15

Simple Harmonic Motion

JEE-Main

SHM: Equation, Phase Velocity, Acceleration, Time period

1. A particle executes simple harmonic motion with an amplitude of 4 cm. At the mean position, velocity of the particle is 10 cm/s. The distance of the particle from the mean position when its speed becomes 5 cm/s is $\sqrt{\alpha}$ cm, where α = ______. **[27 Jan, 2024 (Shift-I)]**

2. A simple harmonic oscillator has an amplitude A and time period 6π second. Assuming the oscillation starts from its mean position, the time required by it to travel from $x = A$ to $x = \frac{\sqrt{3}}{2}A$ will be $\frac{\pi}{x}$ s, where x = _____ : **[29 Jan, 2024 (Shift-II)]**

3. A particle performs simple harmonic motion with amplitude A. Its speed is increased to three times at an instant when its displacement is $\frac{2A}{3}$. The new amplitude of motion is $\frac{nA}{3}$. The value of n is ___. **[31 Jan, 2024 (Shift-I)]**

4. A mass m is suspended from a spring of negligible mass and the system oscillates with a frequency f_1. The frequency of oscillations if a mass 9 m is suspended from the same spring is f_2. The value of $\frac{f_1}{f_2}$ is ______. **[1 Feb, 2024 (Shift-II)]**

5. The displacement of a particle executing SHM is given by $x = 10\sin\left(\omega t + \frac{\pi}{3}\right)m$. The time period of motion is 3.14 s. The velocity of the particle at $t = 0$ is ______ m/s. **[04 April, 2024 (Shift-II)]**

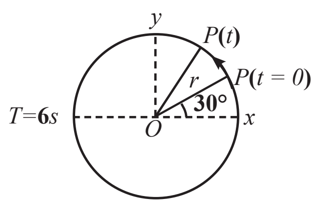
6. A particle is doing simple harmonic motion of amplitude 0.06 m and time period 3.14 s. The maximum velocity of the particle is _______ cm/s. **[06 April, 2024 (Shift-I)]**

7. The position, velocity and acceleration of a particle executing simple harmonic motion are found to have magnitudes of 4 m, 2 ms^{-1} and 16 ms^{-2} at a certain instant. The amplitude of the motion is $\sqrt{x}$ m where x is _______. **[09 April, 2024 (Shift-I)]**

8. A particle of mass 0.50 kg executes simple harmonic motion under force $F = -50(Nm^{-1})x$. The time period of oscillation is $\frac{x}{35}s$. The value of x is ……………..

(Given π = 22?/7) **[09 April, 2024 (Shift-II)]**

9. 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 **[8 April, 2023 (Shift-II)]**



(*a*) $x(t) = r\cos\left(\omega t + \frac{\pi}{6}\right)$ (*b*) $x(t) = r\cos(\omega t)$

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

10. In a linear simple harmonic motion (SHM)

(A) Restoring force is directly proportional to the displacement.
(B) The acceleration and displacement are opposite in direction.
(C) The velocity is maximum at mean position.
(D) The acceleration is minimum at extreme points.

Choose the correct answer from the options given below : **[15 April, 2023 (Shift-I)]**

(*a*) (A), (B) and (C) only (*b*) (C) and (D) only
(*c*) (A), (B) and (D) only (*d*) (A), (C) and (D) only

11. Assume that the earth is a solid sphere having uniform density and a tunnel is dug along its diameter throughout the earth. It is found that when a particle is released in this tunnel, it executes a simple harmonic motion. The mass of the particle is 100 g. The time period of the motion of the particle will be (approximately): ($g = 10m/s^2$, radius of earth = 6400 km) **[25 Jan, 2023 (Shift-I)]**

(*a*) 24 hours (*b*) 1 hour 24 minutes
(*c*) 1 hour 40 minutes (*d*) 12 hours

12. A particle executes simple harmonic motion between $x = -A$ and $x = +A$. If time taken by the particle to go from $x = 0$ to $\frac{A}{2}$ is $2s$; then time taken by the particle in going from $x = \frac{A}{2}$ to A will be: **[25 Jan, 2023 (Shift-II)]**

(*a*) $3s$ (*b*) $2s$
(*c*) $13..5s$ (*d*) $4s$

13. For a periodic motion represented by the equation $y = \sin \omega t + \cos \omega t$. The amplitude of the motion is **[10 April, 2023 (Shift-II)]**

(*a*) 14...5 (*b*) $\sqrt{2}$
(*c*) 1 (*d*) 2

14. A particle executes S.H.M. of amplitude A along x-axis. At $t = 0$, the position of the particle is $x = \frac{A}{2}$ and it moves along positive x-axis the displacement of particle in time t $x = A \sin(\omega t + \delta)$, then the value of δ will be : **[10 April, 2023 (Shift-I)]**

(*a*) $\frac{\pi}{6}$ (*b*) $\frac{\pi}{3}$
(*c*) $\frac{\pi}{4}$ (*d*) $\frac{\pi}{2}$

15. Two simple harmonic waves having equal amplitudes of 8 *cm* and equal frequencies of 10 *Hz* are moving along the same direction. The resultant amplitude is also 8 *cm*. The phase difference between the individual waves is ________ degree. **[29 Jan, 2023 (Shift-I)]**

16. The velocity of a particle executing SHM varies with displacement (x) as $4v^2 = 50 - x^2$. The time period of oscillations is $\frac{x}{7}s$. The value of x is ____ $\left(\text{Take } \pi = \frac{22}{7}\right)$ **[30 Jan, 2023 (Shift-II)]**

17. A particle of mass 250 g executes a simple harmonic motion under a periodic force $F = (-25x)$ N. The particle attains a maximum speed of $4 m/s$ during its oscillation. The amplitude of the motion is _______ cm. **[29 Jan, 2023 (Shift-II)]**

18. When a particle executes Simple Hormonic Motion, the nature of graph of velocity as a function of displacement will be: **[26 July, 2022 (Shift-I)]**

(*a*) Circular (*b*) Elliptical
(*c*) Sinusoidal (*d*) Straight line

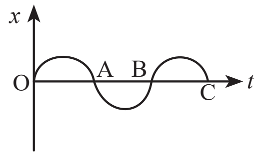
19. The displacement of simple harmonic oscillator after 3 seconds starting from its mean position is equal to half of its amplitude. The time period of harmonic motion is: **[27 June, 2022 (Shift-I)]**

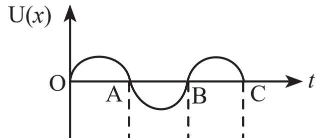
(*a*) 6 s (*b*) 8 s
(*c*) 12 s (*d*) 36 s

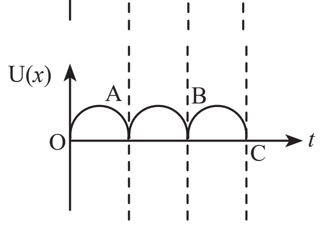
20. A particle executives simple harmonic motion. Its amplitude is 8 cm and time period is 6s. The time it will take to travel from its position of maximum displacement to the point corresponding to half of its amplitude, is ________s. **[27 June, 2022 (Shift-II)]**

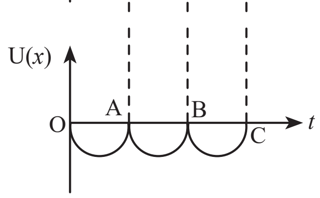
21. A body is performing simple harmonic with an amplitude of 10 cm. The velocity if the body was tripled by air Jet when it is at 5 cm from its mean position. The new amplitude vibration is $\sqrt{x} cm$. The value of x is __________ . **[29 June, 2022 (Shift-I)]**

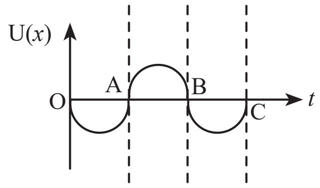
22. The variation of displacement with time of a particle executing free simple harmonic motion is shown in the figure. The potential energy U(x) versus time (t) plot of the particle is correctly shown in figure: **[27 Aug, 2021 (Shift-I)]**



(*a*)


(*b*)


(*c*)


(*d*)


23. Assume that a tunnel is dug along a chord of the earth, at a perpendicular distance (R/2) from the earth's centre, where 'R' is the radius of the Earth. The wall of the tunnel is frictionless. If a particle is released in this tunnel, it will execute a simple harmonic motion with a time period: **[26 Feb, 2021 (Shift-I)]**

(*a*) $2\pi\sqrt{\frac{R}{g}}$ (*b*) $\frac{g}{2\pi R}$ (*c*) $\frac{1}{2p}\sqrt{\frac{g}{R}}$ (*d*) $\frac{2pR}{g}$

24. A particle executes S.H.M., the graph of velocity as a function of displacement is: **[26 Feb, 2021 (Shift-II)]**

(*a*) an ellipse (*b*) a circle
(*c*) a helix (*d*) a parabola

25. The function of time representing a simple harmonic motion with a period of $\frac{\pi}{\omega}$ is: **[18 Mass(Shift-II)]**

(*a*) $\cos(\omega t) + \cos(2\omega t) + \cos(3\omega t)$

(*b*) $\sin^2(\omega t)$

(*c*) $\sin(\omega t) + \cos(\omega t)$

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

26. When a particle executes SHM, the nature of graphical representation of velocity as a function of displacement is:

[24 Feb, 2021 (Shift-II)]

(*a*) Circular (*b*) Straight line

(*c*) Parabolic (*d*) Elliptical

27. A particle is making 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: **[20 July, 2021 (Shift-II)]**

(*a*) $T = 2\pi\sqrt{\dfrac{x_2^2 - x_1^2}{\upsilon_1^2 - \upsilon_2^2}}$ (*b*) $T = 2\pi\sqrt{\dfrac{x_2^2 + x_1^2}{\upsilon_1^2 - \upsilon_2^2}}$

(*c*) $T = 2\pi\sqrt{\dfrac{x_2^2 - x_1^2}{\upsilon_1^2 + \upsilon_2^2}}$ (*d*) $T = 2\pi\sqrt{\dfrac{x_2^2 + x_1^2}{\upsilon_1^2 + \upsilon_2^2}}$

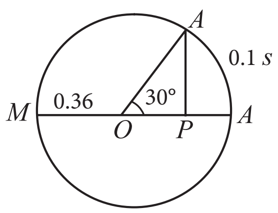
28. $Y = A\sin(\omega t + \phi_0)$ is the time-displacement equation of a SHM. At $t = 0$ the displacement of the particle is $Y = \dfrac{A}{2}$ and it is moving along negative x-direction. Then the initial phase angle ϕ_0 will be:

[25 Feb, 2021 (Shift-II)]

(*a*) $\dfrac{5\pi}{6}$ (*b*) $\dfrac{\pi}{6}$

(*c*) $\dfrac{\pi}{3}$ (*d*) $\dfrac{2\pi}{3}$

29. The point *A* moves with a uniform speed along the circumference of a circle of radius 0.36 m and covers 30° in 0.1 s. The perpendicular projection '*P*' from '*A*' on the diameter *MN* represents the simple harmoic motion of '*P*'. The restoration force per unit mass when *P* touches *M* will be: **[25 Feb, 2021 (Shift-II)]**



(*a*) 100 N (*b*) 50 N

(*c*) 9.87 N (*d*) 0.49 N

30. Two simple harmonic motions are represented by the equations $x_1 = 5\sin\left(2\pi t + \dfrac{\pi}{4}\right)$ 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. **[26 Aug, 2021 (Shift-II)]**

31. A particle executes S.H.M. with amplitude 'a' and time period '*T*'. The displacement of the particle when its speed is half of maximum speed is $\dfrac{\sqrt{xa}}{2}$. The value of *x* is ___. **[26 Feb, 2021 (Shift-II)]**

32. Two simple harmonic motion, are represented by the equations $y_1 = 10\sin\left(3\pi t + \dfrac{\pi}{3}\right)$ $y_2 = 5(\sin 3\pi t + \sqrt{3}\cos 3\pi t)$

Ratio of amplitude of y_1 to $y_2 = x : 1$. The value of *x* is __

[27 Aug, 2021 (Shift-II)]

33. A particle performs simple harmonic motion with a period of 2 second. The time taken by the particle to cover a displacement equal to half of its amplitude from the mean position is $\dfrac{1}{a}s$.

The value of '*a*' to the nearest integer is _________.

[18 March, 2021 (Shift-I)]

34. A particle executes simple harmonic motion represented by displacement function as $x(t) = A\sin(\omega t + \phi)$

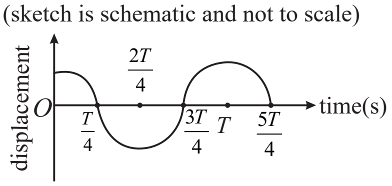
If the position and velocity of the particle at $t = 0$s are 2 cm and 2ω cm s^{-1} respectively, then its amplitude is $x\sqrt{2}\,cm$ where the value of *x* is _____. **[27 July, 2021 (Shift-II)]**

35. A block of mass *m* attached to a massless spring is performing oscillatory motion of amplitude '*A*' on a frictionless horizontal plane. If half of the mass of the block breaks off when it is passing through its equilibrium point, the amplitude of oscillation for the remaining system become *fA*. The value of *f* is

[3 Sep, 2020 (Shift-II)]

(*a*) $\dfrac{1}{\sqrt{2}}$ (*b*) $\sqrt{2}$ (*c*) 1 (*d*) $\dfrac{1}{2}$

36. The displacement time graph of a particle executing S.H.M is given in figure (sketch is schematic and not to scale)



Which of the following statements is/are true for this motion?

[2 Sep, 2020 (Shift-II)]

A. The force is zero at $t = \dfrac{3T}{4}$

B. The acceleration is maximum at $t = T$

C. The speed is maximum at $t = \dfrac{T}{4}$

D. The P.E. is equal to K.E. of the oscillation at $t = \dfrac{T}{2}$

(*a*) B, C and D (*b*) A and D

(*c*) A, B and C (*d*) A, B and D

37. 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 $\dfrac{T_1}{T_2}$ will be

[5 Sep, 2020 (Shift-II)]

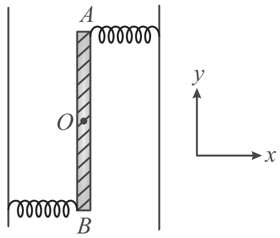
(*a*) $\dfrac{\sqrt{2}}{3}$ (*b*) $\dfrac{2}{\sqrt{3}}$ (*c*) $\dfrac{2}{3}$ (*d*) $\dfrac{3}{\sqrt{2}}$

38. A small circular loop of conducting wire has radius a and carries current *I*. It is placed in a uniform magnetic field *B* perpendicular to its plane such that when rotated slightly about its diameter and released, it starts performing simple harmonic motion of time period *T*. If the mass of the loop is *m* then: **[9 Jan, 2020 (Shift-II)]**

(*a*) $T = \sqrt{\dfrac{\pi m}{IB}}$ (*b*) $T = \sqrt{\dfrac{\pi m}{2IB}}$

(*c*) $T = \sqrt{\dfrac{2\pi m}{IB}}$ (*d*) $T = \sqrt{\dfrac{2m}{IB}}$

39. 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: **[12 Jan, 2019 (Shift-I)]**



(*a*) $\frac{1}{2\pi}\sqrt{\frac{3k}{m}}$ (*b*) $\frac{1}{2\pi}\sqrt{\frac{2k}{m}}$ (*c*) $\frac{1}{2\pi}\sqrt{\frac{6k}{m}}$ (*d*) $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$

40. A simple haromic motion is represented by:

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

The amplitude and time period of the motion are:

[12 Jan, 2019 (Shift-II)]

(*a*) 10 cm, $\frac{2}{3}s$ (*b*) 10 cm, $\frac{3}{2}s$

(*c*) 5 cm, $\frac{3}{2}s$ (*d*) 5 cm, $\frac{2}{3}s$

41. A cylindrical plastic bottle of negligible mass of filled with 310 ml of water and left floating in a pond with still water. If pressed downward slightly and released, it starts performing simple harmonic motion at angular frequency ω. If the radius of the bottle is 2.5 cm then ω is close to: (density of water = 10^3 kg/m^3) **[10 Jan, 2019 (Shift-II)]**

(*a*) 41..75 rad s^{-1} (*b*) 1.25 rad s^{-1}

(*c*) 42..50 rad s^{-1} (*d*) 5.00 rad s^{-1}

Energy in SHM

42. When the displacement of a simple harmonic oscillator is one third of its amplitude, the ratio of total energy to the kinetic energy is $\frac{x}{8}$, where x = _________.

[29 Jan, 2024 (Shift-I)]

43. An object of mass 0.2 kg executes simple harmonic motion along x axis with frequency of $\left(\frac{25}{\pi}\right)$Hz. At the position $x = 0.04$ m the object has kinetic energy 0.5 J and potential energy 0.4 J. The amplitude of oscillation is ………… cm.**[8 April 2024 (Shift-II)]**

44. A particle executes SHM of amplitude A. The distance from the mean position when its's kinetic energy becomes equal to its potential energy is : **[13 April 2023 (Shift-II)]**

(*a*) $\sqrt{2}$A (*b*) 2 A

(*c*) $\frac{1}{\sqrt{2}}$ A (*d*) $\frac{1}{2}$ A

45. The maximum potential energy of a block executing simple harmonic motion is 25 J. A is amplitude of oscillation. At A/2, the kinetic energy of the block is **[31 Jan, 2023 (Shift-I)]**

(*a*) 45.5 J (*b*) 9.75 J

(*c*) 18.75 J (*d*) 12.5 J

46. A particle is executing Simple Harmonic Motion (SHM). The ratio of potential energy and kinetic energy of the particle when its displacement is half of its amplitude will be:

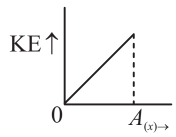
[12 April, 2023 (Shift-I)]

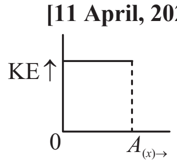
(*a*) 1 : 1 (*b*) 2 : 1

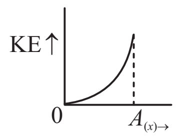
(*c*) 1 : 4 (*d*) 1 : 3

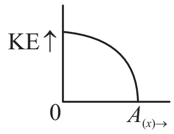
47. The variation of kinetic energy (KE) of a particle executing simple harmonic motion with the displacement (x) starting from mean position to extreme position (A) is given by (1)

[11 April, 2023 (Shift-I)]

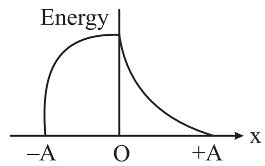
(*a*)


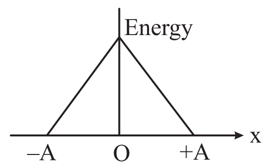
(*b*)


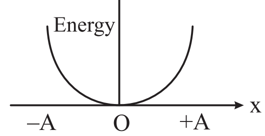
(*c*)


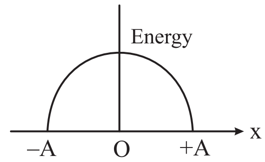
(*d*)


48. Which graph represents the difference between total energy and potential energy of a particle executing SHM Vs it's distance from mean position? **[13 April, 2023 (Shift-I)]**

(*a*)


(*b*)


(*c*)


(*d*)


49. The general displacement of a simple harmonic oscillator is $x = A \sin\omega t$. Let T be its time period. The slope of its potential energy (U) - time (t) curve will be maximum when $t = \frac{T}{\beta}$. The value of β is _______ .

[30 Jan, 2023 (Shift-I)]

50. At a given point of time the value of displacement of a simple harmonic oscillator is given as $y = A\cos(30°)$. If amplitude is 40 cm and kinetic energy at that time is 200 J, the value of force constant is 1.0×10^x Nm^{-1}. The value of x is ________.

[13 April, 2023 (Shift-I)]

51. 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. **[1 Feb, 2023 (Shift-I)]**

52. For a body executing S.H.M.:

(A) Potential energy is always equal to its K.E.

(B) Average potential and kinetic energy over any given time interval are always equal.

(C) Sum of the kinetic and potential energy at any point of time is constant.

(D) Average K.E. in one time period is equal to average potential energy in one time period.

Choose the most appropriate option from the options given below:

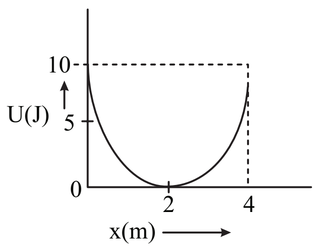
[31 Aug, 2021 (Shift-II)]

(*a*) Only (B) (*b*) (B) and (C)
(*c*) Only (C) (*d*) (C) and (D)

53. An object of mass 0.5 kg executing simple harmonic motion. Its amplitude is 5 cm and time period (T) is 0.2 s. What will be the potential energy of the object at an instant $t = \frac{T}{4}s$ starting from mean position. Assume that the initial phase of the oscillation is zero. **[27 July, 2021 (Shift-II)]**

(*a*) 53....2×10^{-3} J (*b*) 0.62 J
(*c*) 54....2×10^{3} J (*d*) 1.2×10^{3} J

54. 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? **[1 Sep, 2021 (Shift-II)]**



(*a*) 54.....8 m/s^2(*b*) 10 m/s^2 (*c*) 5 m/s^2 (*d*) 4 m/s^2

55. A particle starts executing simple harmonic motion (SHM) of amplitude 'a' and total energy E. At any instant, its kinetic energy is $3E/4$ then its displacement 'y' is given by:

[27 July, 2021 (Shift-I)]

(*a*) $y = \frac{a}{2}$ (*b*) $y = \frac{a}{\sqrt{2}}$

(*c*) $y = \frac{a\sqrt{3}}{2}$ (*d*) $y = a$

56. In a simple harmonic oscillation, what fraction of total mechanical energy is in the form of kinetic energy, when the particle is midway between mean and extreme position? **[25 July, 2021 (Shift-II)]**

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

57. 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:

[11 Jan, 2019 (Shift-II)]

(*a*) $K_2 = 2K_1$ (*b*) $K_2 = \frac{K_1}{2}$

(*c*) $K_2 = \frac{K_1}{4}$ (*d*) $K_2 = K_1$

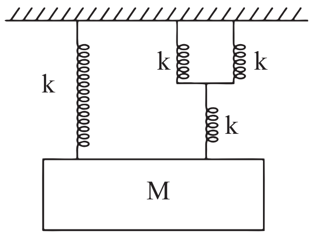
58. A particle undergoing simple harmonic motion has time dependent displacement given by $x(t) = A\sin\frac{\pi t}{90}$. The ratio of kinetic to potential energy of the particle at $t = 210$ s will be **[11 Jan, 2019 (Shift-I)]**

(*a*) 1/9 (*b*) 1 (*c*) 2 (*d*) 3

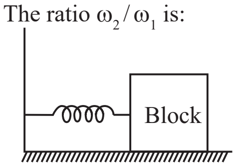
Spring Mass Systems

59. The time period of simple harmonic motion of mass M in the given figure $\sqrt{\frac{\alpha M}{5K}}$ is, where the value of α is _______.

[31 Jan, 2024 (Shift-II)]



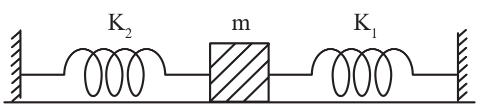
60. For a simple harmonic motion in a mass spring system shown, the surface is frictionless. When the mass of the block is 1kg, the angular frequency is ω_1. When the mass of the block is 2 kg the angular frequency is ω_2. The ratio ω_2/ω_1 is: **[30 Jan, 2023 (Shift-II)]**



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

61. 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

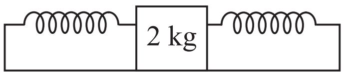
[06 April, 2023 (Shift-I)]



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

(c) $2\pi\sqrt{\frac{m}{K_1+K_2}}$ (d) $2\pi\sqrt{\frac{m}{K_1-K_2}}$

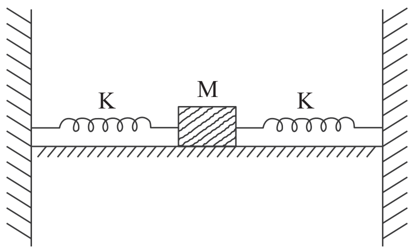
62. A block of mass 2 kg is attached with two identical springs of spring constant $20N/m$ each. The block is placed on a frictionless surface and the ends of the springs are attached to rigid supports (see figure). When the mass is displaced from its equilibrium position, it executes a simple harmonic motion. The time period of oscillation is $\frac{\pi}{\sqrt{x}}$ in SI unit. The value of x is **[24 Jan, 2023 (Shift-I)]**



63. A mass m attached to free end of a spring executes SHM with a period of 1s. If the mass is increased by 3 kg the period of oscillation increases by one second, the value of mass m is _________ kg. **[24 Jan, 2023 (Shift-II)]**

64. A rectangular block of mass 5 kg attached to a horizontal spiral spring executes simple harmonic motion of amplitude 1 m and time period 3.14 s. The maximum force exerted by spring on block is ______ N. **[10 April, 2023 (Shift-II)]**

65. In the figure given below. a block of mass $M = 490$ g placed on a frictionless table is connected with two springs having same spring constant ($K = 2N\,m^{-1}$). If the block is displaced horizontally through 'X' m then the number of complete oscillations it will make in 14π seconds will be ___________. **[31 Jan, 2023 (Shift-I)]**



66. A block is fastened to a horizontal spring. The block is pulled to a distance x = 10 cm from its equilibrium position (at x = 0) on a frictionless surface from rest. The energy of the block at x = 5 cm is 0.25 J. The spring constant of the spring is ________ Nm^{-1}. **[1 Feb, 2023 (Shift-II)]**

67. Two massless springs with spring constants 2k and 9k, carry 50g and 100g 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 **[24 June, 2022 (Shift-II)]**

(a) 1 : 2 (b) 3 : 2

(c) 3 : 1 (d) 2 : 3

68. As per given figures, two spring constants k and 2k are connected to mass m. If the period of oscillation in figure (a) is 3s, then the period of oscillation in figure (b) will be $\sqrt{x}s$. The value of x is _________. **[26 July, 2022 (Shift-II)]**

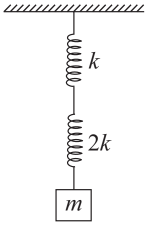


figure (a)

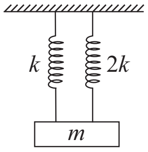
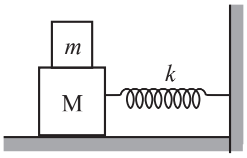


figure (b)

69. 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 Adv, 2022]**

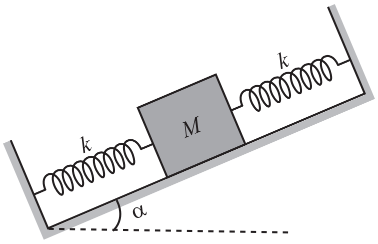
70. In the given figure, a mass M is attached to a horizontal spring which is fixed on one side to a rigid support. The spring constant of the spring is k. The mass oscillates on a frictionless surface with time period T and amplitude A. When the mass is in equilibrium position, as shown in the figure, another mass m is gently fixed upon it. New amplitude of oscillation will be: **[24 Feb, 2021 (Shift-I)]**



(a) $A\sqrt{\frac{M}{M-m}}$ (b) $A\sqrt{\frac{M}{M+m}}$

(c) $A\sqrt{\frac{M-m}{M}}$ (d) $A\sqrt{\frac{M+m}{M}}$

71. 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: **[24 Feb, 2021 (Shift-II)]**



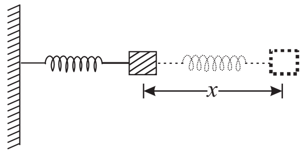
(a) $\frac{1}{2\pi}\sqrt{\frac{k}{2m}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{k}{Mg\sin\alpha}}$

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

72. If two similar spring each of spring constant K_1 are joined in series, the new spring constant and time period would be changed by a factor : **[26 Feb, 2021 (Shift-I)]**

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

73. The motion of a mass on a spring, with spring constant K is as shown in figure. The equation of motion is given by $x(t) = A\sin\omega t + B\cos\omega t$ with $\omega = \sqrt{\frac{K}{m}}$. Suppose that at time $t = 0$, the position of mass is $x(0)$ and velocity $v(0)$, then its displacement can also be represented as $x(t) = C\cos(\omega t - \phi)$, where C and ϕ are: **[22 July, 2021 (Shift-II)]**



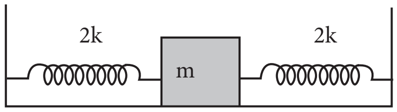
(*a*) $C = \sqrt{\frac{v(0)^2}{\omega^2} + x(0)^2}, \phi = \tan^{-1}\left(\frac{x(0)\omega}{v(0)}\right)$

(*b*) $C = \sqrt{\frac{2v(0)^2}{\omega^2} + x(0)^2}, \phi = \tan^{-1}\left(\frac{x(0)\omega}{2v(0)}\right)$

(*c*) $C = \sqrt{\frac{v(0)^2}{\omega^2} + x(0)^2}, \phi = \tan^{-1}\left(\frac{v(0)}{x(0)\omega}\right)$

(*d*) $C = \sqrt{\frac{2v(0)^2}{\omega^2} + x(0)^2}, \phi = \tan^{-1}\left(\frac{v(0)}{x(0)\omega}\right)$

74. Two identical springs of spring constant '2k' are attached to a block of mass m and to fixed support (see figure). When the mass is displaced from equilibrium position on either side, it executes simple harmonic motion. The time period of oscillations of this system is: **[25 Feb, 2021 (Shift-II)]**



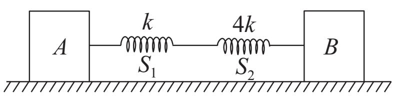
(*a*) $\pi\sqrt{\frac{m}{k}}$ (*b*) $\pi\sqrt{\frac{m}{2k}}$

(*c*) $2\pi\sqrt{\frac{m}{k}}$ (*d*) $2\pi\sqrt{\frac{m}{2k}}$

75. Two particles A and B of equal masses are suspended from two massless springs of spring constants K_1 and K_2 respectively. If the maximum velocities during oscillations are equal, the ratio of the amplitude of A and B is **[17 March, 2021 (Shift-II)]**

(*a*) $\frac{K_1}{K_2}$ (*b*) $\sqrt{\frac{K_1}{K_2}}$ (*c*) $\frac{K_2}{K_1}$ (*d*) $\sqrt{\frac{K_2}{K_1}}$

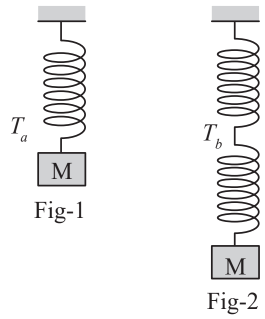
76. In the reported figure, two bodies A and B of masses 200g and 800g are attached with the system of springs. Springs are kept in a stretched position with some extension when the system is released. The horizontal surface is assumed to be frictionless. The angular frequency will be _____ rad /s when $k = 20$ N/m. **[25 July, 2021 (Shift-I)]**



77. 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 ratios of time period of oscillation of the two SHM is $\frac{T_b}{T_a} = \sqrt{x}$, Where value of x is __________ .

[17 March, 2021 (Shift-I)]

(Round off to the Nearest Integer)

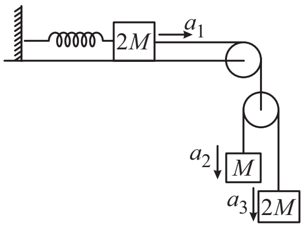


78. When a particle of mass m is attached to a vertical spring of spring constant k and released, its motion is described by $y(t) = y_0\sin^2\omega t$, where 'y' is measured from the lower end of unstretched spring. Then ω is **[6 Sep, 2020 (Shift-II)]**

(*a*) $\sqrt{\frac{5g}{y_0}}$ (*b*) $\frac{1}{2}\sqrt{\frac{g}{y_0}}$

(*c*) $\sqrt{\frac{g}{2y_0}}$ (*d*) $\sqrt{\frac{g}{y_0}}$

79. 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 stale. 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 Adv, 2019]

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

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

(*c*) $a_2 - a_1 = a_1 - a_3$

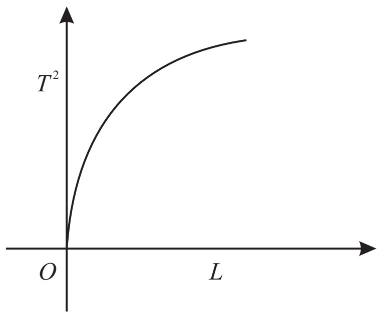
(*d*) At an extension of $x_0/4$ of the spring, the magnitude of acceleration of the block connected to the spring is $\frac{3g}{10}$

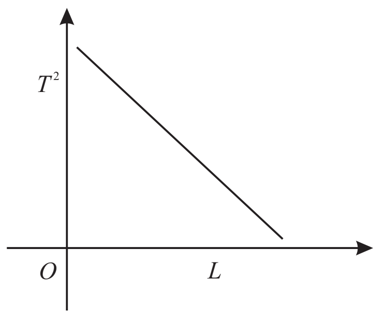
Pendulum

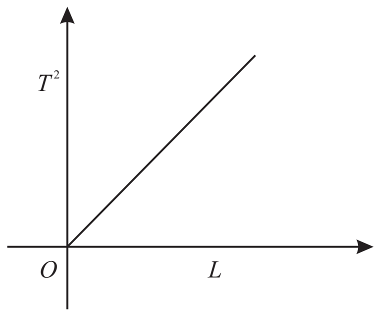
80. A simple pendulum doing small oscillations at a place R height above earth surface has time period of $T_1 = 4s$. T_2 would be it's time period if it is brought to a point which is at a height $2R$ from earth surface. Choose the correct relation [R = radius of Earth]: **[05 April, 2024 (Shift-I)]**

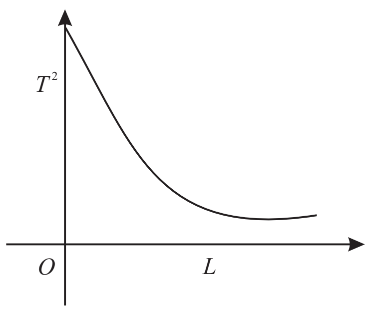
(*a*) $T_1 = T_2$ (*b*) $2T_1 = 3T_2$
(*c*) $3T_1 = 2T_2$ (*d*) $2T_1 = T_2$

81. Choose the correct length (L) versus square of time period (T^2) graph for a simple pendulum executing simple harmonic motion. **[1 Feb, 2023 (Shift-II)]**

(*a*)


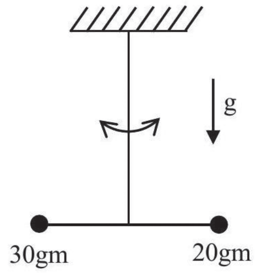
(*b*)


(*c*)


(*d*)


82. A simple pendulum with length 100 cm and bob of mass 250 g is executing S.H.M. of amplitude 10 cm. The maximum tension in the string is found to be $\frac{x}{40}N$. The value of x is **[6 April, 2023 (Shift-II)]**

83. 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 1.2×10^{-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 Adv, 2023]**



84. Time period of a simple pendulum in a stationary lift is 'T'. If the lift accelerates with $\frac{g}{6}$ vertically upwards then the time period will be: **[26 June, 2022 (Shift-I)]**

(Where g = acceleration due to gravity)

(*a*) $\sqrt{\frac{6}{5}}$ T (*b*) $\sqrt{\frac{5}{6}}$ T (*c*) $\sqrt{\frac{6}{7}}$ T (*d*) $\sqrt{\frac{7}{6}}$ T

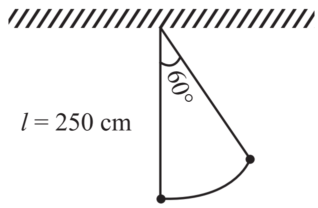
85. The time period of oscillation of a simple pendulum of length L suspended from the roof of a vehicle, which moves without friction down an inclined plane of inclination α, is given by. **[29 July, 2022 (Shift-I)]**

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

86. The motion of a simple pendulum executing S.H.M. is represented by the following equation. $y = A\sin(\pi t + \phi)$, where time is measured in second. The length of pendulum is: **[29 June, 2022 (Shift-II)]**

(*a*) 86..23 cm (*b*) 25.3 cm
(*c*) 87..4 cm (*d*) 406.1 cm

87. A pendulum is suspended by a string of length 250 cm. The mass of the bob of the pendulum is 200g. The bob is pulled aside until the string is at 60° with vertical as shown in the figure. After releasing the bob, the maximum velocity attained by the bob will be ______ ms^{-1}. (if g = 10 m/s^2) **[28 June, 2022 (Shift-I)]**



88. The metallic bob of simple pendulum has the relative density 5. The time period of this pendulum is 10s. If the metallic bob is immersed in water, then the new time period becomes $5\sqrt{x}\,s$. The value of x will be ___________. **[29 July, 2022 (Shift-II)]**

89. Time period of a simple pendulum is T inside a lift when the lift is stationary. If the lift moves upwards with an acceleration $g/2$, the time period of pendulum will be: **[16 March, 2021 (Shift-I)]**

(*a*) $\sqrt{\frac{2}{3}}T$ (*b*) $\sqrt{3}T$ (*c*) $\frac{T}{\sqrt{3}}$ (*d*) $\sqrt{\frac{3}{2}}T$

90. T_0 is the time period of a simple pendulum at a place. If the length of the pendulum is reduced to $\frac{1}{16}$ times of its initial value, the modified time period is:

[22 July, 2021 (Shift-II)]

(*a*) T_0 (*b*) $8\pi\, T_0$ (*c*) $4\, T_0$ (*d*) $\frac{1}{4}\, T_0$

91. If the time period of a two meter long simple pendulum is 2s, the acceleration due to gravity at the place where pendulum is executing S.H.M. is: **[25 Feb, 2021 (Shift-I)]**

(*a*) 91...8 ms^{-2} (*b*) 16 m/s^2
(*c*) $2\pi^2$ ms^{-2} (*d*) π^2 ms^{-2}

92. A bob of mass '*m*' suspended by a thread of length l undergoes simple harmonic oscillations with time period T. If the bob is immersed in a liquid that has density 1/4 times that of the bob and the length of the thread is increased by 1/3rd of the original length, then the time period of the simple harmonic oscillations will be:

[31 Aug, 2021 (Shift-II)]

(*a*) $\frac{3}{4}T$ (*b*) $\frac{3}{2}T$ (*c*) T (*d*) $\frac{4}{3}T$

93. Given below are two statements: **[26 Feb, 2021 (Shift-II)]**

Statement-I: A second's pendulum has a time period of 1 second.

Statement-II: It takes precisely one second to move between the two extreme positions.

In the light of the above statements, choose the correct answer from the options given below:

(*a*) Both Statement-I and Statement-II are false
(*b*) Statement-I is false but Statement-II is true
(*c*) Statement-I is true but Statement-II is false
(*d*) Both Statement-I and Statement-II are true

94. Time period of a simple pendulum is T. The time taken to complete $\frac{5}{8}$ oscillations starting from mean position is $\frac{\alpha}{\beta}T$. The value of α is ______ . **[26 Feb, 2021 (Shift-II)]**

95. A pendulum bob has a speed of 3 m/s at its lowest position. The pendulum is 50 cm long. The speed of bob, when the length makes an angle of 60º to the vertical will be ($g = 10m/s^2$) _________m/s. **[25 July, 2021 (Shift-I)]**

96. 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 **[11 Jan, 2019 (Shift-II)]**

(*a*) 10^{-3} rad/s (*b*) 1 rad/s
(*c*) 10^{-1} rad/s (*d*) 10^{-5} rad/s

97. A simple pendulum, made of a string of length l and a bob of mass m, is released from a small angle θ_0. It strikes a block of mass M, kept on a horizontal surface at its lowest point of oscillations, elastically. It bounces back and goes up to an angle θ_1. Then M is given by: **[12 Jan, 2019 (Shift-I)]**

(*a*) $\frac{m}{2}\left(\frac{\theta_0+\theta_1}{\theta_0-\theta_1}\right)$ (*b*) $m\left(\frac{\theta_0-\theta_1}{\theta_0+\theta_1}\right)$
(*c*) $m\left(\frac{\theta_0+\theta_1}{\theta_0-\theta_1}\right)$ (*d*) $\frac{m}{2}\left(\frac{\theta_0-\theta_1}{\theta_0+\theta_1}\right)$

98. 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: **[9 April, 2019 (Shift-I)]**

(*a*) $4T\sqrt{\frac{1}{15}}$ (*b*) $2T\sqrt{\frac{1}{10}}$ (*c*) $4T\sqrt{\frac{1}{14}}$ (*d*) $2T\sqrt{\frac{1}{14}}$

99. The mass and the diameter of a planet are three times the respective values for the Earth. The period of oscillation of a simple pendulum on the Earth is 2s. The period of oscillation of the same pendulum on the planet would be: **[11 Jan, 2019 (Shift-II)]**

(*a*) $\frac{\sqrt{3}}{2}s$ (*b*) $\frac{2}{\sqrt{3}}s$ (*c*) $\frac{3}{2}s$ (*d*) $2\sqrt{3}\,s$

JEE-Advanced

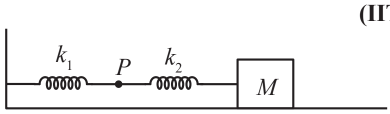
Displacement, Velocity and Acceleration in Shm

Single Correct

1. A point mass is subjected to two simultaneous sinusoidal displacements in x-direction, $x_1(t) = A \sin \omega t$ and $x_2(t) = A \sin(\omega t + 2\pi/3)$. Adding a third sinusoidal displacement $x_3(t) = B \sin(\omega t + \phi)$ brings the mass to a complete rest. The values of B and ϕ are **(IIT-JEE 2011)**

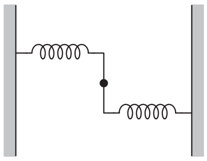
(*a*) $\sqrt{2}A, \frac{3\pi}{4}$ (*b*) $A, \frac{4\pi}{3}$ (*c*) $\sqrt{3}A, \frac{5\pi}{6}$ (*d*) $A, \frac{\pi}{3}$

2. The mass M shown in the figure oscillates in simple harmonic motion with amplitude A. The amplitude of the point P is **(IIT-JEE 2009)**



(*a*) $(k_1A)/k_2$
(*b*) $(k_2A)/k_1$
(*c*) $(k_1A)/(k_1 + k_2)$
(*d*) $(k_2A)/(k_1 + k_2)$

3. A uniform rod of length L and mass M is pivoted at the center. Its two ends are attached to two springs of equal spring constants k. The springs are fixed to rigid supports as shown in the figure and the rod is free to oscillate in the horizontal plane. The rod is gently pushed through a small angle θ in one direction and released. The frequency of oscillation is **(IIT-JEE 2009)**



(*a*) $\frac{1}{2\pi}\sqrt{\frac{2k}{M}}$ (*b*) $\frac{1}{2\pi}\sqrt{\frac{k}{M}}$

(*c*) $\frac{1}{2\pi}\sqrt{\frac{6k}{M}}$ (*d*) $\frac{1}{2\pi}\sqrt{\frac{24k}{M}}$

4. A particle executes simple harmonic motion between $x = -A$ and $x = +A$. The time taken for it to go from O to $A/2$ is t_1 and to go from $A/2$ to A is t_2, then **(IIT JEE 2001)**

(*a*) $t_1 < t_2$ (*b*) $t_1 > t_2$ (*c*) $t_1 = t_2$ (*d*) $t_1 = 2t_2$

5. A uniform cylinder of length L and mass M having cross-sectional area A is suspended, with its length vertical, from a fixed point by a massless spring, such that it is half-submerged in a liquid of density ρ at equilibrium position. When the cylinder is given a small downward push and released it starts oscillating vertically with a small amplitude. If the force constant of the spring is k, the frequency of oscillation of the cylinder is **(IIT JEE 1990)**

(*a*) $\frac{1}{2\pi}\left(\frac{k - A\rho g}{M}\right)^{\frac{1}{2}}$ (*b*) $\frac{1}{2\pi}\left(\frac{k + A\rho g}{M}\right)^{\frac{1}{2}}$

(*c*) $\frac{1}{2\pi}\left(\frac{k - A\rho L^2}{M}\right)^{\frac{1}{2}}$ (*d*) $\frac{1}{2\pi}\left(\frac{k - A\rho g}{A\rho g}\right)^{\frac{1}{2}}$

6. Two bodies M and N of equal masses are suspended from two separate massless springs of spring constants k_1 and k_2 respectively. If the two bodies oscillate vertically such that their maximum velocities are equal, the ratio of the amplitude of vibration of M to that of N is **(IIT-JEE 1988)**

(*a*) $\frac{k_1}{k_2}$ (*b*) $\sqrt{\frac{k_2}{k_1}}$ (*c*) $\frac{k_2}{k_1}$ (*d*) $\sqrt{\frac{k_1}{k_2}}$

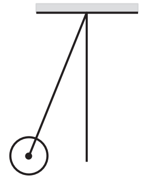
7. An ideal gas is enclosed in a vertical cylindrical container and supports a freely moving piston of mass M. The piston and the cylinder have equal cross-sectional area A. Atmospheric pressure is p_0 and when the piston is in equilibrium, the volume of the gas is V_0. The piston is now displaced slightly from its equilibrium position. Assuming that the system is completely isolated from its surroundings, show that the piston executes simple harmonic motion and find the frequency of oscillation. **(IIT-JEE 1981)**

(*a*) $\frac{A}{5\pi}\sqrt{\frac{\left(p_0 + \frac{Mg}{A}\right)\gamma}{MV_0}}$ (*b*) $\frac{A}{2\pi}\sqrt{\frac{\left(p_0 + \frac{Mg}{A}\right)\gamma}{MV_0}}$

(*c*) $\frac{A}{4\pi}\sqrt{\frac{\left(p_0 + \frac{Mg}{A}\right)\gamma}{MV_0}}$ (*d*) $\frac{A}{6\pi}\sqrt{\frac{\left(p_0 + \frac{Mg}{A}\right)\gamma}{MV_0}}$

Multiple Correct

8. A metal rod of length L and mass m is pivoted at one end. A thin disc of mass M and radius $R < L$ is attached at its center to the free end of the rod. Consider two ways the disc is attached. Case-A—the disc is not free to rotate about its center and Case-B—the disc is free to rotate about its center. The rod-disc system performs SHM in the vertical plane after being released from the same displaced position. Which of the following statement(s) is/are true? **(IIT-JEE 2011)**

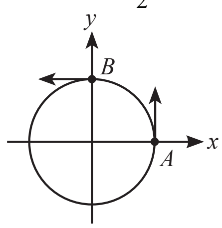
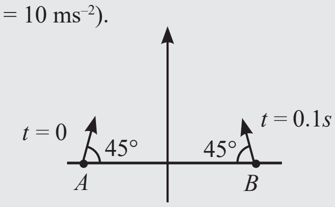


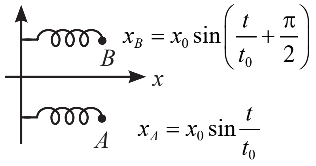
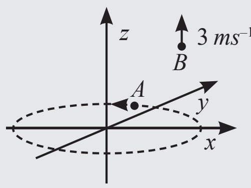
(*a*) Restoring torque in Case-A = Restoring torque in Case-B
(*b*) Restoring torque in Case-A < Restoring torque in Case-B
(*c*) Angular frequency for Case-A > Angular frequency for Case-B.
(*d*) Angular frequency for Case-A < Angular frequency for Case-B

9. Function $x = A\sin^2\omega t + B\cos^2\omega t + C\sin\omega t\cos\omega t$ represents SHM **(IIT-JEE 2005)**

(*a*) For any value of A, B and C (except $C = 0$)
(*b*) If $A = -B$, $C = 2B$, amplitude $= |B\sqrt{2}|$
(*c*) If $A = B$; $C = 0$
(*d*) If $A = B$; $C = 2B$, amplitude $= |B|$

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

	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 $\theta = 0$ and $\theta = \frac{\pi}{2}$, respectively. 	P	$\frac{\sqrt{3}+1}{3}$
(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 $= v = \frac{5\pi}{\sqrt{2}}$ ms^{-1} and at 45° from the horizontal plane. The initial separation between A and B is large enough so that they do not collide. ($g = 10$ ms^{-2}). 	Q	$\frac{(\sqrt{3}-1)}{\sqrt{2}}$

(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 xy plane, with constant angular speed $\omega = 1$ rad s^{-1} in a circle of radius 1 m. Particle B is moving up at a constant speed 3 ms^{-1} in the vertical direction as shown in the figure. (Ignore gravity.) 	S	$\sqrt{2}$
		T	$\sqrt{25\pi^2+1}$

C34.29 W-18.91 UA-46.80 (JEE Adv. 2022)

Which one of the following options is correct?

(*a*) I → R, II → T, III → P, IV → S

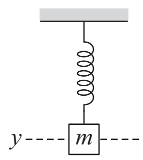
(*b*) I → S, II → P, III → Q, IV → R

(*c*) I → S, II → T, III → P, IV → R

(*d*) I → T. II → P, III → R, IV → S

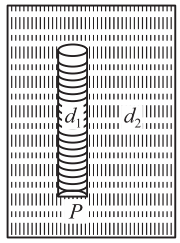
Subjective

11. A mass m is undergoing SHM in the vertical direction about the mean position y_0 with amplitude A and angular frequency ω. At a distance y from the mean position, the mass detaches from the spring. Assume that the spring contracts and does not obstruct the motion of m. Find the distance y (measured from the mean position) such that the height h attained by the block is maximum ($A\omega^2 > g$). **(IIT-JEE 2005)**



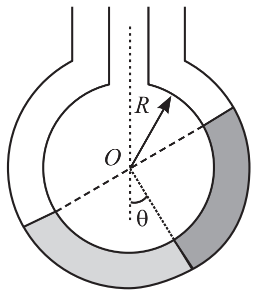
12. A solid sphere of radius R is floating in a liquid of density ρ with half of its volume submerged. If the sphere is slightly pushed and released, it starts performing simple harmonic motion. Find the frequency of these oscillations. **(IIT-JEE 2004)**

13. A thin rod of length L and uniform cross-section is pivoted at its lowest point P inside a stationary homogeneous and non-viscous liquid. The rod is free to rotate in a vertical plane about a horizontal axis passing through P.



The density d_1 of the material of the rod is smaller than the density d_2 of the liquid. The rod is displaced by small angle θ from its equilibrium position and then released. Show that the motion of the rod is simple harmonic and determine its angular frequency in terms of the given parameters. **(IIT-JEE 1996)**

14. Two non-viscous, incompressible and immiscible liquids of densities ρ and 1.5ρ are poured into the two limbs of a circular tube of radius R and small cross-section kept fixed in a vertical plane as shown in figure. Each liquid occupies one-fourth the circumference of the tube.



(*a*) Find the angle θ that the radius to the interface makes with the vertical in equilibrium position.

(*b*) If the whole liquid column is given a small displacement from its equilibrium position, show that the resulting oscillations are simple harmonic. Find the time period of these oscillations

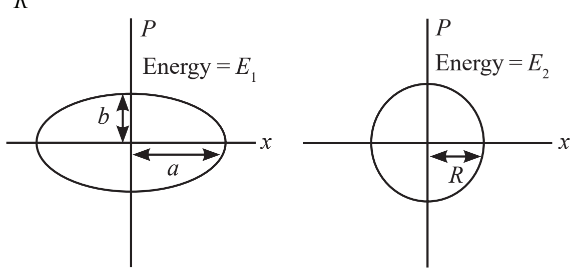
(IIT-JEE 1991)

15. Two simple harmonic motions are represented by the equations $y_1 = 10 \sin\left(3\pi t + \frac{\pi}{4}\right)$ and $y_2 = 5(\sin 3\pi t + \sqrt{3} \cos 3\pi t)$. Their amplitudes are in the ratio of ... **(IIT-JEE 1986)**

Energy in SHM

Single Correct

16. Two independent harmonic oscillators of equal masses 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 equations is/are **(JEE Adv. 2015)**



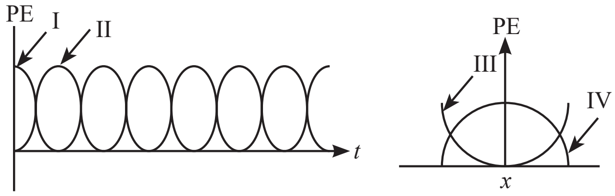
(*a*) $E_1\omega_1 = E_2\omega_2$

(*b*) $\omega_2/\omega_1 = n^2$

(*c*) $\omega_1\omega_2 = n^2$

(*d*) $E_1/\omega_1 = E_2/\omega_2$

17. For a particle executing SHM the displacement x is given by $x = A\cos\omega t$. Identify the graph which represents the variation of potential energy (P.E.) as a function of time t and displacement x. **(IIT-JEE 2003)**



(*a*) I, III (*b*) II, IV
(*c*) II, III (*d*) I, IV

18. A particle free to move along the X-axis has potential energy given by $U(x) = k[1 - \exp(-x^2)]$ for $-\infty \le x \le +\infty$, where k is a positive constant of appropriate dimensions. Then, **(IIT-JEE 1999)**
(*a*) At points away from the origin, the particle is in unstable equilibrium
(*b*) For any finite non-zero value of x, there is a force directed away from the origin
(*c*) if its total mechanical energy is $k/2$, it has its minimum kinetic energy at the origin
(*d*) for small displacements from $x = 0$, the motion is simple harmonic

19. A particle of mass m is executing oscillation about the origin on the X-axis. Its potential energy is $U(x) = k|x|^3$, where k is a positive constant. If the amplitude of oscillation is a, then its time period T is **(IIT-JEE 1998)**
(*a*) proportional to $1/\sqrt{a}$ (*b*) independent of a
(*c*) proportional to $\sqrt{a}$ (*d*) proportional to $a^{3/2}$

20. An object of mass 0.2 kg executes simple harmonic oscillations along the X-axis with a frequency of $\frac{25}{\pi}$ Hz. At the position $x = 0.04$, the object has kinetic energy of 0.5 J and potential energy 0.4 J. The amplitude of oscillations is ... **(IIT-JEE 1994)**
(*a*) 0.12 m (*b*) 0.06 m (*c*) 0.24 m (*d*) 1.2 m

21. A particle executes simple harmonic motion with a frequency f. The frequency with which its kinetic energy oscillates is **(IIT-JEE 1987)**
(*a*) $f/2$ (*b*) f (*c*) $2f$ (*d*) $4f$

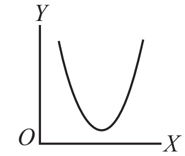
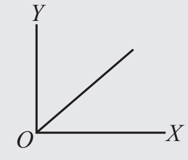
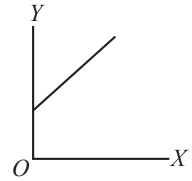
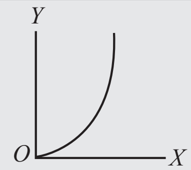
Multiple Correct

22. Three simple harmonic motions in the same direction having the same amplitude a and same period are superposed. If each differ in phase from the next by 45°, then **(IIT-JEE 1999)**
(*a*) The resultant amplitude is $(1 + \sqrt{2})a$
(*b*) The phase of the resultant motion relative to the first is 90°
(*c*) The energy associated with the resulting motion is $(3 + 2\sqrt{2})$ times the energy associated with any single motion
(*d*) The resulting motion is not simple harmonic

23. A linear harmonic oscillator of force constant 2×10^6 N/m and amplitude 0.01 m has a total mechanical energy of 160 J. Its **(IIT-JEE 1989)**
(*a*) Maximum potential energy is 100 J
(*b*) Maximum kinetic energy is 100 J
(*c*) Maximum potential energy is 160 J
(*d*) Maximum potential energy is zero

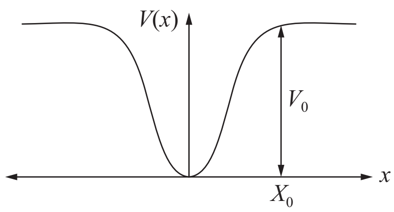
Match the Column

24. Column-I gives a list of possible sets of parameters measured in some experiments. The variations of the parameters in the form of graphs are shown in Column-II. Match the set of parameters given in Column-I with the graphs given in Column-II. **(IIT-JEE 2008)**
Consider the following lists:

	Column-I		Column-II
A.	Potential energy of a simple pendulum (Y-axis) as a function of displacement (X-axis).	p.	
B.	Displacement (Y-axis) as a function of time (X-axis) for a one dimensional motion at zero or constant acceleration when the body is moving along the positive x-direction.	q.	
C.	Range of a projectile (Y-axis) as a function of its velocity (X-axis) when projected at a fixed angle.	r.	
D.	The square of the time period (Y-axis) of a simple pendulum as a function of its length (X-axis).	s.	

Comprehension Based/Statement Based

Passage (Q.25 to Q.27): When a particle of mass m moves on the X-axis in a potential of the form $V(x) = kx^2$, it performs simple harmonic motion. The corresponding time period is proportional to $\sqrt{(m/k)}$, as can be seen easily using dimensional analysis. However, the motion of a particle can be periodic even when its potential energy increases on both sides of $x = 0$ in a way different from kx^2 and its total energy is such that the particle does not escape to infinity. Consider a particle of mass m moving on the X-axis. Its potential energy is $V(x) = \alpha x^4$ ($\alpha > 0$) for $|x|$ near the origin and becomes a constant equal to V_0 for $|x| \ge X_0$ (see figure).



25. If the total energy of the particle is E, it will perform periodic motion only if **(IIT-JEE 2010)**
(*a*) $E < 0$ (*b*) $E > 0$ (*c*) $V_0 > E > 0$ (*d*) $E > V_0$

26. The acceleration of this particle for $|x| > X_0$ is **(IIT-JEE 2010)**
(*a*) Proportional to V_0 (*b*) Proportional to $\frac{V_0}{mX_0}$
(*c*) Proportional to $\sqrt{\frac{V_0}{mX_0}}$ (*d*) Zero

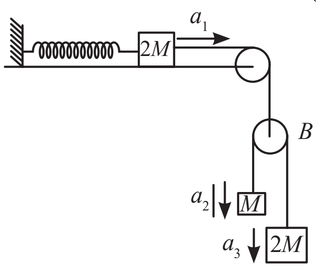
27. For periodic motion of small amplitude A, the time period T of this particle is proportional to **(IIT-JEE 2010)**

(*a*) $A\sqrt{\dfrac{m}{\alpha}}$ (*b*) $\dfrac{1}{A}\sqrt{\dfrac{m}{\alpha}}$ (*c*) $A\sqrt{\dfrac{\alpha}{m}}$ (*d*) $\dfrac{1}{A}\sqrt{\dfrac{\alpha}{m}}$

Spring Mass Systems

Single Correct

28. 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] **C-21.73 W-39.1 UA-39.17 PC-0 (JEE Adv. 2019)**



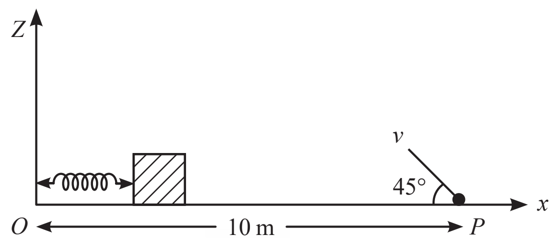
(*a*) $x_0 = \dfrac{4Mg}{k}$

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

(*c*) $a_2 - a_1 = a_1 - a_3$

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

29. A small block is connected to one end of a massless spring of unstretched length 4.9 m. The other end of the spring (see the figure) is fixed. The system lies on a horizontal frictionless surface. The block is stretched by 0.2 m and released from rest at $t = 0$. It then executes simple harmonic motion with angular frequency $\omega = \pi/3$ rad/s. Simultaneously at $t = 0$, a small pebble is projected with speed v from point P at an angle of 45° as shown in the figure.

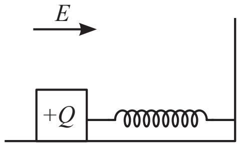


Point P is at a horizontal distance of 10 m from O. If the pebble hits the block at $t = 1$s, the value of v is ? (take, $g = 10$ m/s^2)

C-16.21,W-28.42 UA-55.37 (IIT-JEE 2012)

(*a*) $\sqrt{50}$ m/s (*b*) $\sqrt{51}$ m/s (*c*) $\sqrt{52}$ m/s (*d*) $\sqrt{53}$ m/s

30. A wooden block performs SHM on a frictionless surface with frequency ν_0. The block carries a charge $+Q$ on its surface. If now a uniform electric field E is switched-on as shown, then the SHM of the block will be **(IIT-JEE 2011)**



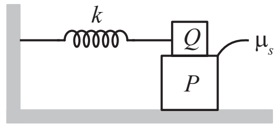
(*a*) Of the same frequency and with shifted mean position

(*b*) Of the same frequency and with the same mean position

(*c*) Of changed frequency and with shifted mean position

(*d*) Of changed frequency and with the same mean position

31. A block P of mass m is placed on a horizontal frictionless plane. A second block of same mass m is placed on it and is connected to a spring of spring constant k, the two blocks are pulled by a distance A. Block Q oscillates without slipping. What is the maximum value of frictional force between the two blocks? **(IIT-JEE 2004)**



(*a*) $kA/2$ (*b*) kA (*c*) μ_s mg (*d*) Zero

32. One end of a long metallic wire of length L is tied to the ceiling. The other end is tied to a massless spring of spring constant k. A mass m hangs freely from the free end of the spring. The area of cross-section and the Young's modulus of the wire are A and Y respectively. If the mass is slightly pulled down and released, it will oscillate with a time period T equal to **(IIT-JEE 1993)**

(*a*) $2\pi\sqrt{\dfrac{m}{k}}$ (*b*) $2\pi\sqrt{\dfrac{m(YA+Lk)}{YAk}}$

(*c*) $2\pi\sqrt{\dfrac{mYA}{kL}}$ (*d*) $2\pi\sqrt{\dfrac{mL}{YA}}$

Multiple Correct

33. 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?

C-4.36 W-15.36 UA-47.5 PC-32.78 (JEE Adv. 2016)

(*a*) The amplitude of oscillation in the first case changes by a factor of $\sqrt{\dfrac{M}{(m+M)}}$, 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

34. A particle of mass m is attached to one end of a massless 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 $0.5u_0$, it collides elastically with a rigid wall. After this collision

C-21.77 W-73.71 UA-4.52 (JEE Adv. 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 $t = \frac{5\pi}{3}\sqrt{\frac{m}{k}}$

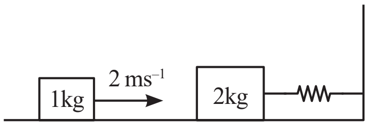
Numerical Type/Integer Type

35. 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____________.

C-8.92 W-17.16 UA-73.92 (JEE Adv. 2022)

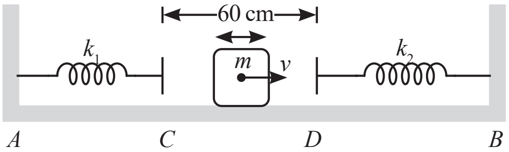
36. A spring block system is resting on a frictionless floor as shown in the figure. The spring constant is 2.0 Nm^{-1} and the mass of the block is 2 kg. Ignore the mass of the spring. Initially, the spring is in an unstretched condition. Another block of mass 1.0 kg moving with a speed of 2.0 ms^{-1} collides elastically with the first block. The collision is such that the 2.0 kg block does not hit the wall. The distance, in meters, between the two blocks when the spring returns to its unstretched position for the first time after the collision is

C-22.19 W-58.72 UA-19.09 (JEE Adv. 2018)



37. Two light springs of force constants k_1 and k_2 and a block of mass m are in one line AB on a smooth horizontal table such that one end of each spring is fixed on rigid supports and the other end is free as shown in the figure. The distance CD between the free ends of the spring is 60 cm. If the block moves along AB with a velocity 120 cm/s in between the springs, calculate the period of oscillation of the block. (Take, $k_1 = 1.8$ N/m, $k_2 = 3.2$ N/m, $m = 200$g)

(IIT-JEE 1985)



Match the Column

38. Column-I describes some situations in which a small object moves. Column-II describes some characteristics of these motions. Match the situations in Column-I with the characteristics in Column-II.

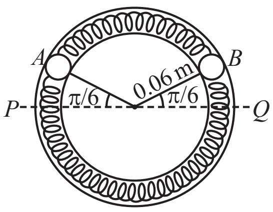
(IIT-JEE 2007)

	Column-I		Column-II
A.	The object moves on the x-axis under a conservative force in such a way that its speed and position satisfy $v = c_1\sqrt{(c_2 - x^2)}$, where c_1 and c_2 are positive constants.	p.	The object executes a simple harmonic motion.
B.	The object moves on the x-axis is in such a way that its velocity and its displacement from the origin are satisfied, $v = -kx$ which is a positive constant.	q.	The object does not change its direction.
C.	The object is attached to one end of a massless spring of a given spring constant. The other end of the spring is attached to the ceiling of an elevator. Initially everything is at rest. The elevator starts going upwards with a constant acceleration a. The motion of the object is observed from the elevator during the period it maintains this acceleration.	r.	The kinetic energy of the object keeps on decreasing.
D.	The object is projected from the earth's surface vertically upwards with a speed $2\sqrt{(GM_e)/R_e}$, where M_e is the mass of the earth and R_e is the radius of the earth. Neglect forces from objects other than the earth.	s.	The object can change its direction only once.

Subjective

39. Two identical balls A and B, each of mass 0.1 kg, are attached to two identical massless springs. The spring-mass system is constrained to move inside a rigid smooth pipe bent in the form of a circle as shown in figure. The pipe is fixed in a horizontal plane. The centers of the balls can move in a circle of radius 0.06 m. Each spring has a natural length of 0.06 πm and spring constant 0.1 N/m. Initially, both the balls are displaced by an angle $\theta = \pi/6$ rad with respect to the diameter PQ of the circle (as shown in figure) and released from rest.

(IIT-JEE 1993)

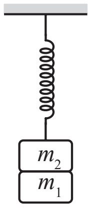


(*a*) Calculate the frequency of oscillation of ball B.

(*b*) Find the speed of ball A when A and B are at the two ends of the diameter PQ.

(*c*) What is the total energy of the system?

40. Two masses m_1 and m_2 are suspended together by a massless spring of spring constant k (Fig.). When the masses are in equilibrium, m_1 is removed without disturbing the system. Find the angular frequency and amplitude of oscillation of m_2. **(IIT-JEE 1981)**



Pendulum

Single Correct

41. A 0.1 kg mass is suspended from a wire of negligible mass. The length of the wire is 1 m and its cross-sectional area is 4.9×10^{-7}m^2. If the mass is pulled a little in the vertically downward direction and released, it performs simple harmonic motion of angular frequency 140 rads^{-1}. If the Young's modulus of the material of the wire is $n \times 10^9$ Nm^{-2}, the value of n is **(IIT-JEE 2010)**

(*a*) $n = 1$ (*b*) $n = 2$ (*c*) $n = 4$ (*d*) $n = 3$

42. A simple pendulum has a time period T_1. The point of suspension is now moved upward according to the relation $y = kt^2$, ($k = 1$ m/s^2), where y is the vertical displacement. The time period now becomes T_2. The ratio $\frac{T_1^2}{T_2^2}$ is (Take, $g = 10$ m/s^2) **(IIT-JEE 2005)**

(*a*) $\frac{6}{5}$ (*b*) $\frac{5}{6}$ (*c*) 1 (*d*) $\frac{4}{5}$

43. The period of oscillation of simple pendulum of length L suspended from the roof of the vehicle which moves without friction, down an inclined plane of inclination α, is given by **(IIT-JEE 2000)**

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

(*c*) $2\pi\sqrt{\frac{L}{g}}$ (*d*) $2\pi\sqrt{\frac{L}{g\tan\alpha}}$

44. A highly rigid cubical block A of small mass M and side L is fixed rigidly on to another cubical block B of the same dimensions and of low modulus of rigidity η such that the lower face of A completely covers the upper face of B. The lower face of B is rigidly held on a horizontal surface. A small force F is applied perpendicular to one of the side faces of A. After the force is withdrawn, block A executes small oscillations, the time period of which is given by **(IIT-JEE 1992)**

(*a*) $2\pi\sqrt{ML\eta}$ (*b*) $2\pi\sqrt{\frac{M\eta}{L}}$ (*c*) $2\pi\sqrt{\frac{ML}{\eta}}$ (*d*) $2\pi\sqrt{\frac{M}{\eta L}}$

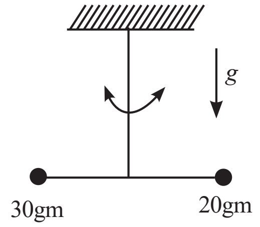
45. A thin fixed ring of radius 1 m has a positive charge 1×10^{-5} C uniformly distributed over it. A particle of mass 0.9 g and having a negative charge of 1×10^{-6} C is placed on the axis at a distance of 1 cm from the centre of the ring. Show that the motion of the negatively charged particle is approximately simple harmonic. Calculate the time period of oscillations. **(IIT-JEE 1982)**

(*a*) 0.5 secs (*b*) 9.28 secs (*c*) 0.628 sec (*d*) 0.1 sec

Numerical Type/Integer Type

46. 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 1.2×10^{-8} N m rad^{-1}. The angular frequency of the oscillations is $n \times 10^{-3}$ rad s^{-1}. The value of n is ________.

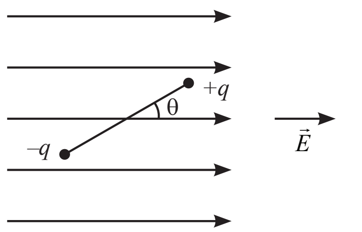
C-6.86 W-60.62 UA-32.52 (JEE Adv. 2023)



47. A mass M attached to a spring oscillates with a period of 2s. 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. **(IIT-JEE 1979)**

Subjective

48. A point particle of mass M is attached to one end of a massless rigid non-conducting rod of length L. Another point particle of the same mass is attached to the other end of the rod. The two particles carry charges $+q$ and $-q$ respectively. This arrangement is held in a region of a uniform electric field E such that the rod makes a small angle θ (say of about 5 degrees) with the field direction. Find an expression for the minimum time needed for the rod to become parallel to the field after it is set free. **(IIT-JEE 1989)**



49. A point mass m is suspended at the end of massless wire of length L and cross-sectional area A. If Y is the Young's modulus of elasticity of the material of the wire, obtain the expression for the frequency of the simple harmonic motion along the vertical line.

(IIT-JEE 1978)

ANSWER KEY

JEE-Main

1. [12]	**2.** [2]	**3.** [7]	**4.** [3]	**5.** [10]	**6.** [2]	**7.** [17]	**8.** [22]	**9.** (*a*)	**10.** (*a*)
11. (*b*)	**12.** (*d*)	**13.** (*b*)	**14.** (*a*)	**15.** [120]	**16.** [88]	**17.** [40]	**18.** (*b*)	**19.** (*d*)	**20.** [1]
21. [700]	**22.** (*b*)	**23.** (*a*)	**24.** (*a*)	**25.** (b,d)	**26.** (*d*)	**27.** (*a*)	**28.** (*a*)	**29.** (*c*)	**30.** [2]
31. [3]	**32.** [1]	**33.** [6]	**34.** [2]	**35.** (*a*)	**36.** (*c*)	**37.** (*b*)	**38.** (*c*)	**39.** (*c*)	**40.** (*a*)
41. (*b*)	**42.** [9]	**43.** [6]	**44.** (*c*)	**45.** (*c*)	**46.** (*d*)	**47.** (*d*)	**48.** (*d*)	**49.** [8]	**50.** [4]
51. [2]	**52.** (*d*)	**53.** (*b*)	**54.** (*d*)	**55.** (*a*)	**56.** (*b*)	**57.** (*a*)	**58.** (*)	**59.** [12]	**60.** (*b*)
61. (*c*)	**62.** [5]	**63.** [1]	**64.** [20]	**65.** [20]	**66.** [67]	**67.** (*b*)	**68.** [2]	**69.** [6]	**70.** (*b*)
71. (*c*)	**72.** (*a*)	**73.** (*c*)	**74.** (*a*)	**75.** (*d*)	**76.** [10]	**77.** [2]	**78.** (*c*)	**79.** (*c*)	**80.** (*c*)
81. (*c*)	**82.** [99]	**83.** [10]	**84.** (*c*)	**85.** (*a*)	**86.** (*c*)	**87.** [5]	**88.** [5]	**89.** (*a*)	**90.** (*d*)
91. (*c*)	**92.** (*d*)	**93.** (*b*)	**94.** [7]	**95.** [2]	**96.** (*a*)	**97.** (*c*)	**98.** (*a*)	**99.** (*d*)	

JEE-Advanced

1. (*b*) **2.** (*d*) **3.** (*c*) **4.** (*a*) **5.** (*b*) **6.** (*b*) **7.** (*b*) **8.** (*a*, *d*) **9.** (*a*, *b*, *d*) **10.** (*c*)

16. (*b, d*) **17.** (*a*) **18.** (*d*) **19.** (*a*) **20.** (*b*) **21.** (*c*) **22.** (*a*,*c*) **23.** (*b*,*c*)

24. (A $\rightarrow$ p, s; B $\rightarrow$p, q, r, s; C $\rightarrow$ s; D $\rightarrow$ q) **25.** (*c*) **26.** (*d*) **27.** (*b*) **28.** (*c*) **29.** (*a*) **30.** (*a*) **31.** (*a*)

32. (*b*) **33.** (*a*,*b*,*d*) **34.** (*a*,*d*) **35.** [6] **36.** [2.09] **37.** [2.83] **38.** (A $\rightarrow$ p; B $\rightarrow$ q, r; C $\rightarrow$ p; D $\rightarrow$ q, r) **41.** (*c*)

42. (*a*) **43.** (*a*) **44.** (*d*) **45.** (*c*) **46.** [10] **47.** [1.6]