (\sin \omega t + \sqrt{3} \cos \omega t)$ represent the motion of two particles.
(A) Only one of these is S.H.M.
(B) Ratio of maximum speeds is 2 : 1
(C) Ratio of maximum speeds is 1 : 1
(D) Ratio of maximum accelerations is 1 : 4

PSH138

45. 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)
(A) $\sqrt{\frac{g}{2}}, \frac{\pi}{6}\sqrt{\frac{2}{g}}$
(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) $\sqrt{2g}, \sqrt{\frac{2\pi}{3g}}$

PSH139

MULTIPLE CORRECT TYPE QUESTIONS

General Equation of SHM

46. A particle is executing SHM between points $-X_m$ and X_m, as shown in figure-I. The velocity $V(t)$ of the particle is partially graphed and shown in figure-II. Two points A and B corresponding to time t_1 and time t_2 respectively are marked on the $V(t)$ curve.

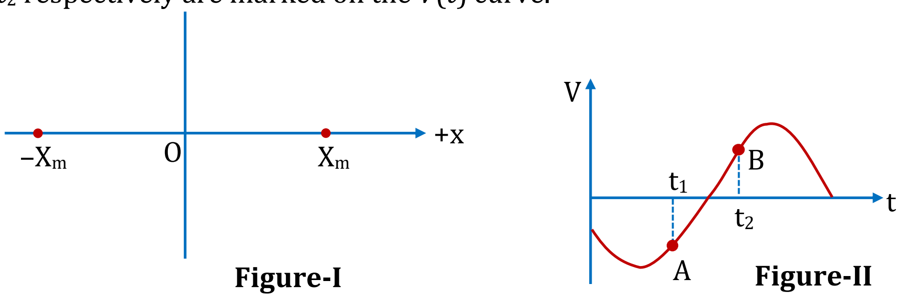


Figure-I **Figure-II**

(A) At time t_1, it is going towards X_m.
(B) At time t_1, its speed is decreasing.
(C) At time t_2, its position lies in between $-X_m$ and O.
(D) The phase difference $\Delta\phi$ between points A and B must be expressed as $90° < \Delta\phi < 180°$.

PSH100

47. Two particles are in SHM with same amplitude A and same angular frequency ω. At time $t = 0$, one is at $x = +\frac{A}{2}$ and other is at $x = -\frac{A}{2}$. Both are moving in same direction.
(A) Phase difference between the two particle is $\frac{\pi}{3}$
(B) Phase difference between the two particle is $\frac{2\pi}{3}$
(C) They will collide after time $t = \frac{\pi}{2\omega}$
(D) They will collide after time $t = \frac{3\pi}{\omega}$

PSH102

48. For a body executing SHM with amplitudes A, time period T, max velocity v_{max} and phase constant zero, which of the following statements are correct?

(A) At $y = (A/2)$, $v > (v_{max}/2)$ (B) $v = (v_{max}/2)$ for $|y| > (A/2)$

(C) For $t = (T/8)$, $y > (A/2)$ (D) For $y = (A/2)$, $t < (T/8)$

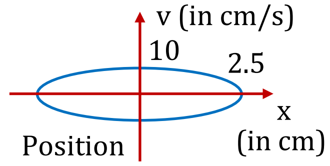
PSH106

49. A particle is executing SHM with amplitude A, time period T, maximum acceleration a_0 and maximum velocity v_0. Its starts from mean position at $t = 0$ and at time t, it has the displacement $A/2$, acceleration a and velocity v then :-

(A) $t = T/12$ (B) $a = a_0/2$ (C) $v = v_0/2$ (D) $t = T/8$

PSH110

50. The figure shows a graph between velocity and displacement (from mean position) of a particle performing SHM



(A) the time period of the particle is $1.57s$

(B) the maximum acceleration will be 40 cm/s^2

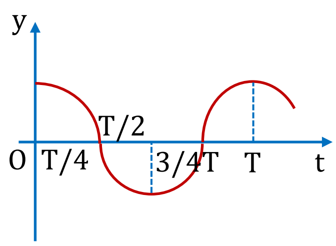
(C) the velocity of particle is $2\sqrt{21}$ cm/s when it is at a distance 1 cm from the mean position.

(D) minimum acceleration is 4 cm/s^2

PSH143

Energy of Particle in SHM

51. The displacement-time graph of a particle executing SHM is shown. Which of the following statements is/are true?



(A) The velocity is maximum at $t = T/2$

(B) The acceleration is maximum at $t = T$

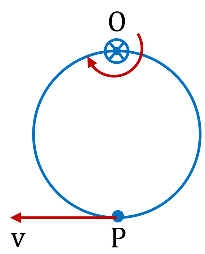
(C) The force is zero at $t = 3T/4$

(D) The potential energy equals the oscillation energy at $t = T/2$.

PSH114

Angular SHM

52. A ring of mass m, radius r can oscillate in a vertical plane about is top most point 'O' as shown. Axis is normal to the plane of ring. Maximum speed of lowest point 'P' of ring is v.



(A) Time period of SHM for small amplitude is $2\pi\sqrt{\dfrac{2r}{g}}$

(B) Acceleration of centre of mass of ring at lowest position is zero

(C) Hinge force when centre of mass is at lowest point is $\dfrac{mv^2}{4r}$

(D) Mechanical energy of oscillation is $\dfrac{mv^2}{4}$ (when potential energy at mean position is taken as zero)

PSH144

Superposition of SHM

53. A particle moves in x-y plane according to equation $\vec{S} = (2\hat{i} + \hat{j})\cos\omega t$. The motion of particle is:-

(A) On straight line (B) On ellipse (C) Periodic (D) SHM

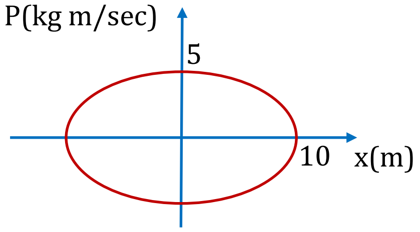
PSH140

COMPREHENSION TYPE QUESTIONS

Linear SHM

PARAGRAPH FOR QUESTION NO. 54 AND 55

Momentum (P) displacement (x) graph of a particle of unit mass performing SHM along x-axis is shown in the figure.



54. Angular frequency of the SHM is :

(A) 1 rad/sec (B) $\frac{1}{2}rad/sec$ (C) 2 rad/sec (D) 4 rad/sec

PSH145

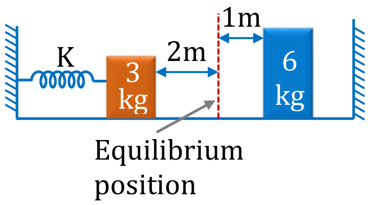
55. Total energy of oscillation is (potential energy at mean position = 0) :

(A) 50 Joule (B) 25 Joule (C) 12.5 Joule (D) 100 Joule

PSH146

PARAGRAPH FOR QUESTION NO. 56 AND 57

Two blocks of masses 3 kg and 6 kg rest on a horizontal frictionless surface. The 3 kg block is attached to a spring with a force constant $K = 900\ N/m$ which is compressed 2 m initially from its equilibrium position. When 3 kg mass is released, it strikes the 6 kg mass and the two stick together.



56. The common velocity of the blocks after collision is :-

(A) 10 m/s (B) 30 m/s (C) 15 m/s (D) 2 m/s

PSH125

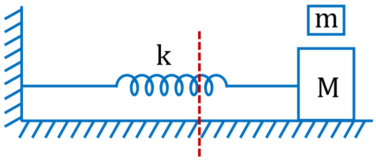
57. The amplitude of resulting oscillation after the collision is :-

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

PSH126

PARAGRAPH FOR QUESTION NO. 58 AND 59

A horizontal spring block system executes SHM ($x = A\sin(\omega t + \phi)$) with amplitude $A = 10\ cm$, initial phase $\phi = 0$ and angular frequency ω. The mass of block is $M = 25\ kg$ and there is no friction between the block and the horizontal surface. The spring constant is $2500\ N/m$. At $t = t_1$ sec [for which $\omega t_1 = 30°$]. A mass $m = 75\ kg$ is gently put on the block. [Assume that collision between the block and the mass is perfectly inelastic and mass m remains stationary *w.r.t.* the block M always].



58. The new angular frequency of the system will be :

(A) 5 rad/sec (B) 10 rad/sec (C) 15 rad/sec (D) 20 rad/sec

PSH147

59. The total energy of system after collision at any moment of time is :-

(A) $\frac{175}{32}$ Joule (B) $\frac{88}{15}$ Joule (C) $\frac{96}{25}$ Joule (D) None of these

PSH148

MATRIX MATCH TYPE QUESTION

General Equation of SHM

60. For a particle under going linear SHM about $x = 0$, find the possible combination. Symbols have their usual meaning.

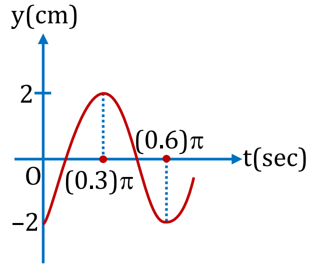
	List–I		List–II
(P)	$(\vec{v}\cdot\vec{a}) > 0$	(1)	Extreme position
(Q)	$v < 0$	(2)	Mean position
(R)	$a < 0$	(3)	$0 < x < A$
(S)	$\vec{v}\times\vec{a} = 0$	(4)	$-A < x < 0$

PSH149

EXERCISE - S

General Equation of SHM

1. Part of a simple harmonic motion is graphed in the figure, where y is the displacement from the mean position. The correct equation describing this S.H.M is :-



PSH150

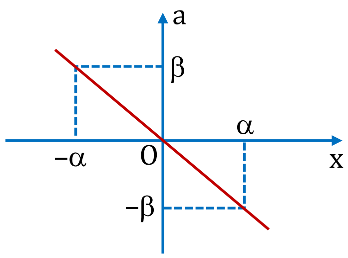
2. The displacement of a body executing SHM is given by $x = A \sin (2\pi t + \pi/3)$. The first time from $t = 0$ when the velocity is maximum is.

PSH151

3. A body undergoing SHM about the origin has its equation given by $x = 0.2 \cos 5\pi t$. Find its average speed from $t = 0$ to $t = 0.7$ sec.

PSH152

4. The acceleration-displacement $(a - x)$ graph of a particle executing simple harmonic motion is shown in the figure. Find the frequency of oscillation.



PSH153

5. A simple harmonic motion has an amplitude A and time period T. Find the time required by it to travel directly from

(a) $x = 0$ to $x = A/2$ (b) $x = 0$ to $x = \frac{A}{\sqrt{2}}$ (c) $x = A$ to $x = A/2$

(d) $x = -\frac{A}{\sqrt{2}}$ to $x = \frac{A}{\sqrt{2}}$ (e) $x = \frac{A}{\sqrt{2}}$ to $x = A$

PSH154

6. A particle executes simple harmonic motion with an amplitude of 10 cm and time period 6s. At $t = 0$ it is at position $x = 5$ cm going towards positive x-direction. Write the equation for the displacement x at time t. Find the magnitude of the acceleration of the particle at $t = 4s$.

PSH155

Energy of Particle in SHM

7. An object of mass 0.2 kg executes SHM along the x-axis with frequency of $(25/\pi)$ Hz. At the point $x = 0.04m$ the object has KE 0.5 J and PE 0.4 J. The amplitude of oscillation is _______.

PSH156

8. A point particle of mass 0.1*kg* is executing SHM with amplitude of 0.1*m*. When the particle passes through the mean position, its *K.E.* is $8 \times 10^{-3} J$. Obtain the equation of motion of this particle if the initial phase of oscillation is 45°.

PSH157

9. Potential Energy (U) of a body of unit mass moving in a one-dimension conservative force field is given by $U = (x^2 - 4x + 3)$. All units are in S.I.

(i) Find the equilibrium position of the body.

(ii) Show that oscillations of the body about this equilibrium position is simple harmonic motion and find its time period.

(iii) Find the amplitude of oscillations if speed of the body at equilibrium position is $2\sqrt{6}\ m/s$.

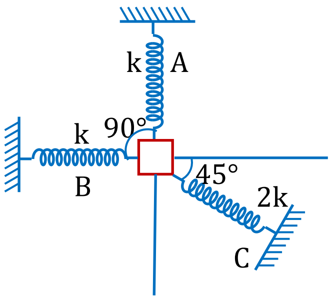
PSH158

10. Calculate the ratio between the kinetic energy E_k and the potential energy E_p of an oscillating point for the moment $t = T/12$, where T = time period.

PSH159

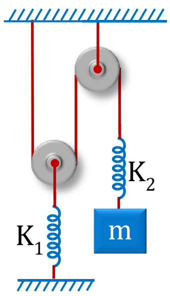
Linear SHM

11. A block of mass m is attached to three springs A, B and C having force constants k, k and $2k$ respectively as shown in figure. Block is slightly pushed against spring C. If the angular frequency of oscillations is $\sqrt{\frac{Nk}{m}}$, then find N. The system is placed on horizontal smooth surface.



PSH128

12. For given spring mass system, If the time period of small oscillations of block about its mean position is $\pi\sqrt{\frac{nm}{K}}$, then find n. Assume ideal conditions. The system is in vertical plane and take $K_1 = 2K$, $K_2 = K$.



PSH129

13. A small body of mass m is fixed to the middle of a stretched string of length 2ℓ. In the equilibrium position the string tension is equal to T_0. Find the angular frequency of small oscillations of the body in the transverse direction. The mass of the string is negligible, the gravitational field is absent. Assume tension in string to be constant.

PSH160

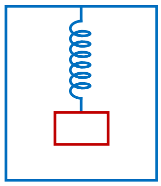
14. A body is in SHM with period T when oscillated from a freely suspended spring. If this spring is cut in two parts of length ratio 1 : 3 & again oscillated from the two parts separately, then the periods are T_1 and T_2 then find T_1/T_2.

PSH161

15. A mass M attached to a spring, oscillates with a period of 2 sec. If the mass is increased by 2 kg the period increases by one sec. Find the initial mass M assuming that Hooke's Law is obeyed.

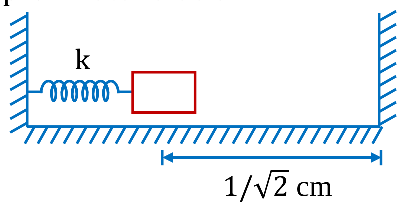
PSH162

16. A spring mass system is hanging from the ceiling of an elevator in equilibrium. Elongation of spring is l. The elevator suddenly starts accelerating downwards with acceleration $g/3$, find:
(a) the frequency and (b) the amplitude of the resulting SHM.



PSH163

17. A block of mass 0.9 kg attached to a spring of force constant k is lying on a frictionless floor. The spring is compressed to $\sqrt{2}$ cm and the block is at a distance $1/\sqrt{2}$ cm from the wall as shown in the figure. When the block is released, it makes elastic collision with the wall and its period of motion is 0.2 sec. Find the approximate value of k.

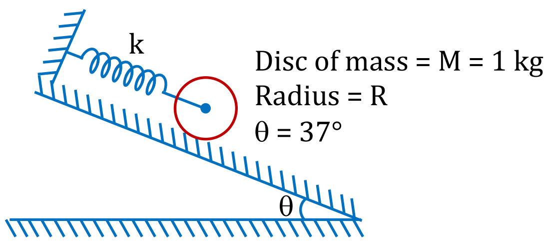


PSH164

18. A body of mass 1 kg is suspended from a weightless spring having force constant $600 N/m$. Another body of mass 0.5 kg moving vertically upwards hits the suspended body with a velocity of $3.0 m/s$ and get embedded in it. Find the frequency of oscillations and amplitude of motion.

PSH165

19. A disc of mass m is connected to an ideal spring of force constant 'k'. If disc is released from rest, then what is maximum friction force on disc (in N). Assuming friction is sufficient for pure rolling



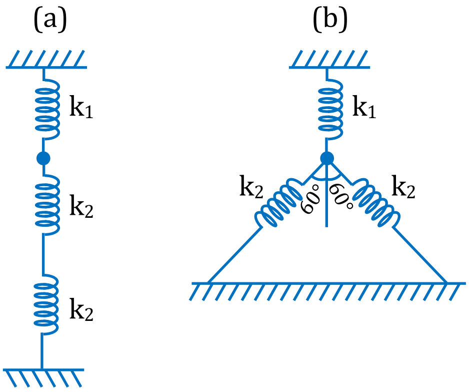
PSH166

20. A particle of mass 5×10^{-5} *kg* is placed at the lowest point of a smooth parabola having the equation $20x^2 = y$ (x, y in m). Here y is the vertical height. If it is displaced slightly and it moves such that it is constrained to move along the parabola, the angular frequency of oscillation will be, (in rad/s). If your answer is N fill value $N/4$.

PSH167

21. Mass m is suspended by ideal massless springs in two different ways, indicated by (a) and (b) in the figure. The mass is displaced upwards by a small amount from equilibrium position and is then released resulting in a SHM of the mass in the vertical direction. We denote the oscillation frequencies associated with the two cases (a) and (b) by f_a and f_b respectively. Find $\frac{f_a}{f_b}$.

Given $k_2 = 2k_1$.

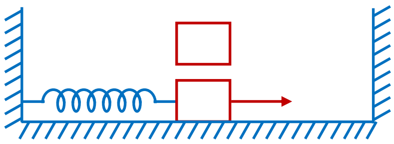


PSH168

22. A solid sphere of radius R is floating in a liquid of density ρ with half of its volume submerged. If the sphere is slightly pushed and released, it starts performing simple harmonic motion. Find the frequency of these oscillations.

PSH169

23. A 1 *kg* block is executing simple harmonic motion of amplitude 0.1 m on a smooth horizontal surface under the restoring force of a spring of spring constant 100 N/m. A block of mass 3 *kg* is gently placed on it at the instant it passes through the mean position. Assuming that the two blocks move together, find the frequency and the amplitude of the motion.

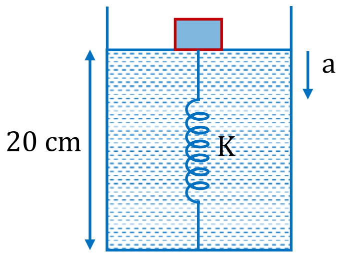


PSH170

24. A spring stores 5 J of energy when stretched by 25 cm. It is kept vertical with the lower end fixed. A block fastened to its other end is made to undergo small oscillations. If the block makes 5 oscillations each second, what is the mass of the block ?

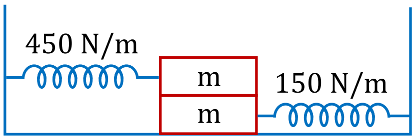
PSH171

25. A rectangular tank having base $15cm \times 20cm$ is filled with water (density $\rho = 1000\ kg\ m^{-3}$) upto 20 cm height. One end of an ideal spring of natural length $h_0 = 20\ cm$ and force constant $K = 280\ Nm^{-1}$ is fixed to the bottom of a tank so that spring, remains vertical. This system is in an elevator moving downwards with acceleration $a = 2\ ms^{-2}$. A cubical block of side $\ell = 10\ cm$ and mass $m = 2\ kg$ is gently placed over the spring and released gradually, as shown in figure. If block is slightly pushed down from equilibrium position and released, and the frequency of its vertical oscillations is $\frac{a\sqrt{2}}{\pi}$, then calculate a.



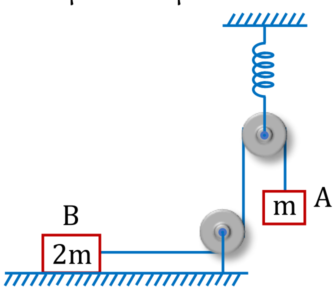
PSH172

26. When the system shown in the diagram is in equilibrium, the right spring is stretched by 1 cm. The coefficient of static friction between the blocks is 0.3. There is no friction between the bottom block and the supporting surface. The force constants of the springs are 150 N/m and 450 N/m (refer figure). The blocks have equal mass of 2 kg each. Find the maximum amplitude (in cm) of the oscillations of the system shown in the figure that does not allow the top block to slide on the bottom.



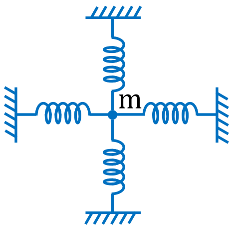
PSH173

27. In the given figure, spring and pulleys are massless. Block A is performing SHM of amplitude $1m$ and time period π sec. If block B remains at rest, then minimum value of coefficient of friction between block B and surface will be μ. Fill 10μ in OMR sheet. ($g = 10\ m/s^2$)



PSH174

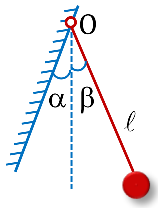
28. As shown in figure a particle of mass $m = 100\ gm$ is attached with four identical springs each of length $\ell = 10\ cm$. Initial tension in each spring is $f_0 = 25\ N$. Neglecting gravity the period of small oscillations of the particle in 10^{-2} sec along a line perpendicular to plane of figure is nearly.



PSH175

Angular SHM

29. A ball is suspended by a thread of length ℓ at the point O on the wall, forming a small angle α with the vertical as shown in figure. Then the thread with the ball was deviated through a small angle β ($\beta > \alpha$) and set free. Assuming the collision of the ball against the wall to be perfectly elastic, find the oscillation period of such a pendulum.

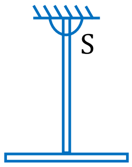


PSH120

30. A uniform disc of radius r is to be suspended through a small hole made in the disc. Find the minimum possible time period of the disc for small oscillations. What should be the distance of the hole from the centre for it to have minimum time period?

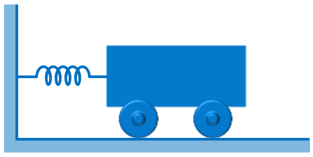
PSH133

31. Two identical rods each of mass m and length L, are rigidly joined and then suspended in a vertical plane so as to oscillate freely about an axis normal to the plane of paper passing through 'S' (point of suspension). Find the time period of such small oscillations.



PSH176

32. A cart consists of a body and four wheels on frictionless axles. The body has a mass m. The wheels are uniform disks of mass M and radius R. The cart rolls, without slipping, back and forth on a horizontal plane under the influence of a spring attached to one end of the cart (figure). The spring constant is k. Taking into account the moment of inertia of the wheels, find a formula for the frequency of the back and forth motion of the cart.



PSH177

33. (a) Find the time period of oscillations of a torsional pendulum, if the torsional constant of the wire is $K = 10\pi^2 J/rad$. The moment of inertia of rigid body is 10 $kg\ m^2$ about the axis of rotation.

(b) A simple pendulum of length $l = 0.5\ m$ is hanging from ceiling of a car. The car is kept on a horizontal plane. The car starts accelerating on the horizontal road with acceleration of 5 m/s^2. Find the time period of oscillations of the pendulum for small amplitudes about the mean position.

PSH178

34. The motion of a simple pendulum is given by

$$\theta = A\cos\left(\sqrt{\frac{g}{\ell}}\,t\right) \text{ (symbols have their usual meaning)}$$

(a) Find the tension in the string of this pendulum as a function of time assume that $\theta << \ell$.

(b) At what time is the tension maximum? What is the value of this maximum tension?

PSH179

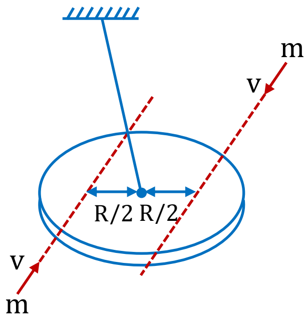
35. A physical pendulum has the shape of a disk of radius R. The pendulum swings about an axis perpendicular to the plane of the disk and at distance ℓ from the center of the disk.

(a) Show that the frequency of the oscillations of this pendulum is $\omega = \sqrt{\dfrac{g\ell}{\frac{1}{2}R^2 + \ell^2}}$

(b) For what value of ℓ is this frequency at a maximum ?

PSH180

36. A torsional pendulum consists of a uniform disc of mass m and radius R attached to a thin rod of torsional constant C. Two particles of mass m strike with the disc with speed v each and stick to it as shown in figure.



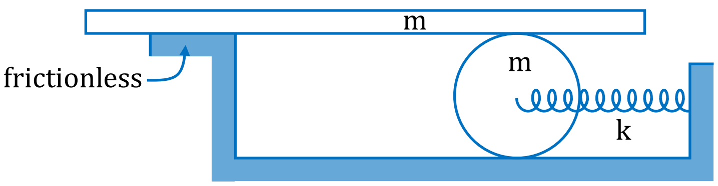
Find the angular amplitude (radian) of oscillation.
[Take m = 2kg, v = 20 m/s, R = 20 cm, C = 80Nm/rad]

PSH181

37. A rod whose ends are A & B of length 25 cm is hanged in vertical plane. When hanged from point A and point B the time periods calculated are 3 sec & 4 sec respectively. Given the moment of inertia of rod about axis perpendicular to the rod is in ratio 9 : 4 at points A and B. Find the distance of the centre of mass from point A.

PSH182

38. The axle of a uniform cylinder with mass m and radius R is connected to a spring with spring constant k, as shown in the Fig. A horizontal board with mass m rests on top of the cylinder, and the board also rests on top of a frictionless support near its left end. The system is slightly displaced from equilibrium. There is no slipping between the cylinder and the board, or between the cylinder and the ground. The angular frequency of the oscillatory motion is p. The value of $\dfrac{11p^2m}{k}$ is:



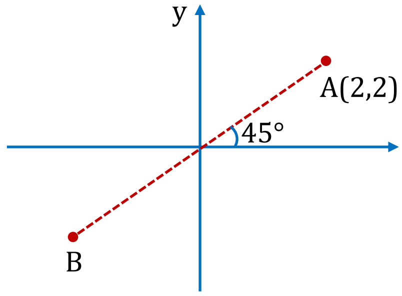
PSH183

Superposition of SHM

39. A simple harmonic motion is given by $y = 5$ (sin $3\pi t + \sqrt{3}$ cos $3\pi t$). What is the amplitude (in *cm*) of motion if y is in m ?

PSH134

40. A particle of mass $m = 2$ *kg* executes SHM in *xy*-plane between points *A* and *B* as shown in figure under action of force $\vec{F} = F_x i + F_y j$. Minimum time taken by particle to move from *A* to *B* is 1 *sec*. At $t = 0$ the particle is at $x = 2$ and $y = 2$. Then find the value of F_x as the function of time.



PSH184

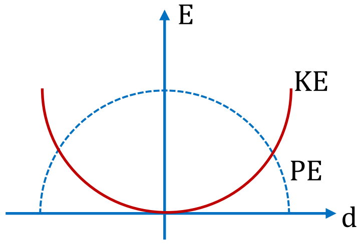
EXERCISE - JEE (Main) PYQ

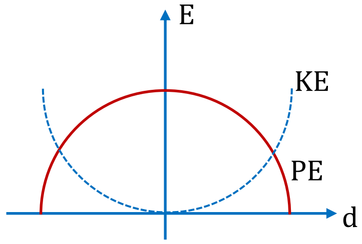
1. A particle moves with simple harmonic motion in a straight line. In first τ s, after starting from rest it travels a distance a, and in next τ s it travels $2a$, in same direction, then : **[JEE (Main) 2014]**

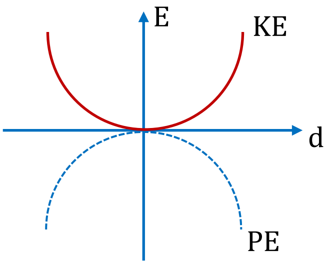
(1) amplitude of motion is $3a$
(2) time period of oscillations is 8τ
(3) amplitude of motion is $4a$
(4) time period of oscillations is 6τ

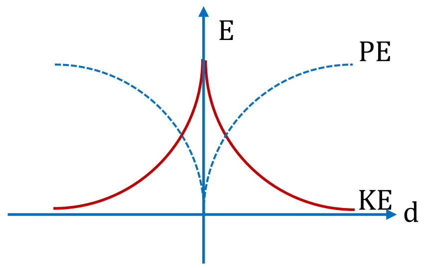
PSH031

2. For a simple pendulum, a graph is plotted between its kinetic energy (KE) and potential energy (PE) against its displacement d. Which one of the following represents these correctly? (graphs are schematic and not drawn to scale) **[JEE (Main) 2014]**

(1) 

(2) 

(3) 

(4) 

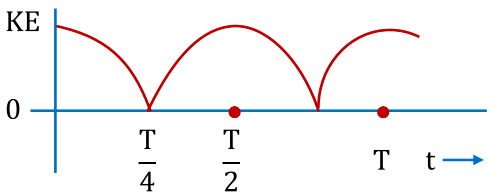
PSH032

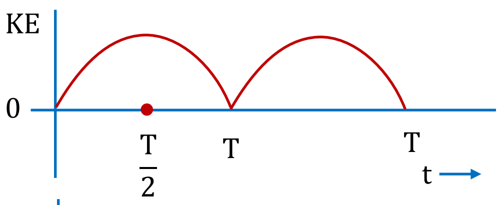
3. A particle performs simple harmonic motion with amplitude A. Its speed is trippled at the instant that it is at distance $2A/3$ from equilibrium position. The new amplitude of the motion is.
[JEE (Main) 2016]

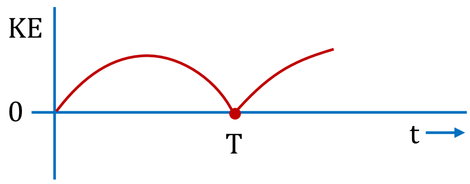
(1) $3A$
(2) $\sqrt{3}\,A$
(3) $\frac{7A}{3}$
(4) $\frac{A}{3}\sqrt{41}$

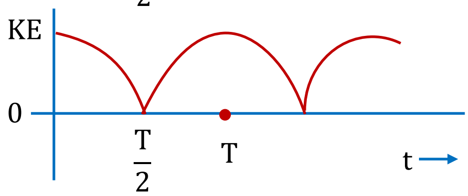
PSH033

4. A particle is executing simple harmonic motion with a time period T. At time = 0, it is at its position of equilibrium. The kinetic energy-time graph of the particle will look like : **[JEE (Main) 2017]**

(1) 

(2) 

(3) 

(4) 

PSH034

5. A silver atom in a solid oscillates in simple harmonic motion in some direction with a frequency of $10^{12}/sec$. What is the force constant of the bonds connecting one atom with the other ? (Mole wt. of silver = 108 gm and Avagadro number = 6.02×10^{23} mole^{-1}) **[JEE (Main) 2018]**

(1) 2.2 N/m (2) 5.5 N/m (3) 6.4 N/m (4) 7.1 N/m

PSH035

6. A rod of mass 'M' and length '$2L$' is suspended at its middle by a wire. It exhibits torsional oscillations; If two masses each of 'm' are attached at distance '$L/2$' from its centre on both sides, it reduces the oscillation frequency by 20%. The value of ratio m/M is close to: **[JEE (Main) 2019]**

(1) 0.17 (2) 0.37 (3) 0.57 (4) 0.77

PSH036

7. A particle executes simple harmonic motion with an amplitude of 5 cm. When the particle is at 4 cm from the mean position, the magnitude of its velocity in SI units is equal to that of its acceleration. Then, its periodic time in seconds is : **[JEE (Main) 2019]**

(1) $\frac{7}{3}\pi$ (2) $\frac{3}{8}\pi$ (3) $\frac{4}{8}\pi$ (4) $\frac{8\pi}{3}$

PSH037

8. A simple pendulum of length 1 m is oscillating with an angular frequency 10 rad/s. The support of the pendulum starts oscillating up and down with a small angular frequency of 1 rad/s and an amplitude of 10^{-2} m. The relative change in the angular frequency of the pendulum is best given by: **[JEE (Main) 2019]**

(1) 10^{-3} rad/s (2) 10^{-1} rad/s (3) 1 rad/s (4) 10^{-5} rad/s

PSH038

9. A pendulum is executing simple harmonic motion and its maximum kinetic energy is K_1. If the length of the pendulum is doubled and it performs simple harmonic motion with the same amplitude as in the first case, its maximum kinetic energy is K_2. Then :- **[JEE (Main) 2019]**

(1) $K_2 = \frac{K_1}{4}$ (2) $K_2 = \frac{K_1}{2}$ (3) $K_2 = 2K_1$ (4) $K_2 = K_1$

PSH039

10. A particle undergoing simple harmonic motion has time dependent displacement given by $x(t) = A\sin\frac{\pi t}{90}$. The ratio of kinetic to potential energy of this particle at t = 210 s will be :

[JEE (Main) 2019]

(1) 2 (2) $\frac{1}{9}$ (3) $\frac{1}{3}$ (4) 1

PSH040

11. A simple harmonic motion is represented by:

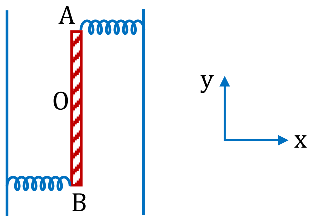
$$y = 5(\sin 3\pi t + \sqrt{3}\cos 3\pi t)\ cm$$

The amplitude and time period of the motion are: **[JEE (Main) 2019]**

(1) $5cm, \frac{3}{2}s$ (2) $5cm, \frac{2}{3}s$ (3) $10cm, \frac{3}{2}s$ (4) $10cm, \frac{2}{3}s$

PSH041

12. Two light identical springs of spring constant k are attached horizontally at the two ends of a uniform horizontal rod AB of length ℓ and mass m. The rod is pivoted at its centre 'O' and can rotate freely in horizontal plane. The other ends of the two springs are fixed to rigid supports as shown in figure. The rod is gently pushed through a small angle and released. The frequency of resulting oscillation is: **[JEE (Main) 2019]**



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

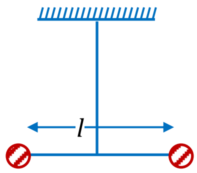
PSH042

13. A simple pendulum oscillating in air has period T. The bob of the pendulum is completely immersed in a non-viscous liquid. The density of the liquid is $\frac{1}{16}$th of the material of the bob. If the bob is inside liquid all the time, its period of oscillation in this liquid is : **[JEE (Main) 2019]**

(1) $4T\sqrt{\frac{1}{15}}$ (2) $2T\sqrt{\frac{1}{10}}$ (3) $4T\sqrt{\frac{1}{14}}$ (4) $2T\sqrt{\frac{1}{14}}$

PSH043

14. Two masses m and $\frac{m}{2}$ are connected at the two ends of a massless rigid rod of length l. The rod is suspended by a thin wire of torsional constant k at the centre of mass of the rod-mass system (see figure). Because of torsional constant k, the restoring torque is $\tau = k\theta$ for angular displacement θ. If the rod is rotated by θ_0 and released so that rod oscillates. The tension in it when it passes through its mean position will be: **[JEE (Main) 2019]**



(1) $\frac{3k\theta_0^2}{l}$ (2) $\frac{k\theta_0^2}{2l}$ (3) $\frac{2k\theta_0^2}{l}$ (4) $\frac{k\theta_0^2}{l}$

PSH044

15. A ring is hung on a nail. It can oscillate, without slipping or sliding (i) in its plane with a time period T_1 and, (ii) back and forth in a direction perpendicular to its plane, with a period T_2. The ratio $\frac{T_1}{T_2}$ will be : **[JEE (Main) 2020]**

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

PSH045

16. When a particle of mass m is attached to a vertical spring of spring constant k and released, its motion is described by $y(t) = y_0 \sin^2 \omega t$, where '$y$' is measured from the lower end of unstretched spring. Then ω is : **[JEE (Main) 2020]**

(1) $\sqrt{\frac{g}{y_0}}$ (2) $\sqrt{\frac{g}{2y_0}}$ (3) $\frac{1}{2}\sqrt{\frac{g}{y_0}}$ (4) $\sqrt{\frac{2g}{y_0}}$

PSH046

17. A simple pendulum is being used to determine the value of gravitational acceleration g at a certain place. The length of the pendulum is 25.0 cm and a stop watch with 1s resolution measures the time taken for 40 oscillations to be 50 s. The accuracy in g is : **[JEE (Main) 2020]**

(1) 3.40% (2) 5.40% (3) 4.40% (4) 2.40%

PSH047

18. Consider two identical springs, each of spring constant k and negligible mass compared to the mass M as shown. Fig. 1 shows one of them and Fig.2 shows their series combination. The ratio of time period of oscillation of the two SHM is $\frac{T_b}{T_a} = \sqrt{x}$, where value of x is ______.

(Round off to the Nearest Integer) **[JEE (Main) 2021]**

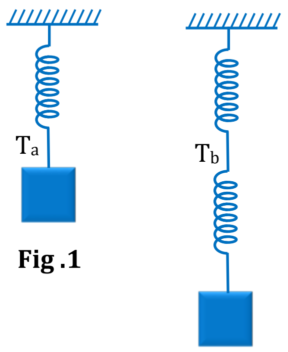
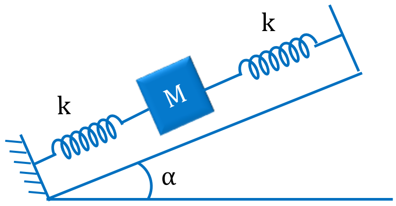


Fig .1 **Fig .2**

PSH048

19. In the given figure, a body of mass M is held between two massless springs, on a smooth inclined plane. The free ends of the springs are attached to firm supports. If each spring has spring constant k, the frequency of oscillation of given body is : **[JEE (Main) 2021]**



(1) $\frac{1}{2\pi}\sqrt{\frac{k}{2M}}$ (2) $\frac{1}{2\pi}\sqrt{\frac{2k}{Mg\sin\alpha}}$ (3) $\frac{1}{2\pi}\sqrt{\frac{2k}{M}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{k}{Mg\sin\alpha}}$

PSH049

20. $Y = A \sin(\omega t + \phi_0)$ is the displacement-time equation of a SHM. At $t = 0$ the displacement of the particle is $Y = \frac{A}{2}$ and it is moving along negative x-direction. Then the initial phase angle ϕ_0 will be:

[JEE (Main) 2021]

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

PSH050

21. The function of time representing a simple harmonic motion with a period of $\frac{\pi}{\omega}$ is :

[JEE (Main) 2021]

(1) $\sin(\omega t) + \cos(\omega t)$ (2) $\cos(\omega t) + \cos(2\omega t) + \cos(3\omega t)$

(3) $\sin^2(\omega t)$ (4) $3\cos\left(\frac{\pi}{4} - 2\omega t\right)$

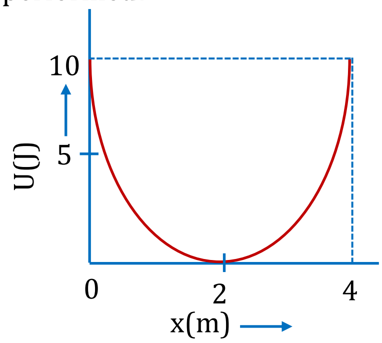
PSH051

22. A particle is executing simple harmonic motion along the X-axis. If at a distances x_1 and x_2 from the mean position the velocities of the particle are v_1 and v_2 respectively. The time period of its oscillation is given as : **[JEE (Main) 2021]**

(1) $T = 2\pi\sqrt{\frac{x_2^2 + x_1^2}{v_1^2 - v_2^2}}$ (2) $T = 2\pi\sqrt{\frac{x_2^2 + x_1^2}{v_1^2 + v_2^2}}$ (3) $T = 2\pi\sqrt{\frac{x_2^2 - x_1^2}{v_1^2 + v_2^2}}$ (4) $T = 2\pi\sqrt{\frac{x_2^2 - x_1^2}{v_1^2 - v_2^2}}$

PSH052

23. A mass of 5 kg is connected to a spring. The potential energy curve of the simple harmonic motion executed by the system is shown in the figure. A simple pendulum of length 4 m has the same period of oscillation as the spring system. What is the value of acceleration due to gravity on the planet where these experiments are performed? **[JEE (Main) 2021]**



(1) 10 m/s^2 (2) 5 m/s^2 (3) 4 m/s^2 (4) 9.8 m/s^2

PSH053

24. Two simple harmonic motions are represented by the equations $x_1 = 5 \sin\left(2\pi t + \frac{\pi}{4}\right)$ and $x_2 = 5\sqrt{2}$ ($\sin 2\pi t + \cos 2\pi t$). The amplitude of second motion is .... times the amplitude in first motion. **[JEE (Main) 2021]**

PSH054

25. Two simple harmonic motion, are represented by the equations $y_1 = 10 \sin\left(3\pi t + \frac{\pi}{3}\right)$

$y_2 = 5(\sin 3\pi t + \sqrt{3}\cos 3\pi t)$

Ratio of amplitude of y_1 to $y_2 = x : 1$. The value of x is _______. **[JEE (Main) 2021]**

PSH055

26. Two massless springs with spring constants 2 k and 9 k, carry 50 g and 100 g masses at their free ends. These two masses oscillate vertically such that their maximum velocities are equal. Then, the ratio of their respective amplitudes will be : **[JEE (Main) 2022]**

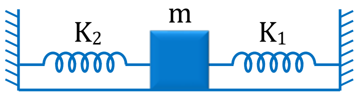
(1) 1 : 2 (2) 3 : 2 (3) 3 : 1 (4) 2 : 3

PSH056

27. The amplitude of a particle executing SHM is 3 cm. The displacement at which its kinetic energy will be 25% more than the potential energy is: _______ cm. **[JEE (Main) 2023]**

PSH185

28. A mass m is attached to two springs as shown in figure. The spring constants of two springs are K_1 and K_2. For the frictionless surface, the time period of oscillation of mass m is

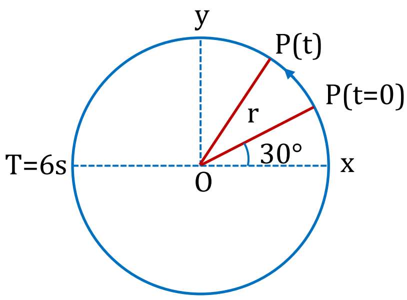


[JEE (Main) 2023]

(1) $\frac{1}{2\pi}\sqrt{\frac{K_1+K_2}{m}}$ (2) $\frac{1}{2\pi}\sqrt{\frac{K_1-K_2}{m}}$ (3) $2\pi\sqrt{\frac{m}{K_1+K_2}}$ (4) $2\pi\sqrt{\frac{m}{K_1-K_2}}$

PSH186

29. For particle P revolving round the centre O with radius of circular path r and angular velocity ω, as shown in below figure, the projection of OP on the x-axis at time t is



[JEE (Main) 2023]

(1) $x(t)=r\cos\left(\omega t+\frac{\pi}{6}\right)$ (2) $x(t)=r\cos(\omega t)$

(3) $x(t)=r\sin\left(\omega t+\frac{\pi}{6}\right)$ (4) $x(t)=r\cos\left(\omega t-\frac{\pi}{6}\omega\right)$

PSH187

EXERCISE - JEE (Advanced) PYQ

1. A particle of mass m is attached to one end of a mass-less spring of force constant k, lying on a frictionless horizontal plane. The other end of the spring is fixed. The particle starts moving horizontally from its equilibrium position at time $t = 0$ with an initial velocity u_0. When the speed of the particle is 0.5 u_0, it collides elastically with a rigid wall. After this collision :-

[JEE (Advanced) 2013]

(A) the speed of the particle when it returns to its equilibrium position is u_0.

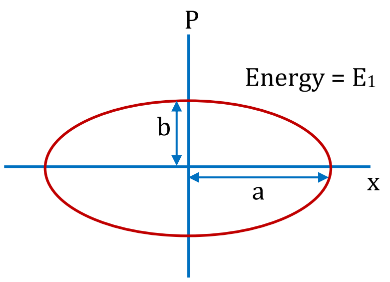
(B) the time at which the particle passes through the equilibrium position for the first time is $t = \pi\sqrt{\frac{m}{k}}$.

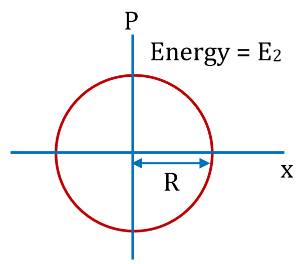
(C) the time at which the maximum compression of the spring occurs is $t = \frac{4\pi}{3}\sqrt{\frac{m}{k}}$.

(D) the time at which the particle passes through the equilibrium position for the second time is $t = \frac{5\pi}{3}\sqrt{\frac{m}{k}}$.

PSH077

2. Two independent harmonic oscillators of equal mass are oscillating about the origin with angular frequencies ω_1 and ω_2 and have total energies E_1 and E_2, respectively. The variations of their momenta p with positions x are shown in the figures. If $\frac{a}{b} = n^2$ and $\frac{a}{R} = n$, then the correct equation(s) is (are) **[JEE (Advanced) 2015]**





(A) $E_1\omega_1 = E_2\omega_2$

(B) $\frac{\omega_2}{\omega_1} = n^2$

(C) $\omega_1\omega_2 = n^2$

(D) $\frac{E_1}{\omega_1} = \frac{E_2}{\omega_2}$

PSH078

3. A particle of unit mass is moving along the x-axis under the influence of a force and its total energy is conserved. Four possible forms of the potential energy of the particle are given in column I (a and U_0 are constants). Match the potential energies in column I to the corresponding statement(s) in column-II **[JEE (Advanced) 2015]**

Column-I	**Column-II**
(A) $U_1(x) = \frac{U_0}{2}\left[1-\left(\frac{x}{a}\right)^2\right]^2$	(P) The force acting on the particle is zero at $x = a$.
(B) $U_2(x) = \frac{U_0}{2}\left(\frac{x}{a}\right)^2$	(Q) The force acting on the particle is zero at $x = 0$.
(C) $U_3(x) = \frac{U_0}{2}\left(\frac{x}{a}\right)^2 exp\left[-\left(\frac{x}{a}\right)^2\right]$	(R) The force acting on the particle is zero at $x = -a$.
(D) $U_4(x) = \frac{U_0}{2}\left[\frac{x}{a}-\frac{1}{3}\left(\frac{x}{a}\right)^3\right]$	(S) The particle experiences an attractive force towards $x = 0$ in the region $\lvert x\rvert < a$.
	(T) The particle with total energy $\frac{U_0}{4}$ can oscillate about the point $x = -a$.

PSH079

4. A block with mass M is connected by a massless spring with stiffness constant k to a rigid wall and moves without friction on a horizontal surface. The block oscillates with small amplitude A about an equilibrium position x_0. Consider two cases : (i) when the block is at x_0; and (ii) when the block is at $x = x_0 + A$. In both the cases, a particle with mass m ($<M$) is softly placed on the block after which they stick to each other. Which of the following statement(s) is(are) true about the motion after the mass m is placed on the mass M? **[JEE (Advanced) 2016]**

(A) The amplitude of oscillation in the first case changes by a factor of $\sqrt{\frac{M}{m+M}}$, whereas in the second case it remains unchanged

(B) The final time period of oscillation in both the cases is same

(C) The total energy decreases in both the cases

(D) The instantaneous speed at x_0 of the combined masses decreases in both the cases.

PSH080

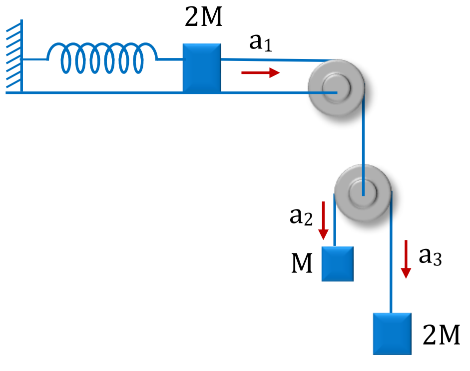
5. A block of mass $2M$ is attached to a massless spring with spring-constant k. This block is connected to two other blocks of masses M and $2M$ using two massless pulleys and strings. The accelerations of the blocks are a_1, a_2 and a_3 as shown in figure. The system is released from rest with the spring in its unstretched state. The maximum extension of the spring is x_0. Which of the following option(s) is/are correct ? [g is the acceleration due to gravity. Neglect friction] **[JEE (Advanced) 2019]**

(A) $x_0 = \frac{4Mg}{k}$

(B) When spring achieves an extension of $\frac{x_0}{2}$ for the first time, the speed of the block connected to the spring is $3g\sqrt{\frac{M}{5k}}$

(C) $a_2 - a_1 = a_1 - a_3$

(D) At an extension of $\frac{x_0}{4}$ of the spring, the magnitude of acceleration of the block connected to the spring is $\frac{3g}{10}$



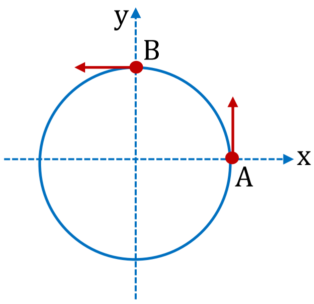
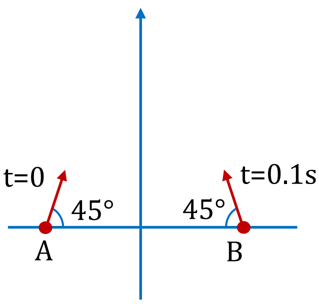
PSH081

6. On a frictionless horizontal plane, a bob of mass m = 0.1 kg is attached to a spring with natural length l_0 = 0.1 m. The spring constant is k_1 = 0.009 Nm^{-1} when the length of the spring $l > l_0$ and is k_2 = 0.016 Nm^{-1} when $l < l_0$. Initially the bob is released from l = 0.15 m. Assume that Hooke's law remains valid throughout the motion. If the time period of the full oscillation is $T = (n\pi)$ s, then the integer closest to n is _______. **[JEE (Advanced) 2021]**

PSH082

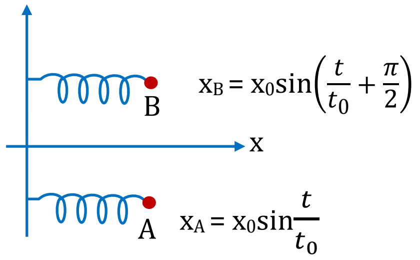
7. List I describes four systems, each with two particles A and B in relative motion as shown in figure. List II gives possible magnitudes of the relative velocities (in ms^{-1}) at time $t = \frac{\pi}{3} s$.

[JEE (Advanced) 2022]

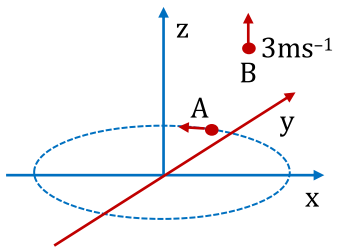
List-I	**List-II**
(I) A and B are moving on a horizontal circle of radius 1 m with uniform angular speed ω = 1 rad s^{-1}. The initial angular positions of A and B at time t = 0 are θ = 0 and $\theta = \frac{\pi}{2}$ respectively. 	(P) $\frac{\sqrt{3}+1}{2}$
(II) Projectiles A and B are fired (in the same vertical plane) at t = 0 and t = 0.1 s respectively, with the same speed $v = \frac{5\pi}{\sqrt{2}}$ m s^{-1} and at 45° from the horizontal plane. The initial separation between A and B is large enough so that they do not collide, (g = 10 m s^{-2}). 	(Q) $\frac{(\sqrt{3}-1)}{\sqrt{2}}$

List-I | **List-II**

(III) Two harmonic oscillators A and B moving in the x direction according to $x_A = x_0 \sin\frac{t}{t_0}$ and $x_B = x_0 \sin\left(\frac{t}{t_0}+\frac{\pi}{2}\right)$ respectively, starting from $t = 0$. Take $x_0 = 1\ m$, $t_0 = 1$ s. — (R) $\sqrt{10}$



(IV) Particle A is rotating in a horizontal circular path of radius 1 m on the xy plane, with constant angular speed $\omega = 1\ rad\ s^{-1}$. Particle B is moving up at a constant speed 3 $m\ s^{-1}$ in the vertical direction as shown in the figure. (Ignore gravity.) — (S) $\sqrt{2}$



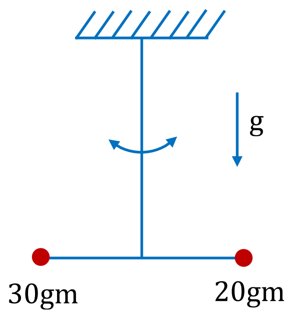
(T) $\sqrt{25\pi^2+1}$

Which one of the following options is correct?

(A) I → R, II → T, III → P, IV → S
(B) I → S, II → P, III → Q, IV → R
(C) I → S, II → T, III → P, IV → R
(D) I → T, II → P, III → R, IV → S

PSH083

8. Two point-like objects of masses 20 gm and 30 gm are fixed at the two ends of a rigid massless rod of length 10 cm. This system is suspended vertically from a rigid ceiling using a thin wire attached to its center of mass, as shown in the figure. The resulting torsional pendulum undergoes small oscillations. The torsional constant of the wire is $1.2 \times 10^{-8}\ N\ m\ rad^{-1}$. The angular frequency of the oscillations is $n \times 10^{-3}\ rad\ s^{-1}$. The value of n is ____. **[JEE (Advanced) 2023]**



PSH188

JEE (Main) Practice Paper

This paper is for yourself practice and assessment the discussion of this paper is optional though you can see PDF solutions or video solutions or solutions in hardcopy whichever is provided.

SECTION–A

- This section contains **TWENTY** questions.
- Each question has **FOUR** options (1), (2), (3) and (4). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks : +4, if only the bubble corresponding to the correct option is darkened.
Zero Marks : 0, if none of the bubbles is darkened.
Negative Marks : −1 in all other cases.

1. Two particles A and B perform SHM along the same straight line with the same amplitude 'a', same frequency 'f' and same equilibrium position 'O'. The greatest distance between them is found to be $\frac{3a}{2}$. At some instant of time they have the same displacement from mean position. What is the displacement?

(1) $a/2$ (2) $a\sqrt{7}/4$ (3) $\sqrt{3}a/2$ (4) $3a/4$

PSH001

2. A particle performing SHM is found at positive extreme at $t = 0$. What will be the equation of SHM? [A = amplitude, ω = angular frequency] :

(1) $A\sin\left(\omega t+\frac{\pi}{6}\right)$ (2) $A\sin\left(\omega t+\frac{\pi}{3}\right)$ (3) $A\sin\left(\omega t+\frac{\pi}{2}\right)$ (4) $A\sin\left(\omega t+\frac{2\pi}{3}\right)$

PSH189

3. The angular frequency of a spring block system is ω_0. This system is suspended from the ceiling of an elevator moving downwards with a constant speed v_0. The block is at rest relative to the elevator. Lift is suddenly stopped. Assuming the downwards as a positive direction, choose the wrong statement:

(1) The amplitude of the block is $\frac{v_0}{\omega_0}$

(2) The initial phase of the block is π.

(3) The equation of motion for the block is $\frac{v_0}{\omega_0}\sin\omega_0 t$.

(4) The maximum speed of the block is v_0.

PSH003

4. Two particles are performing SHM with same angular frequency and amplitudes A and $2A$ respectively along same straight line with same mean position. They cross each other at position $A/2$ distance from mean position in opposite direction. The phase between them is :

(1) $\frac{5\pi}{6}-\sin^{-1}\left(\frac{1}{4}\right)$ (2) $\frac{\pi}{6}-\sin^{-1}\left(\frac{1}{4}\right)$ (3) $\frac{5\pi}{6}-\cos^{-1}\left(\frac{1}{4}\right)$ (4) $\frac{\pi}{6}-\cos^{-1}\left(\frac{1}{4}\right)$

PSH004

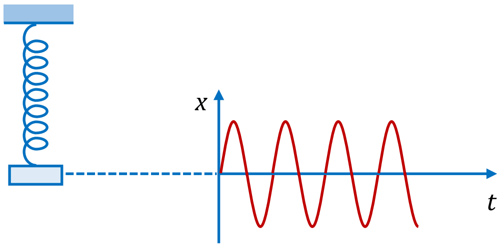
5. A particle is executing SHM of amplitude A, about the mean position $x = 0$. Which of the following cannot be a possible phase difference between the positions of the particle at $x = +\ A/2$ and $x = -\ A/\sqrt{2}$.

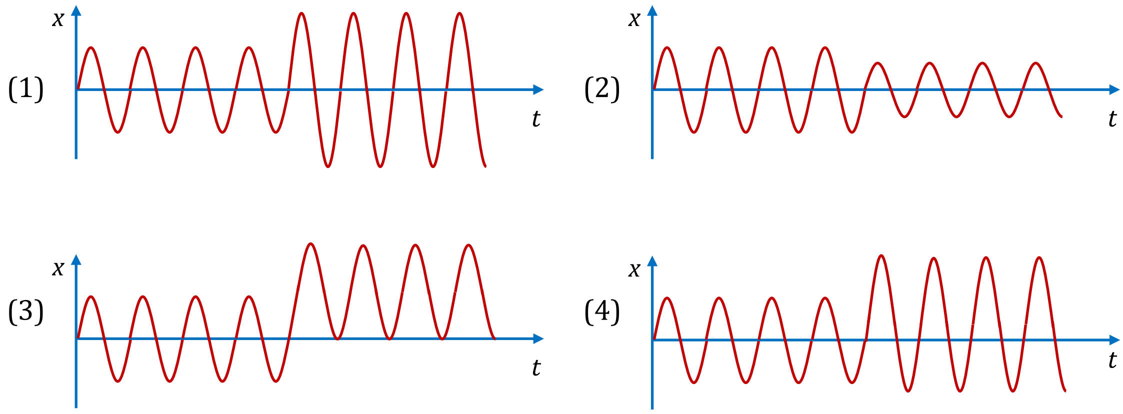
(1) 75° (2) 165° (3) 135° (4) 195°

PSH005

6. In the figure is shown a spring-mass system oscillating in uniform gravity. If we neglect all dissipative forces, it will keep on oscillating endlessly with constant amplitude and frequency. Accompanying graph shows how displacement x of the block from the equilibrium position varies with time t.

Now at a certain instant $t = t_0$ when the block reaches its lowest position, gravity is switched off by some unknown mechanism. Which of the following graphs would correctly describes the changes taking place due to switching off the gravity?





PSH006

7. Time period of a particle executing SHM is 8 sec. At $t = 0$ it is at the mean position. The ratio of the distance covered by the particle in the 1st second to the 2nd second is :

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

PSH007

8. A particle executes SHM with time period T and amplitude A. The maximum possible average velocity in time $\dfrac{T}{4}$ is

(1) $\dfrac{2A}{T}$ (2) $\dfrac{4A}{T}$ (3) $\dfrac{8A}{T}$ (4) $\dfrac{4\sqrt{2}A}{T}$

PSH008

9. A wire frame in the shape of an equilateral triangle is hinged at one vertex so that it can swing freely in a vertical plane, with the plane of the Δ always remaining vertical. The side of the frame is $1/\sqrt{3}$ *m*. The time period in seconds of small oscillations of the frame will be

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

PSH009

10. A particle executing a simple harmonic motion of period 2*s*. When it is at its extreme displacement from its mean position, it receives an additional energy equal to what it had in its mean position. Due to this, in its subsequent motion,

(1) its amplitude will change and become equal to $\sqrt{2}$ times its previous amplitude

(2) its periodic time will become doubled i.e. 4*s*

(3) its potential energy will be decreased

(4) it will continue to execute simple harmonic motion of the same amplitude and period as before receiving the additional energy.

PSH010

11. A particle free to move along the *x*-axis has potential energy given by $U(x) = k[1-\exp(-x^2)]$ for $-\infty < x < +\infty$, where *k* is a positive constant of appropriate dimensions. Then

(1) at point away from the origin, the particle is in unstable equilibrium.

(2) for any finite non-zero value of *x*, there is a force directed away from the origin.

(3) if its total mechanical energy is $k/2$, it has its minimum kinetic energy at the origin.

(4) for small displacements from $x = 0$, the motion is simple harmonic.

PSH011

12. A rod whose ends are *A* and *B* of length 25 *cm* is hanged in vertical plane. When hanged from point *A* and point *B* the time periods calculated are 3 sec and 4 sec respectively. Given the moment of inertia of rod about axis perpendicular to the rod is in ratio 9 : 4 at points *A* and *B*. Find the distance of the centre of mass from point *A*.

(1) 9 *cm* (2) 5 *cm* (3) 25 *cm* (4) 20 *cm*

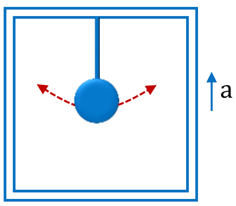
PSH012

13. A ring of diameter 2*m* oscillates as a compound pendulum about a horizontal axis passing through a point at its rim. It oscillates such that its centre move in a plane which is perpendicular to the plane of the ring. The equivalent length of the simple pendulum is :-

(1) 2*m* (2) 4*m* (3) 1.5*m* (4) 3*m*

PSH013

14. A scientist measures the time period of a simple pendulum as *T* in a lift at rest. If the lift moves up with acceleration as one fourth of the acceleration of gravity, the new time period is

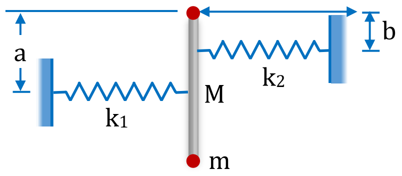


(1) $\frac{T}{4}$ (2) $4T$

(3) $\frac{2}{\sqrt{5}}T$ (4) $\frac{\sqrt{5}}{2}T$

PSH014

15. A rod of mass M and length L is hinged at its one end and carries a particle of mass m at its lower end. A spring of force constant k_1 is installed at distance a from the hinge and another of force constant k_2 at a distance b as shown in the figure. If the whole arrangement rests on a smooth horizontal table top, the frequency of vibration is

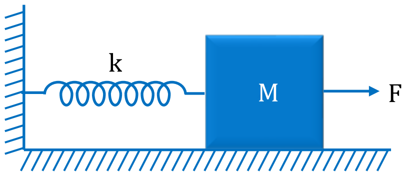


(1) $\frac{1}{2\pi}\sqrt{\frac{k_1a^2+k_2b^2}{L^2(m+\frac{M}{3})}}$ (2) $\frac{1}{2\pi}\sqrt{\frac{k_2+k_1}{M+m}}$

(3) $\frac{1}{2\pi}\sqrt{\frac{k_2+k_1\frac{a^2}{b^2}}{4\frac{M}{3}+m}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{k_1+\frac{k_2b^2}{a^2}}{\frac{4}{3}m+M}}$

PSH015

16. A spring mass system is shown in figure, spring is initially unstretched. A man starts pulling the block with constant force *F*. Find the *K.E.* of the block at mean position



(1) $F^2/3K$ (2) $F^2/2K$ (3) $F^2/4K$ (4) F^2/K

PSH016

17. The period of small oscillations of a simple pendulum of length ℓ if its point of suspension O moves with a constant acceleration $a = \alpha_1\hat{\imath} - \alpha_2\hat{\jmath}$ with respect to earth is ($\hat{\imath}$ and $\hat{\jmath}$ are unit vectors in horizontal and vertically upward directions respectively)

(1) $T = 2\pi\sqrt{\frac{\ell}{\{(g-\alpha_2)^2+\alpha_1^2\}^{1/2}}}$ (2) $T = 2\pi\sqrt{\frac{\ell}{\{(g-\alpha_1)^2+\alpha_2^2\}^{1/2}}}$

(3) $T = 2\pi\sqrt{\frac{\ell}{g}}$ (4) $T = 2\pi\sqrt{\frac{\ell}{(g^2+\alpha_1^2)^{1/2}}}$

PSH017

18. Compound pendulum is made of A uniform square plate of edge a suspended through a corner. Find the time period-

(1) $T = 2\pi\sqrt{\frac{\sqrt{8}a}{3g}}$ (2) $T = 2\pi\sqrt{\frac{\sqrt{8}a}{4g}}$ (3) $T = 2\pi\sqrt{\frac{4a}{4g}}$ (4) $T = 2\pi\sqrt{\frac{\sqrt{4}a}{3g}}$

PSH018

19. A compound pendulum is made of A uniform rod of length L. Find the minimum possible time period and distance between centre and point of suspension.

(1) $2\pi\sqrt{\frac{L}{\sqrt{3}g}}, \frac{L}{2\sqrt{3}}$ (2) $2\pi\sqrt{\frac{L}{\sqrt{3}g}}, \frac{L}{2\sqrt{2}}$ (3) $2\pi\sqrt{\frac{L}{\sqrt{2}g}}, \frac{L}{2\sqrt{2}}$ (4) $2\pi\sqrt{\frac{L}{\sqrt{2}g}}, \frac{4L}{2\sqrt{2}}$

PSH019

20. A particle is subjected to three SHM's in same direction simultaneously each having equal amplitude a and equal time period. The phase of the second motion is 30° ahead of the first and the phase of the third motion is 30° ahead of the second. Find the amplitude of the resultant motion.

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

PSH020

SECTION–B

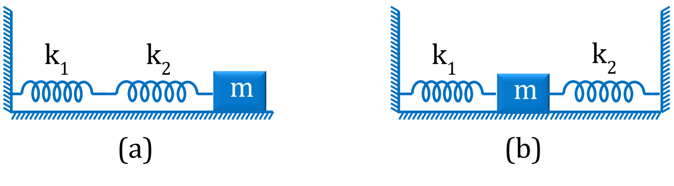
- This section will have **TEN questions**. Candidate can choose to attempt any 5 questions out of these 10 questions. In case if candidate attempts more than 5 questions, first 5 attempted questions will be considered for marking.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value (Answer should be rounded off to the nearest integer).
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks	:	+4,	if only correct answer is given.
Zero Marks	:	0,	if no answer is given.
Negative Marks	:	–1	for incorrect answer.

1. A block is placed on a horizontal platform vibrating up and down, simple harmonically. It is observed that the block loses its contact with the platform when its angular frequency is 5 rad/s. The amplitude of vibration can not be less than 'A' (in cm), then find the value of A.

PSH190

2. In the figure shown, a block executes SHM under the influence of two springs on a smooth surface as shown. It is found that the time period of oscillation in case (a) is double that in case (b). If k_1 is 10 N/m, what is the value of k_2 (in N/m)?



PSH191

3. The angle made by the string of a simple pendulum with the vertical depends upon time as $\theta = \frac{\pi}{90}\sin\pi t$. Find the length of the pendulum if $g = \pi^2\ ms^{-2}$.

PSH192

4. A particle performs SHM such that at $t = 0$, $x = 0$. The time taken by it to go from $x = A/2$ to A is t_1 and the time taken to go from $x = 0$ to $A/2$ is t_2. Find the value of $\frac{t_1}{t_2}$.

PSH193

5. Two particles execute SHM with amplitude A and $2A$ and angular frequency ω and 2ω respectively. At t = 0 they start with some initial phase difference. At, $t = \frac{2\pi}{3\omega}$. They are in same phase. If initial phase difference is $\frac{2\pi}{n}$ where n is :

PSH194

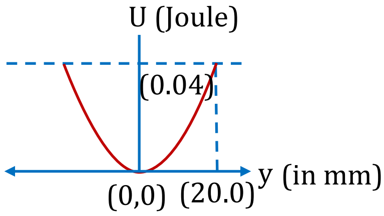
6. The displacement x of a particle at a time t is given by x = 5 sin 2t where x is in meter and t is in second. A simple pendulum has the same period as the particle when the length of the pendulum is ℓ then value of 10ℓ is

PSH195

7. A linear harmonic oscillator of force constant $2 \times 10^6\ N/m$ and amplitude $0.01m$ has a total mechanical energy of 160 joule. Its maximum kinetic energy is (in Joule) :

PSH196

8. The variation in potential energy of a harmonic oscillator is as shown in fig. The spring constant is:-

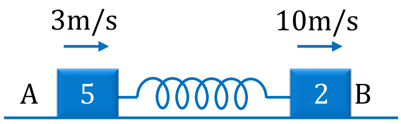


PSH197

9. A particle performing linear SHM with time period T is at $x = +\frac{A}{2}$ moving towards positive extreme. The time after which it will first come to rest is $\frac{T}{N}$. Find N.

PSH198

10. Two blocks A (5kg) and B(2kg) attached to the ends of a spring constant 1120N/m are placed on a smooth horizontal plane with the spring undeformed. Simultaneously velocities of 3m/s and 10m/s along the line of the spring in the same direction are imparted to A and B then find the maximum extension (in cm) of the spring.



PSH199

JEE (Advanced) Practice Paper

This paper is for yourself practice and assessment the discussion of this paper is optional though you can see PDF solutions or video solutions or solutions in hardcopy whichever is provided.

SECTION–I

- This section contains **SIX** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

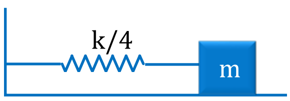
Full Marks : +3 if only the bubble corresponding to the correct option is darkened.
Zero Marks : 0 if none of the bubbles is darkened.
Negative Marks : –1 in all other cases.

1. A particle is performing SHM on x-axis about mean position $x = 0$ having amplitude A and angular frequency ω. At $t = 0$ particle is at $x = \frac{A}{2}$ and moving in $+ve$ x direction. If equation of SHM is $x = A\sin(\omega t + \phi)$ then ϕ is :

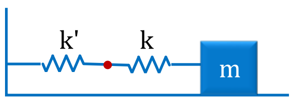
(A) $\frac{\pi}{6}$ (B) $\frac{\pi}{3}$ (C) $\frac{2\pi}{3}$ (D) $\frac{5\pi}{6}$

PSH057

2. Oscillators A and B shown in figure are oscillating with same amplitude and energy. Respective spring constants are mentioned in the figure. Then:



(A)

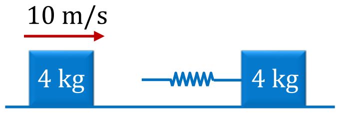


(B)

(A) $k' = \frac{k}{3}$ (B) $k' = \frac{2k}{3}$ (C) $k' = \frac{4k}{3}$ (D) $k' = \frac{k}{6}$

PSH058

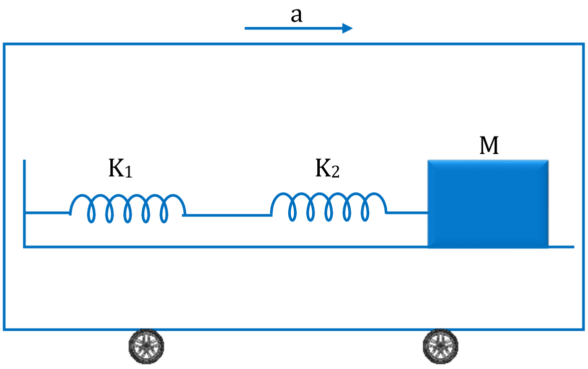
3. A 4 kg block moving with 10 m/s strikes a spring of constant π^2 N/m attached to 4 kg block at rest kept on a smooth floor. The time for which rear moving block remain in contact with spring will be:



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

PSH059

4. As shown, inside a cart that is accelerating horizontally at acceleration a there is a block of mass M connected to two light springs of force constants k_1 and k_2. The block can move without friction horizontally. Find the vibration frequency of the block.

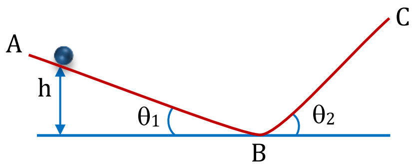


(A) $\frac{1}{2\pi}\sqrt{\frac{k_1+k_2}{M}}$ (B) $\frac{1}{2\pi}\sqrt{\frac{k_1+k_2}{M}-a}$

(C) $\frac{1}{2\pi}\sqrt{\frac{k_1k_2}{(k_1+k_2)M}}$ (D) $\frac{1}{2\pi}\sqrt{\frac{k_1k_2}{(k_1+k_2)M}+a}$

PSH060

5. A small glass bead of mass m initially at rest starts from a point at height h above the horizontal and rolls down the inclined plane AB as shown. Then it rises along the inclined plane BC. Assuming no loss of energy and sufficient friction for pure rolling, the time period of oscillation of the glass bead is:

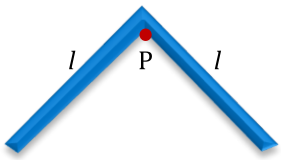


(A) $\sqrt{\frac{8h}{g}}(\sin\theta_1+\sin\theta_2)$ (B) $2\sqrt{\frac{14h}{5g}}\left(\frac{1}{\sin\theta_1}+\frac{1}{\sin\theta_2}\right)$

(C) $\sqrt{\frac{8h}{g}}\left(\frac{1}{\sin\theta_1}+\frac{1}{\sin\theta_2}\right)$ (D) $\sqrt{\frac{8h}{5g}}\left(\frac{1}{\sin\theta_1}+\frac{1}{\sin\theta_2}\right)$

PSH061

6. A system of two identical rods (L-shaped) of mass m and length l are resting on a peg P as shown in the figure. If the system is displaced in its plane by a small angle θ, find the period of oscillations:



(A) $2\pi\sqrt{\frac{\sqrt{2}\,l}{3g}}$ (B) $2\pi\sqrt{\frac{2\sqrt{2}l}{3g}}$ (C) $2\pi\sqrt{\frac{2l}{3g}}$ (D) $3\pi\sqrt{\frac{l}{3g}}$

PSH062

SECTION-II

- This section contains **SIX** questions.
- Each question has **FOUR** options for correct answer(*s*). **ONE OR MORE THAN ONE** of these four option(*s*) is (are) correct option(*s*).
- For each question, choose the correct option(*s*) to answer the question.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 if only (all) the correct option(*s*) is (are) chosen.

Partial Marks : +3 if all the four options are correct but ONLY three options are chosen.

Partial Marks : +2 if three or more options are correct but ONLY two options are chosen, both of which are correct options.

Partial Marks : +1 if two or more options are correct but ONLY one option is chosen and it is a correct option.

Zero Marks : 0 if none of the options is chosen (i.e. the question is unanswered).

Negative Marks : –2 in all other cases.

For Example : If first, third and fourth are the **ONLY** three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(*s*) (second option in this case), with or without selection of any correct option(*s*) will result in –2 marks.

---

7. The amplitude of a particle executing SHM about *O* is 10 *cm*. Then :

(A) When the *K.E.* is 0.64 of its max. *K.E.* its displacement is 6*cm* from *O*.

(B) When the displacement is 5 *cm* from *O* its *K.E.* is 0.75 of its max.*P.E.*

(C) Its total energy at any point is equal to its maximum *K.E.*

(D) Its velocity is half the maximum velocity when its displacement is half the maximum displacement.

PSH063

8. The position vector of a particle that is moving in space is given by

$$\vec{r} = (1 + 2\cos 2\,\omega t)\hat{\imath} + (3\sin^2 \omega\, t)\hat{\jmath} + (3)\hat{k}$$

in the ground frame. All units are in SI. Choose the correct statement (s) :

(A) The particle executes SHM in the ground frame about the mean position $\left(1, \frac{3}{2}, 3\right)$.

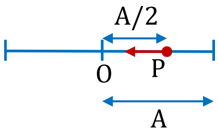
(B) The particle executes SHM in a frame moving along the *z*-axis with a velocity of 3 *m/s.*

(C) The amplitude of the SHM of the particle is $\frac{5}{2}$ *m*.

(D) The direction of the SHM of the particle is given by the vector $\left(\frac{4}{5}\hat{i} - \frac{3}{5}\hat{j}\right)$.

PSH064

9. A particle starts from a point P at a distance of $A/2$ from the mean position O and travels towards left as shown in the figure. If the time period of SHM, executed about O is T and amplitude A then the equation of motion of particle is :



(A) $x = A\sin\left(\frac{2\pi}{T}t + \frac{\pi}{6}\right)$ (B) $x = A\sin\left(\frac{2\pi}{T}t + \frac{5\pi}{6}\right)$

(C) $x = A\cos\left(\frac{2\pi}{T}t + \frac{\pi}{6}\right)$ (D) $x = A\cos\left(\frac{2\pi}{T}t + \frac{\pi}{3}\right)$

PSH065

10. A spring has natural length 40 cm and spring constant 500 N/m. A block of mass 1 kg is attached at one end of the spring and other end of the spring is attached to ceiling. The block released from the position, where the spring has length 45 cm.

(A) the block will perform SHM of amplitude 5 cm.

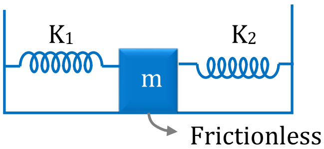
(B) the block will have maximum velocity $30\sqrt{5}\ cm/\text{sec}$.

(C) the block will have maximum acceleration 15 m/s^2

(D) the minimum potential energy of the spring will be zero.

PSH066

11. Two springs with negligible masses and force constant of K_1 = 200 Nm^{-1} and K_2 = 160 Nm^{-1} are attached to the block of mass m = 10 kg as shown in the figure. Initially the block is at rest, at the equilibrium position in which both springs are neither stretched nor compressed. At time t = 0, a sharp impulse of 50 Ns is given to the block with a hammer.



(A) Period of oscillations for the mass m is $\frac{\pi}{3}$ s.

(B) Maximum velocity of the mass m during its oscillation is 5 ms^{-1}.

(C) Data are insufficient to determine maximum velocity.

(D) Amplitude of oscillation is 0.42 m.

PSH067

12. A mass of 0.2kg is attached to the lower end of a massless spring of force-constant 200 N/m, the upper end of which is fixed to a rigid support. Which of the following statements is/are true?

(A) In equilibrium, the spring will be stretched by 1cm.

(B) If the mass is raised till the spring is unstretched state and then released, it will go down by 2cm before moving upwards.

(C) The frequency of oscillation will be nearly 5 Hz.

(D) If the system is taken to the moon, the frequency of oscillation will be the same as on the earth.

PSH068

SECTION-III

- This section contains **THREE** paragraphs.
- Based on each paragraph, there are **TWO** questions.
- Each question has **FOUR** options (A), (B), (C) and (D) **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :

Full Marks : +3 if only the bubble corresponding to the correct answer is darkened.

Zero Marks : 0 in all other cases.

PARAGRAPH FOR QUESTION NO. 13 AND 14

A particle can move along x-axis under influence of a conservative force. The potential energy of the particle is given by $U = 5x^2 - 20x + 2$ joule, where x is co-cordinate of the particle expressed in meter. The particle is released from rest at $x = -3m$.

13. Amplitude of the particle is :

(A) $3m$ (B) $2m$ (C) $5m$ (D) None of these

PSH069

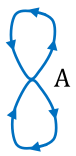
14. The maximum x-coordinate of the particle :

(A) $-3m$ (B) $7m$ (C) $5m$ (D) None of these

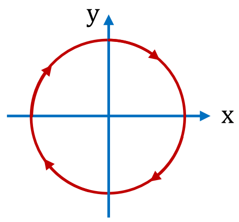
PSH070

PARAGRAPH FOR QUESTION NO. 15 AND 16

Lissajous figures are produced by superposition of 2 SHM's in mutually perpendicular directions. If both SHM have same frequency, the lissajous figure is simple. It may be a circle, ellipse or a straight line depending on the phase difference between two SHMs. Interesting case occurs when one of the SHM is at double frequency of another. Suppose a body executes SHM vertically with frequency f_0, but horizontally with a frequency $2f_0$ and is initially at A, mean position of vertical as well as horizontal SHM. It can be seen to trace out a figure of 8 in space as shown. Since horizontal SHM has half the time period, it executes two horizontal oscillations by the time it completes a vertical oscillation.



15. A lissajous figure as shown here can be produced by



(A) $x = A \sin \omega t$; $y = A \cos \omega t$

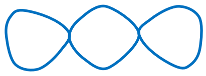
(B) $x = A \cos \omega t$; $y = A \sin \omega t$

(C) $x = A \sin \omega t$; $y = A \sin\left(\omega t + \frac{\pi}{4}\right)$

(D) $x = A \sin \omega t$; $y = A \sin\left(\omega t + \frac{3\pi}{4}\right)$

PSH071

16. For the Lissajous figure shown here, the frequency in vertical direction is ______ times the frequency in horizontal direction :-



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

PSH072

PARAGRAPH FOR QUESTION NO. 17 AND 18

A particle of mass 'm' moves on a horizontal smooth line AB of length 'a' such that when particle is at any general point P on the line two forces act on it. A force $\frac{mg(AP)}{a}$ towards A and another force $\frac{2mg(BP)}{a}$ towards B.

17. Find its time period when released from rest from mid-point of line AB.

(A) $T = 2\pi\sqrt{\frac{3a}{g}}$ (B) $T = 2\pi\sqrt{\frac{a}{2g}}$ (C) $T = 2\pi\sqrt{\frac{a}{g}}$ (D) $T = 2\pi\sqrt{\frac{a}{3g}}$

PSH073

18. If the force acting towards A stops acting when the particle is nearest to B then find the velocity with which it crosses point B.

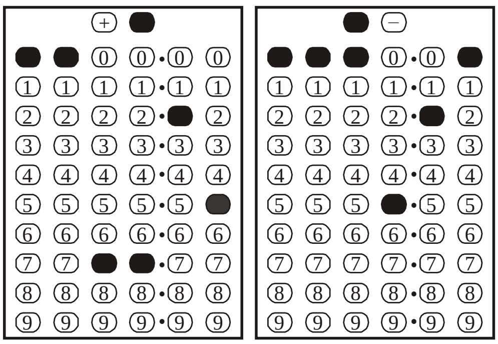
(A) $\frac{\sqrt{2ga}}{3}$ (B) $\frac{\sqrt{2ga}}{6}$ (C) $\frac{\sqrt{2ga}}{5}$ (D) $\frac{\sqrt{ga}}{3}$

PSH074

SECTION-IV

- This section contains **TWO** questions.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the **second decimal place**; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30, if answer is 11.36777..... then both 11.36 and 11.37 will be correct) by darken the corresponding bubbles in the ORS.

  For Example : If answer is –77.25, 5.2 then fill the bubbles as follows:

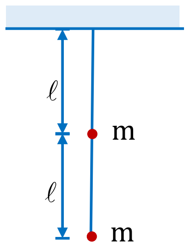


- Answer to each question will be evaluated according to the following marking scheme:

  Full Marks : +3 if ONLY the correct numerical value is entered as answer.

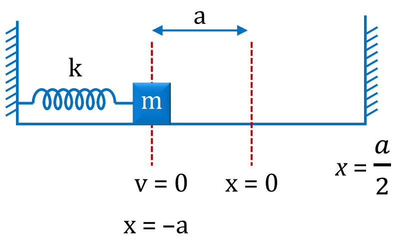
  Zero Marks : 0 in all other cases.

19. Two particle of mass m each are fixed to a massless rod of length 2ℓ. The rod is smoothly hinged at one end to a ceiling. It performs oscillation of small angle in vertical plane. The length of the equivalent simple pendulum is $\left(\frac{x\ell}{3}\right)$. Then find x.



PSH200

20. A spring (spring constant k) having one end attached to rigid wall and other end attached to a block of mass m kept on a smooth surface as shown in figure. Initially spring is in its natural length at $x = 0$, now spring is compressed to $x = -a$ and released. (Coefficient of restitution $(e) = \frac{1}{2}$). If velocity of block just after first collision is $a\sqrt{\frac{nk}{16m}}$. Find the value of n.



PSH076

ANSWER KEY

EXERCISE - O

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	C	D	A	C	A	A	A	A	B	C
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	B	A	C	A	B	D	C	A	C	A
Que.	21	22	23	24	25	26	27	28	29	30
Ans.	C	A	B	B	B	B	B	C	A	C
Que.	31	32	33	34	35	36	37	38	39	40
Ans.	B	A	A	A	C	C	A	C	B	A
Que.	41	42	43	44	45	46	47	48	49	50
Ans.	C	B	D	C	A	BC	AC	ABCD	AB	ABC
Que.	51	52	53	54	55	56	57	58	59	
Ans.	BCD	AD	ACD	B	C	A	C	A	A	
Que.	60									
Ans.	(P-3,4), (Q-2,3,4), (R-1,3), (S-1,2,3,4)									

EXERCISE - S

1. $y = 2\sin\left(\frac{10}{3}t - \frac{\pi}{2}\right)$ **2.** 0.33 sec **3.** 2 m/s

4. $\frac{1}{2\pi}\sqrt{\frac{\beta}{\alpha}}$ **5.** (a) $T/12$, (b) $T/8$, (c) $T/6$, (d) $T/4$, (e) $T/8$

6. $x = (10\ cm)\sin\left[\left(\frac{\pi}{3}s^{-1}\right)t + \frac{\pi}{6}\right]$, $\frac{10}{9}\pi^2 \approx 11\ cm/s^2$ **7.** $0.06m$

8. $y = 0.1\sin(4t + \pi/4)$ **9.** (i) $x_0 = 2m$; (ii) $T = \sqrt{2}\,\pi$ sec.; (iii) $2\sqrt{3}$

10. 3 **11.** 3 **12.** 12

13. $\omega = \sqrt{\frac{2T_0}{m\ell}}$ **14.** $1/\sqrt{3}$ **15.** $M = 1.6\ kg$

16. (a) $\frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$, (b) $\frac{L}{3}$ **17.** 100 Nm^{-1} **18.** $10/\pi\ Hz$, $\frac{5\sqrt{37}}{6}\ cm$

19. 2 **20.** 5 **21.** 1

22. $f = \frac{1}{2\pi}\sqrt{\frac{3g}{2R}}$ **23.** $\frac{5}{2\pi}\ Hz$, 5 cm **24.** 0.16 kg

25. 5 **26.** 3 **27.** 7

28. 6 **29.** $T = 2\sqrt{\ell/g}\ [\pi/2 + \sin^{-1}(\alpha/\beta)]$

30. $2\pi\sqrt{\frac{r\sqrt{2}}{g}}, r/\sqrt{2}$ **31.** $2\pi\sqrt{\frac{17L}{18g}}$ **32.** $\omega = \sqrt{\frac{k}{(m+6M)}}$

33. (a) 2 sec, (b) $T = \frac{2}{5^{1/4}}$ sec

34. (a) $T = mg + mgA^2 \sin^2 \sqrt{\frac{g}{\ell}}\, t$ (b) $t = (2n+1)\frac{\pi}{2}\sqrt{\frac{\ell}{g}}$; $n \in I$ $T_{max} = mg + mgA^2$

35. (a) $\omega = \sqrt{\frac{g\ell}{\frac{1}{2}R^2 + \ell^2}}$ (b) $\ell = \frac{R}{\sqrt{2}}$

36. 2

37. 20

38. 2

39. 1000

40. $-4\pi^2 \cos \pi t$

EXERCISE - JEE (Main) PYQ

Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ans.	4	2	3	1	4	2	4	1	3	3
Que.	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	4	1	1	4	1	2	3	2	3	3
Que.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	
Ans.	4	4	3	2	1	2	2	3	1	

EXERCISE - JEE (Advanced) PYQ

Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Ans.	AD	BD	(A-P,Q,R,T), (B-Q,S), (C-P,Q,R,S), (D-P,R,T)	ABD	C	6	C	10

JEE (Main) Practice Paper

Section-A	**Q.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	A.	2	3	2	1	3	4	4	4	4	1
	Q.	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
	A.	4	4	3	3	1	2	1	1	1	1
Section-B	**Q.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	A.	40	10	1	2	3	25	100	200	6	25

JEE (Advanced) Practice Paper

Section-I	**Q.**	**1**	**2**	**3**	**4**	**5**	**6**
	A.	A	A	A	C	B	B
Section-II	**Q.**	**7**	**8**	**9**	**10**	**11**	**12**
	A.	ABC	ACD	BD	BCD	AB	ABCD
Section-III	**Q.**	**13**	**14**	**15**	**16**	**17**	**18**
	A.	C	B	A	A	D	B
Section-IV	**Q.**	**19**	**20**				
	A.	5.00	3				

Important Notes