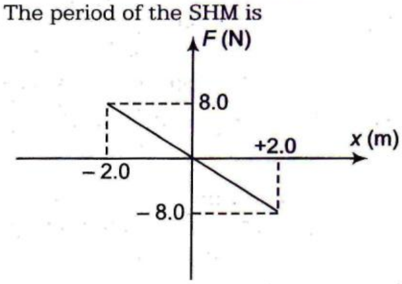
Objective Problems (Level 2)

1. A body of mass 0.01 kg executes simple harmonic motion (SHM) about $x = 0$ under the influence of a force shown in figure. The period of the SHM is

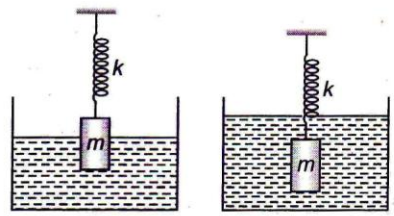


(a) 1.05 s (b) 0.52 s (c) 0.25 (d) 0.31 s

2. The vertical motion of a ship at sea is described by the equation $\frac{d^2x}{dt^2} = -4x$, where x is the vertical height of the ship (in metre) above its mean position. If it oscillates through a height of 1 m

(a) its maximum vertical speed will be 1 m/s
(b) its maximum vertical speed will be 2 m/s
(c) its greatest vertical acceleration is 2 m/s^2
(d) its greatest vertical acceleration is 1 m/s^2

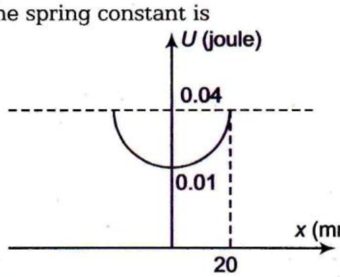
3. Period of small oscillations in the two cases shown in figure is T_1 and T_2 respectively, then



(a) $T_1 = T_2$
(b) $T_1 < T_2$
(c) $T_1 > T_2$
(d) Cannot say anything

4. The potential energy of a particle of mass 2 kg in SHM is $(9x^2)$ J. Here x is the displacement from mean position. If total mechanial energy of the particle is 36 J. Then maximum speed of the particle is
(a) 4 m/s (b) 2 m/s
(c) 6 m/s (d) 10 m/s

5. The variation of PE of harmonic oscillator is as shown in figure. The spring constant is

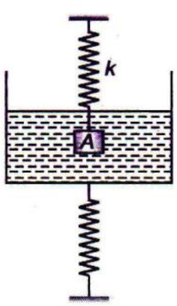


(a) 1×10^2 N/m (b) 1.5×10^2 N/m
(c) 2×10^2 N/m (d) 3×10^2 N/m

6. A particle of mass 0.1 kg is executing SHM of amplitude 0.1 m. When the particle passes through the mean position, its KE is 8×10^{-3} J. Find the equation of motion of the particle if the initial phase of oscillation is 45°
(a) $y = 0.1\cos\left(3t+\frac{\pi}{4}\right)$ (b) $y = 0.1\sin\left(6t+\frac{\pi}{4}\right)$
(c) $y = 0.1\sin\left(4t+\frac{\pi}{4}\right)$ (d) $y = 0.1\cos\left(4t+\frac{\pi}{4}\right)$

7. Force constant of a weightless spring is 16 N/m. A body of mass 1.0 kg suspended from it is pulled down through 5 cm from its mean position and then released. The maximum kinetic energy of the system (spring + body) will be
(a) 2×10^{-2} J (b) 4×10^{-2} J (c) 8×10^{-2} J (d) 16×10^{-2} J

8. The system shown in figure is in equilibrium. The mass of the container with liquid is M, density of liquid in the container is ρ and the volume of the block is V. If the container is now displaced downwards through a distance x_0 and released such that the block remains well inside the liquid then during subsequent motion



(a) time period of SHM of the container will be $2\pi\sqrt{\frac{M}{k}}$
(b) time period of SHM of the container will be $2\pi\sqrt{\frac{M+\rho V}{k}}$
(c) amplitude of SHM of the container is x_0
(d) amplitude of SHM of the container is $2x_0$

9. A particle is in linear SHM of amplitude A and time period T. If v refers to its average speed during any interval of $\frac{T}{3}$, then the maximum possible value of v is
(a) $\frac{3\sqrt{3}}{T}A$ (b) $\frac{\sqrt{3}\,A}{T}$
(c) $\frac{2\sqrt{3}}{T}A$ (d) $\frac{3A}{T}$

10. A simple pendulum is suspended from the ceiling of a car and its period of oscillation is T when the car is at rest. The car starts moving on a horizontal road with a constant acceleration g (equal to the acceleration due to gravity, in magnitude) in the forward direction. To keep the time period same, the length of the pendulum
(a) will have to be increased by $\sqrt{2}\,l$
(b) will have to be increased by $(\sqrt{2}-1)\,l$
(c) will have to be decreased by $\sqrt{2}\,l$
(d) will have to be decreased by $(\sqrt{2}-1)\,l$

11. A particle of mass m is dropped from a great height h above the hole in the earth dug along its diameter.
(a) The motion of the particle is simple harmonic
(b) The motion of the particle is periodic
(c) The speed of the particle at the centre of earth equals $\sqrt{\frac{2GM}{(R+h)}}$, where R and M are the radius and mass of the earth respectively
(d) The speed of the particle at the centre of earth equals $\sqrt{\frac{GM(R+3h)}{R(R+h)}}$, where R and M are the radius and mass of the earth respectively

12. A solid cube floats in water half immersed and has small vertical oscillations of time period $\frac{\pi}{5}$ s. Its mass (in kg) is (Take $g = 10\ \text{m/s}^2$)
(a) 4 (b) 2
(c) 1 (d) 0.5

13. Maximum kinetic energy of a particle of mass 1 kg in SHM is 8 J. Time period of SHM is 4 s. Maximum potential energy during the motion is 10 J. Then
(a) amplitude of oscillations is approximately 2.53 m
(b) minimum potential energy of the particle is 2 J
(c) maximum acceleration of the particle is approximately 6.3 m/s^2
(d) minimum kinetic energy of the particle is 2 J

14. The potential energy of a particle of mass 0.1 kg, moving along the x-axis, is given by $U = 5x(x-4)$ J, where x is in metres. Choose the wrong option.
(a) The speed of the particle is maximum at $x = 2$ m
(b) The particle executes simple harmonic motion
(c) The period of oscillation of the particle is $\frac{\pi}{5}$ s
(d) None of the above

15. The 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 $v^2 = 144 - 9x^2$. Select wrong alternate.
(a) Displacement of the particle $\le$ distance moved by it
(b) The magnitude of acceleration at a distance 3 units from the fixed point is 27 units
(c) The motion is simple harmonic with $T = \frac{\pi}{3}$ units
(d) The maximum displacement from the fixed point is 4 units

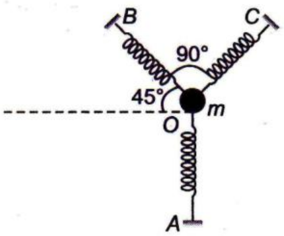
16. Two pendulums of time periods 3 s and 7 s respectively start oscillating simultaneously from two opposite extreme positions. After how much time they will be in same phase?

(a) $\frac{21}{8}$ s (b) $\frac{21}{4}$ s
(c) $\frac{21}{2}$ s (d) $\frac{21}{10}$ s

17. A particle under the action of a SHM has a period of 3 s and under the effect of another it has a period 4 s. What will be its period under the combined action of both the SHM's in the same direction?

(a) 7 s (b) 5 s
(c) 2.4 s (d) 0.4 s

18. A particle of mass m is attached to three identical springs A, B and C each of force constant k as shown in figure. If the particle of mass m is pushed slightly against the spring A and released, then the time period of oscillation is



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

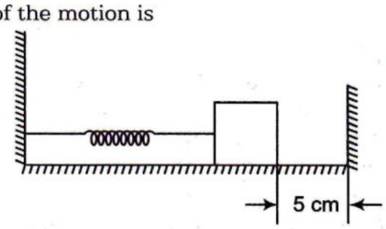
19. In SHM, potential energy of a particle at mean position is E_1 and kinetic energy is E_2, then

(a) $E_1 = E_2$
(b) total potential energy at $x = \frac{\sqrt{3}A}{2}$ is $E_1 + \frac{3E_2}{4}$
(c) total kinetic energy at $x = \frac{\sqrt{3}A}{2}$ is $\frac{3E_2}{4}$
(d) total kinetic energy at $x = \frac{A}{\sqrt{2}}$ is $\frac{E_2}{4}$

20. A particle performs SHM in a straight line. In the first second, starting from rest, it travels a distance a and in the next second it travels a distance b in the same side of mean position. The amplitude of the SHM is

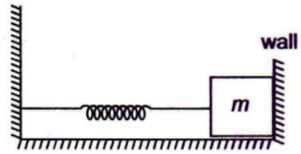
(a) $a - b$ (b) $\frac{2a-b}{3}$
(c) $\frac{2a^2}{3a-b}$ (d) None of these

21. A block of mass 100 g attached to a spring of spring constant 100 N/m is lying on a frictionless floor as shown. The block is moved to compress the spring by 10 cm and then released. If the collisions with the wall in front are elastic then the time period of the motion is



(a) 0.2 s (b) 0.1 s
(c) 0.15 s (d) 0.132 s

22. In the figure, the block of mass m, attached to the spring of stiffness k is in contact with the completely elastic wall, and the compression in the spring is e. The spring is compressed further by e by displacing the block towards left and is then released. If the collision between the block and the wall is completely elastic then the time period of oscillations of the block will be



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

23. A cubical block of mass M vibrates horizontally with amplitude of 4.0 cm and a frequency of 2.0 Hz. A small block of mass m is palced on the bigger block. In order that the smaller block does not slide on the bigger block, the minimum value of the coefficient of static friction between the two blocks is

(a) 0.36 (b) 0.40
(c) 0.64 (d) 0.72

24. A spring has a natural length of 50 cm and a force constant of 2.0×10^3 Nm^{-1}. A body of mass 10 kg is suspended from it and the spring is stretched. If the body is pulled down to a length of 58 cm and released, it executes simple harmonic motion. What is the net force on the body when it is at its lowermost position of its oscillation? (Take $g = 10$ ms^{-2}).

(a) 20 N (b) 40 N
(c) 60 N (d) 80 N

25. Two masses 8 kg and 4 kg are suspended together by a massless spring of spring constant 1000 N/m. When the masses are in equilibrium 8 kg is removed without disturbing the system. The amplitude of oscillation is

(a) 0.5 m
(b) 0.08 m
(c) 0.4 m
(d) 0.04 m

26. The 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

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

27. A horizontal platform with an object placed cn it is executing SHM in the vertical direction. The amplitude of oscillation is 4×10^{-3} m. What must be least period of these oscillations, so that the object is not detached from the platform? Take $g = 10$ m/s^2

(a) $\frac{\pi}{25}$ s (b) $\frac{\pi}{5}$ s
(c) $\frac{\pi}{10}$ s (d) $\frac{\pi}{50}$ s

28. A block of mass m, attached to a spring of spring constant k, oscillates on a smooth horizontal table. The other end of the spring is a fixed to a wall. The block has a speed v when the spring is at its natural length. Before coming to an instantaneous rest. If the block moves a distance x from the mean position, then

(a) $x = \sqrt{\frac{m}{k}}$ (b) $x = \frac{1}{v}\sqrt{\frac{m}{k}}$

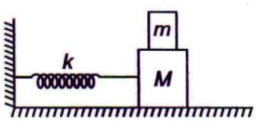
(c) $x = v\sqrt{\frac{m}{k}}$ (d) $x = \sqrt{\frac{mv}{k}}$

29. One end of a long metallic wire of length L is tied to the ceiling. The other end is tied to massless spring of spring constant k. A mass m hangs freely from the free end of the spring. The area of cross-section and 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

(a) $2\pi\sqrt{\frac{m}{k}}$ (b) $2\pi\sqrt{\frac{(YA+kL)}{YAk}}$

(c) $2\pi\sqrt{\frac{(YA+kL)}{Ak}}$ (d) $2\pi\sqrt{\frac{(Y+kL)}{YAk}}$

30. A mass M is attached to a horizontal spring of force constant k fixed one side to a rigid support as shown in figure. The mass oscillates on a frictionless surface with time period T and amplitude A. When the mass is in equilibrium position, another mass m is gently placed on it. What will be the new amplitude of oscillations?



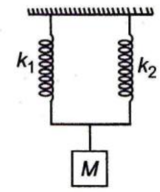
(a) $\sqrt{\frac{(M+m)}{M}}A$ (b) $\sqrt{\frac{(M-m)}{M}}A$

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

31. 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

(a) maximum potential energy is 160 J
(b) maximum potential energy is 100 J
(c) minimum potential energy is zero
(d) minimum potential energy is 100 J

32. A mass is suspended separately by two springs of spring constants k_1 and k_2 in successive order. The time periods of oscillations in the two cases are T_1 and T_2 respectively. If the same mass be suspended by connecting the two springs in parallel, (as shown in figure) then the time period of oscillations is T. The correct relation is



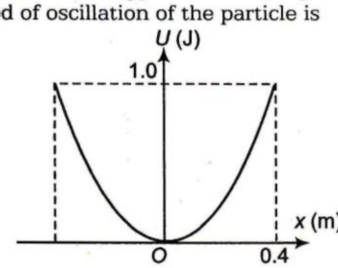
(a) $T^2 = T_1^2 + T_2^2$ (b) $T^{-2} = T_1^{-2} + T_2^{-2}$

(c) $T^{-1} = T_1^{-1} + T_2^{-1}$ (d) $T = T_1 + T_2$

33. Two particles executes SHM of the same amplitude and frequency along the same straight line. They pass one another when going in opposite directions each time their displacement is half their amplitude. What is the phase difference between them?

(a) 60° (b) 30°
(c) 90° (d) 120°

34. A particle of mass 2 kg moves in simple harmonic motion and its potential energy U varies with position x as shown. The period of oscillation of the particle is



(a) $\frac{2\pi}{5}$ s (b) $\frac{2\sqrt{2}\,\pi}{5}$ s

(c) $\frac{\sqrt{2}\,\pi}{5}$ s (d) $\frac{4\pi}{5}$ s

35. Two simple harmonic motions are represented by the following equations

$$y_1 = 40\sin\omega t$$

and $$y_2 = 10(\sin\omega t + c\cos\omega t)$$

If their displacement amplitudes are equal, then the value of c (in appropriate units) is

(a) $\sqrt{13}$ (b) $\sqrt{15}$
(c) $\sqrt{17}$ (d) 4

36. A mass M is suspended from a massless spring. An additional mass m stretches the spring further by a distance x. The combined mass will oscillate with a period

(a) $2\pi\sqrt{\left\{\frac{(M+m)\,x}{mg}\right\}}$ (b) $2\pi\sqrt{\left\{\frac{mg}{(M+m)\,x}\right\}}$

(c) $2\pi\sqrt{\left\{\frac{(M+m)}{mgx}\right\}}$ (d) $\frac{\pi}{2}\sqrt{\left\{\frac{mg}{(M+m)\,x}\right\}}$