PHYSICS

BOOKS - CHHAYA PHYSICS (BENGALI ENGLISH)

SIMPLE HARMONIC MOTION

Examples

1. A particle of mass 0.5g is executing SHM with a time period of 2s and an amplitude of 5 cm. Calculate its (i) maximum velocity, (ii) maximum acceleration and (iii) velocity, acceleration and force acting on the particle when it is at a distance of 4 cm from its position of equilibrium.

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2. A particle executing SHM possesses velocities $20cm \cdot s^{-1}$ and $15cm \cdot s^{-1}$ at distances 6 cm and 8 cm respectively from its mean position. Calculate the amplitude and the time period of the particle.

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3. The time period and amplitude of a particle executing SHM are 10 s and 0.12 m respectively. Find its velocity at a distance 0.04 m from its position of equilibrium.

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4. The frequency of a vibrating wire is 200 Hz. The velocity of a particle on the wire is $4.35m \cdot s^{-1}$ when it is at a distance of half its amplitude. Calculate the acceleration of the particle at that instant.

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5. Two particles executing SHM possess the same frequency. When the first particle just passes the mean position of its path, the second particle moving in the same direction is at a distance of 3 cm from its mean position. If the amplitude of vibration of the second particle is 6 cm, when is the phase difference of the two particles?

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6. A particle executing SHM possesses velocities v_1 and v_2 when it is at distances x_1 and x_2 respectively from its mean position. Show that, the time period of oscillation is given by $T = 2\pi\left(\frac{x_2^2 - x_1^2}{v_1^2 - v_2^2}\right)^{1/2}$

.

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7. The equation of a simple harmonic motion is $x = 10\sin\left(\frac{\pi}{3}t - \frac{\pi}{12}\right)cm$. Calculate its (i) amplitude, (ii) time period, (iii) maximum speed, (iv) maximum acceleration, (v) epoch and (vi) speed after 1 s of initiation of motion.

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8. Write down the equation of a simple harmonic motion whose amplitude is 5 cm, epoch is 0° and the number of vibrations per minute is 150.

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9. The displacement of a vibrating particle at time t is given by $x = A' \sin\left(\frac{\pi}{6}t\right) + B' \cos\left(\frac{\pi}{6}t\right)$, where A' = 0.03m, B' = 0.04m. Calculate the (i) amplitude, (ii) epoch, (iii) displacement, velocity and acceleration of the particle after 2 seconds.

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10. The equation of motion of a particle executing SHM is expressed by $x = 10 \sin\left(10t - \frac{\pi}{6}\right)$. Establish an equation to express its velocity and also calculate the magnitude of its maximum acceleration.

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11. Equation of a simple harmonic motion is $y = 2\sin\left(4t + \frac{\pi}{6}\right)$. Find out its period and initial phase.

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12. The equations of two SHMs are $x_1 = A\sin(\omega t + \delta_1)$ and $x_2 = A\sin(\omega t + \delta_2)$ respectively. They superimpose on each other. Find the amplitude of the resultant.

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13. The displacements of a particle executing SHM at three consecutive seconds are 6 cm, 10 cm and 6 cm respectively. Find out the frequency of oscillation of the particle.

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14. Equation of SHM is $y = 3 \sin 60\pi t$. Calculate its amplitude, time period and acceleration at its position of maximum displacement.

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15. Displacement of a particle is given by $x = 4(\cos \pi t + \sin \pi t)m$. Find its amplitude.

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16. Equation of motion of a particle executing SHM is $x = 5 \sin\left(4t - \frac{\pi}{6}\right)m$, where x is the displacement. If the displacement is 3 m, find the velocity of the particle?

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17. A point mass oscillates along the x-axis according to the law, $x = x_0 \cos\left(\omega t - \frac{\pi}{4}\right)$. If the acceleration of the particle is written as $\alpha = A\cos(\omega t + \delta)$, find A and δ.

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18. Two simple harmonic motions are represented by the equations $y_1 = 0.1 \sin\left(100\pi t + \frac{\pi}{3}\right)$ and $y_2 = 0.1 \cos \pi t$. What is the initial phase difference of the velocity of the first particle with respect to the second?

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19. The displacement of an object attached to a spring and executing SHM is given by $x = 2 \times 10^{-2} \cos \pi t m$. In what time the object attains maximum speed first?

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20. If x, v and a denote the displacement, the velocity and the acceleration of a particle executing simple harmonic motion of time period T, show that the expressions $\frac{aT}{x}$ and $a^2T^2 + 4\pi^2v^2$ do not change with time.

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21. Two simple harmonic motions of angular frequencies 100 and $1000 \text{rad} \cdot s^{-1}$ have the same displacement amplitude. What is the ratio of their maximum acceleration?

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22. A particle initially at rest at a distance of 5 cm from its mean position performs a SHM completing 60 oscillations in 2 seconds. Find the equation representing the displacement of the particle at any subsequent instant. What will be its equation if initially the particle were at the mean position?

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23. The equations of two SHM are $y_1 = 10 \sin\left(4\pi t + \frac{\pi}{4}\right), y_2 = 5\left(\sin 3\pi t + \sqrt{3} \cos 3\pi t\right)$. What is the ratio of their amplitudes?

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24. When a particle executing SHM is at a distance of 0.02 m from its mean position, then its kinetic energy is thrice its potential energy. Calculate the amplitude of motion of the particle.

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25. When a particle executing SHM is at a distance of 0.02 m from its position of equilibrium, then its kinetic energy is twice its potential energy. Calculate the distance from the position of equilibrium where its potential energy is twice its kinetic energy.

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26. A particle of mass 0.2kg is executing SHM along x-axis with a frequency of $\frac{25}{\pi}Hz$. If its kinetic energy is 0.5 J at x = 0.04 m, then find its amplitude of vibration?

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27. Total energy of a particle executing SHM is 3 J. A maximum force of 1.5 N acts on it. Time period and epoch of the SHM are 2s and 30^0 respectively. Establish the equation of this SHM and also find the mass of the particle.

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28. The equation of motion of a particle executing SHM is $x = A\sin(\omega t + \theta)$. Calculate the velocity and acceleration of the particle. If m is the mass of the particle, then what is the maximum value of its kinetic energy?

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29. Amplitude of a particle of mass 0.1 kg executing SHM is 0.1 m. At the mean position its kinetic energy is $8 \times 10^{-3} J$. Find the time period of its vibration.

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30. An object of mass 10 kg executes SHM. Its time period and amplitude are 2s and 10 m respectively. Find its kinetic energy when it is at a distance of (i) 2 m and (ii) 5 m respectively from its position of equilibrium. Justify the two different results for (i) and (ii).

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31. A particle of mass m executes SHM with amplitude a and frequency n. What is the average kinetic energy of the particle during its motion from the position of equilibrium to the end?

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32. A simple pendulum executes 40 complete oscillations in a minute. What is the effective length of the pendulum? $g = 980cm \cdot s^{-2}$.

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33. What will be the percentage increase in the time period of a simple pendulum when its length is increased by 21% ?

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34. Two simple pendulums of lengths 100 cm and 101 cm are set into oscillation at the same time. After what time does one pendulum gain one complete oscillation over the other?

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35. Find the length of a simple pendulum on the surface of the moon that has a time period same as that of a simple pendulum of the earth's surface. Mass of earth is 80 times that of moon and the radius of earth is 4 times that of moon.

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36. Two pendulums of time periods 1.8 s and 2 s are set into oscillation at the same time. After how many seconds will the faster moving pendulum execute one complete oscillation more than the outher? How many complete oscillations will the faster moving pendulum execute during this time?

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37. A pendulum clock runs 20s slow per day. What should be the change in length of the clock so that it records correct time? Take the pendulum as a simple pendulum.

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38. A pendulum of length 60 cm is suspended inside an aeroplane. The aeroplane is flying up with an acceleration of $4m \cdot s^{-2}$ making an angle of 30° with the horizontal. Find the time period of oscillation of the pendulum.

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39. The effective length of a simple pendulum is 1 m and the mass of its bob is 5 g. If the amplitude of motion of the pendulum is 4 cm, what is the maximum tension on the string to which the bob is attached?

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40. Prove that the change in the time period t of a simple pendulum due to a change ΔT of temperature is, $\Delta t = \frac{1}{2} \alpha t \Delta T$, where α = coefficient of linear expansion.

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41. The bob of a simple pendulum is made of brass and its time period is T. It is completely immersed in a liquid and is allowed to oscillate. If the density of the liquid is $\frac{1}{8}$ th of the density of brass, what will be the time period of oscillation of the pendulum now?

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42. A brass sphere is hung from one end of a massless and inextensible thread. When the sphere is set into oscillation, it oscillates with a time period T. If now the sphere is dipped completely into a non-viscous liquid, then what will be the time period of its oscillation? (density of the liquid is $\frac{1}{10}$th of that of brass)

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43. The normal length of a steel spring is 8cm. Keeping one end of the spring fixed at a point, if a weight is attached to the other end, its length becomes 14 cm. The weight is pulled down slightly and then released. Find the time period of oscillation of the spring?

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44. Two bodies of mass m_1 and m_2 are suspended from a weightless spring. The force constant of the spring is k. When the bodies are in equilibrium position, the body of mass m_1 is taken away from the system such that the equilibrium condition of the system is not disturbed at that very moment. Determine the angular frequency and the amplitude of motion for the body of mass m_2.

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45. A spring is elongated by 2 cm due to a 80 g mass attached to it. Another body of mass 600g is attached to the end of the spring and it is displaced by 8 cm from its equilibrium position. Calculate the energy of the system in this position. Considering the principle of conservation of energy, determine the velocity of the body when it is at a distance of 4 cm.

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46. A particle is executing SHM. If time is measured from when it is at one end of its path of motion, calculate the ratio of its kinetic energy to the potential energy at $t = \frac{T}{12}$. Here T is the time period of the motion. Suppose the initial phase is zero.

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47. When a man of mass 60 kg sits inside a car, the centre of gravity of the car descends by 0.3 cm. If the mass of the car is 1000 kg, calculate the frequency of oscillation of the empty car.

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48. A wooden block of cross-sectional area $10cm^2$ is floating vertically on water. The volume of the immersed portion of the block is $200cm^3$. The block is depressed slightly inside water and then released. Calculate the time period of vibration of the block.

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49. A small coin is kept on a horizontal platform. The platform is oscillating vertically with a time period of 0.5s. What should be the maximum amplitude of vibration so that the coin always remains in contact with the platform?

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50. Two identical bodies, each of mass m, are connected by a spring having spring constant k and they are placed on a frictionless floor. The spring is compressed a little and then released. What will be the frequency of oscillation of the system?

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51. The time period of a body of mass M executing SHM, connected to a spring, is 2 s. If the mass of the body is increased by 2 kg, its time period increases by 1 s. Considering that Hooke's law is obeyed, calculate the initial mass M.

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52. Time period of a spring of negligible mass, with a mass M hanging from it, is T. The time period chnages to $\frac{5T}{3}$ on attaching an additional mass m to it. Find out the value of $\frac{m}{M}$.

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53. A smooth-walled tunnel is made along the straight line connecting any two points on the earth's surface. A body is released at one end of the tunnel. Considering the earth to be a sphere of uniform density, calculate the time period of oscillation of the particle for its simple harmonic motion.

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54. A particle at the end of a spring executes SHM with a period t_1, while corresponding period for another spring is t_2. If the period of oscillation when the two springs are connected in series is T, then prove that, $t_1^2 + t_2^2 = T^2$.

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Section Related Questions

1. Establish the mathematical expression for simple harmonic motion.

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2. If the equation of motion of a particle executing SHM is $x = A\sin(\omega t + \alpha)$, then determine the expression for velocity of the particle and also determine the value of its maximum acceleration.

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3. Write down the characteristics of simple harmonic motion.

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4. What is the result of superposition of two collinear simple harmonic motions of the same frequency but of different amplitudes when they are (i) in the same phase and (ii) in opposite phase?

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5. Show that the total mechanical energy remains constant for a particle executing simple harmonic motion.

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6. Find out the total mechanical energy of a particle executing SHM.

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7. Find expressions for potential and kinetic energies of a particle executing simple harmonic motion.

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8. What is a seconds pendulum? Determine its length in the CGS system $\left[g = 980 cm \cdot s^{-2}\right]$.

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Higher Order Thinking Skill Hots Questions

1. Simple harmonic motion is a periodic motion, but all periodic motions are not simple harmonic' - explain.

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2. What should be the displacement of a particle, executing SHM, from its position of equilibrium so that the velocity of the particle is half of its maximum velocity?

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3. What should be the displacement of a particle, executing SHM, from its position of equilibrium so that its acceleration is half of its maximum acceleration?

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4. What should be the displacement of a particle, executing SHM, from its position of equilibrium so that the kinetic energy of the particle is half of its maximum kinetic energy?

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5. What should be the displacement of a particle, executing SHM, from its position of equilibrium so that the kinetic energy and the potential energy of the particle are equal?

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6. Two equal masses M and N are suspended from the ends of two separate weightless springs having spring constants k_1 and k_2. If the maximum velocities of the two masses for their vertical oscillations are the same, what is the ratio of the amplitudes of vibration of M and N?

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7. A weight is suspended from a spring balance and the time period for its vertical oscillatory motion is T. The spring is divided into two equal parts and from any one of them the same weight is suspended. Determine the time period of vertical oscillatory motion of that spring.

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8. Show that the equation $x = A \sin \omega t$ represents a simple harmonic motion.

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9. The potential energy of a spring pendulum, with a mass m connected to it, is given by $V = \frac{1}{2}kx^2$ (where x = displacement from the position of equilibrium and k = a constant). How does the applied force on the mass vary with displacement?

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10. A billiard ball strikes perpendicularly on one side of a smooth billiard table and after rebounding it strikes the opposite side. As there is no friction the motion continues. Thus the ball makes a to and fro oscillation with repeated rebounds. Is the motion of the billiard ball simple harmonic?

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11. A small spherical body is placed on the concave side of a curved surface of radius of curvature R. The curved surface is placed on a table. The spherical body is displaced a little from its position of equilibrium and then released. If the displacement of the body is very small in comparison to the radius of curvature of the curved surface, show that the spherical body will perform a SHM and also calculate its time period.

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12. A body of mass m is suspended from a weightless wire of length l. If Y is the Young's modulus of the material of the wire, calculate the frequnecy of vibration in the vertical direction.

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13. A wooden cylinder floats in water with length h immersed into it. If it is pushed a little inside water and then released, show that it will perform a simple harmonic motion. Calculate the time period of this motion.

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14. An object attached to a spring is executing a SHM. If the spring constant of the spring is increased, what changes in its frequency will be noticed?

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15. A particle of mass m executes SHM with an amplitude A. If its mass is changed to $\frac{1}{4}$m, then what will be its (i) new frequency and (ii) total energy?

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16. The equation, $\frac{d^2x}{dt^2} + ax = 0$, represents an SHM.

Find its time period.

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17. What is the time period of the SHM indicated by the

function $\sin^2 \omega t$?

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18. Write the equation of motion of a particle executing

SHM if at t = 0 its displacement is maximum.

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19. If the time period and amplitude are T and A respectively, then find the time taken by a particle executing SHM to reach the position $x = \frac{A}{2}$ from x = A.

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20. A simple harmonic motion is represented as $x = A \sin \omega t + B \cos \omega t$. Find the amplitude and initial phase.

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21. Show that the equation $x = A\cos(\omega t - \alpha)$ is a mathematical representation of simple harmonic motion. Find the time period and the maximum speed of the motion.

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22. If the frequency of a simple harmonic motion be n then find the frequency of its kinetic energy.

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23. The kinetic energy of a particle is $\frac{1}{2}m\omega^2(A^2 - x^2)$, where m, ω and A are constants. Prove that the motion of the particle is simple harmonic.

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24. The speed of a body of mass m, when it is at a distance x from the orign, is v. Its total energy is $\frac{1}{2}mv^2 + \frac{1}{2}kx^2$, where k is constant. Prove that the body executes a simple harmonic motion.

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25. The mass and radius of a satellite is twice that of the earth. If a seconds pendulum is taken to that satellite, what will be its time period?

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26. A lift is moving vertically upwards with an acceleration a. What will be the changed time period of a simple pendulum suspended from the roof of the lift? If the lift becomes free and starts falling down with the acceleration due to gravity, what will be the change in the time period?

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27. The bob of a simple pendulum is hollow. If half of it is filled with water, what will be the effect on its time period?

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28. A hollow sphere is filled up with water and is suspended using a long string. As water trickels out slowly through an orifice at the lower part of the sphere, it is observed that the time period of the pendulum first increases and later continues to decrease. Explain these observations.

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29. The bob of a simple pendulum is made of iron. Exactly below the equilibrium position of the pendulum, the pole of a strong magnet is placed. What will be the change in the time period of the pendulum?

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30. If the point of suspension of a simple pendulum is in a horizontal motion, with constant acceleration, what will be the effect on the time period?

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31. A simple pendulum, suspended from the roof of a car, is oscillating. What will be the time period of the pendulum when the car moves in a circular path at a constant speed?

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32. State the changes in time period of a pendulum, when (i) the pendulum is taken to a mountain top from the earth's surface (ii) the pendulum is set on the floor of a mine (iii) diameter of the bob of the pendulum is increased (iv) keeping the radius of the bob unchanged, its mass is increased. Give reasons for your answer.

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Exercise

1. The motion of any hand of a clock is a (an)

A. periodic motion

B. simple harmonic motion

C. vibration

D. oscillation

Answer: A

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2. If the mass of a particle executing SHM is m and its angular frequency is ω, then the force constant of that

SHM will be

A. $m\omega$

B. $m\omega^2$

C. $\sqrt{\frac{m}{\omega}}$

D. $\sqrt{\frac{\omega}{m}}$

Answer: B

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3. In case of a simple harmonic motion, which of the following statements is not true?

A. the moving particle repeats the same path periodically

B. the restoring force acting on the particle is always directed towards the equilibrium position

C. the restoring force acting on the particle is always proportional to its displacement

D. the restoring force acting on the particle is always proportional to the velocity of the particle

Answer: D

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4. If the displacement and the restoring force acting on a particle executing simple harmonic motion are x and F respectively, then $F = -kx$. Here the negative sign on the right hand side indicates that

A. the restoring force is directed towards the equilibrium position

B. the restoring force is directly proportional to the displacement

C. the force constant is always negative

D. the restoring force is always negative

Answer: A

5. If the mass of a particle executing SHM is m and its angular frequency is ω, then time period of its oscillation will be

A. $\frac{1}{\omega}$

B. $\frac{m}{\omega}$

C. $\frac{\omega}{2\pi}$

D. $\frac{2\pi}{\omega}$

Answer: D

6. The magnitude of maximum velocity of the SHM expressed by the equation $x = A\sin\omega t$ is

A. A

B. $A\omega$

C. $A\omega^2$

D. $A^2\omega$

Answer: B

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7. The magnitude of maximum acceleration of the SHM expressed by the equation $x = A\sin\omega t$ is

A. A

B. $A\omega$

C. $A\omega^2$

D. $A^2\omega$

Answer: C

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8. If the equation $x = a\sin\omega t$ represents a simple harmonic motion of a particle, then its initial position is

A. equilibrium point

B. terminal point

C. any point in the right side of the point of equilibrium

D. any point in the left side of the point of equilibrium

Answer: A

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9. The time period of the SHM expressed by the equation $x = 4\sin 4\pi t m$ is

A. 4 s

B. $4\pi s$

C. 2 s

D. $\frac{1}{2}$ s

Answer: D

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10. If the displacement and the acceleration of a particle executing SHM at any instant are x and a respectively, then the time period of that motion will be

A. $2\pi\sqrt{\frac{a}{x}}$

B. $2\pi\sqrt{\frac{x}{a}}$

C. $\frac{1}{2\pi}\sqrt{\frac{a}{x}}$

D. $\frac{1}{2\pi}\sqrt{\frac{x}{a}}$

Answer: B

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11. Which one of the following is not the equation of an SHM?

A. F = - kx

B. $a = -\frac{k}{m}x$

C. $a = -\omega^2 x$

D. $a = \omega^2 x$

Answer: D

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12. A particle executing SHM follows a straight path of length l. The amplitude of its motion is

A. 2l

B. l

C. $\frac{l}{2}$

D. $\frac{l}{4}$

Answer: C

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13. The phase difference between two SHM $x = B\cos\omega t$ and $x = A\sin\omega t$ is

A. 180°

B. 90°

C. -90°

D. zero

Answer: B

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14. The amplitude of vibration of the SHM represented by the equation $x = A\sin\omega t + B\cos\omega t$ is

A. A + B

B. A - B

C. $\sqrt{A^2 + B^2}$

D. $\sqrt{A^2 - B^2}$

Answer: C

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15. The initial phase or epoch of the SHM represented by the equation $x = A\sin\omega t + B\cos\omega t$ is

A. $\frac{A}{B}$

B. $\frac{B}{A}$

C. $\tan^{-1}\frac{A}{B}$

D. $\tan^{-1}\frac{B}{A}$

Answer: D

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16. The SHM executed by a particle of mass 2 kg is represented by the equation $x = 4\sin 4\pi t m$. Total mechanical energy of the particle (in joule) will be

A. $256\pi^2$

B. $64\pi^2$

C. $16\pi^2$

D. 16π

Answer: A

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17. A particle is executing SHM with frequency a. The frequency of the variation of its kinetic energy is

A. $\frac{a}{2}$

B. a

C. 2a

D. 4a

Answer: C

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18. The distance between the positions of maximum potential energy and maximum kinetic energy of a particle executing SHM is

A. $\pm \frac{A}{2}$

B. $\pm \frac{A}{\sqrt{2}}$

C. $\pm A$

D. $\pm 2A$

Answer: C

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19. If the amplitude of an SHM is A, then for what position of the particle, half of its total energy will be potential energy and the remaining half will be kinetic energy?

A. $\pm \frac{A}{2}$

B. $\pm \frac{A}{\sqrt{2}}$

C. $\pm \frac{A}{3}$

D. $\pm \frac{A}{2\sqrt{2}}$

Answer: B

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20. Kinetic energy and potential energy of a simple harmonic motions are K and V respectively. Then which one is always true

A. $K > V$

B. $K < V$

C. K = V

D. K + V = constant

Answer: D

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21. When a spring is stretched by 3 cm, stored potential energy becomes u and when it is stretched by 6 cm potential energy becomes

A. 2u

B. 3u

C. 4u

D. 6u

Answer: C

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22. Time period of a simple pendulum is 2 s. If its length is doubled, then the new time period will be

A. 2s

B. $\sqrt{2}s$

C. $2\sqrt{2}s$

D. 4 s

Answer: C

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23. If the time period of a simple pendulum of effective length L is T, then the effective length of a simple pendulum having time period 2T will be

A. $\frac{L}{2}$

B. L

C. 2L

D. 4L

Answer: D

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24. The time period of a seconds pendulum is

A. 1 s

B. 2 s

C. $\frac{1}{2}$ s

D. $1\frac{1}{2}s$

Answer: B

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25. If a seconds pendulum is taken to the surface of the moon from the earth, its time period would be (acceleration due to gravity on the surface of the moon is $\frac{1}{6}$th that on the earth's surface)

A. 12s

B. 6s

C. $2\sqrt{6}s$

D. $\frac{2}{\sqrt{6}}s$

Answer: C

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26. The nature of the graph of the effective length of a pendulum versus its time period will be

A. linear

B. parabolic

C. exponential

D. sinusoidal

Answer: B

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27. The length of a seconds pendulum on the surface of the earth is

A. 1 m (approx.)

B. 1.1 m (approx.)

C. 0.25 m (approx.)

D. 2 m (approx.)

Answer: A

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28. Time period of a simple pendulum on the surface of the earth is T_1 and at a hight R above the surface of the earth is T_2, here R is the radius of the earth. The ratio T_2 / T_1 is

A. 1

B. $\sqrt{2}$

C. 4

D. 2

Answer: D

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29. A simple pendulum has time period T_1. The point of suspension is now moved upwards according to the relation $y = Kt^2, \left(K = 1m \cdot s^{-2}\right)$ where y is the vertical displacement. The time period now becomes T_2. The ratio of T_1^2 / T_2^2 is $(g = 10m \cdot s^{-2})$

A. $\frac{6}{5}$

B. $\frac{5}{6}$

C. 1

D. $\frac{4}{5}$

Answer: A

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30. Length of a pendulum is l. The bob is pulled to one side to make an angle α with the vertical and is then released. Velocity of the bob, when it crosses the position of equilibrium, is

A. $\sqrt{2gl}$

B. $\sqrt{2gl\cos\alpha}$

C. $\sqrt{2gl(1-\cos\alpha)}$

D. $\sqrt{2gl(1-\sin\alpha)}$

Answer: C

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31. A simple pendulum of length l has a maximum angular displacement θ. The maximum kinetic energy of the bob of mass m will be

A. $mgl(1 - \cos\theta)$

B. $mgl\cos\theta$

C. $mgl\sin\theta$

D. None of these

Answer: A

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32. A wooden cube (density of wood d) of side l floats in a liquid of density ρ with its upper and lower surfaces horizontal. If the cube is pushed slightly down and released, and it performs simple harmonic motion of period T, then T is equal

A. $2\pi\sqrt{\dfrac{l\rho}{(\rho-d)g}}$

B. $2\pi\sqrt{\dfrac{ld}{\rho g}}$

C. $2\pi\sqrt{\dfrac{l\rho}{dg}}$

D. $2\pi\sqrt{\dfrac{ld}{(\rho-d)g}}$

Answer: B

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33. A spring is cut into two pieces in such a way that one piece is double the length of the other. If the force constant of main spring is k then force constant of the longer part is

A. $\frac{2}{3}k$

B. $\frac{3}{2}k$

C. 3k

D. 6k

Answer: B

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Very Short Answer Type Questions

1. If the time period of an SHM is 2 s, then what will be its frequency?

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2. If the frequency of an SHM is 200 Hz, then what will be its time period?

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3. What is the unit of force constant of SHM in SI?

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4. Motion of the earth around the sun is a _______ motion. [Fill in the blank]

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5. What is the maximum displacement of a vibrating particle from the equilibrium position called?

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6. What is the phase difference between the displacement and the velocity of a particle executing SHM?

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7. What is the phase difference between the displacement and the acceleration of a particle executing SHM?

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8. If the time period is T then what will be the time taken by a particle executing SHM to traverse from the position of equilibrium to an extremity?

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9. What will be the change in time period of a simple pendulum if the metallic bob of the pendulum is replaced by a wooden bob of the same radius?

(provided both bobs are of uniform density)

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10. In which direction is the acceleration of a particle executing SHM directed?

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11. At which points of its path, the velocity of a particle executing SHM becomes zero?

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12. At which position, the velocity of a particle executing SHM becomes maximum?

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13. At which position, the acceleration of a particle executing SHM becomes zero?

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14. At which points of its path, the acceleration of a particle executing SHM becomes maximum?

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15. At which position, the kinetic energy of a particle executing SHM becomes maximum?

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16. At which points of its path, the potential energy of a particle executing SHM becomes maximum?

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17. Total mechanical energy of a simple pendulum is directly proportional to the mass of the pendulum. Is the statement true or false?

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18. How is the total mechanical energy of a simple pendulum related to the length of the pendulum?

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19. Total mechanical energy of a simple pendulum is directly proportional to the amplitude of the pendulum. Is the satement true or false?

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20. The bob of a simple pendulum is made of iron. A powerful magnetic pole is placed below the bob in its equilibrium position. How will the time period of the pendulum change?

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21. A body attached to a spring is executing SHM. If the force constant of the spring is increased then what will be the change in the frequency of oscillation?

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22. If a straight tunnel is bored from the north pole to the south pole of the earth and if a body is dropped into that tunnel then what time will the body take to move from one end to the other end of the tunnel?

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23. What is the type of motion of a body along the tunnel passing through the centre of the earth?

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Short Answer Type Questions I

1. A moving particle has an acceleration a = -bx, where b is a positive constant and x is the distance of the particle from the equilibrium position. What is the time period of oscillation of the particle?

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2. If $y = \frac{1}{\sqrt{a}}\sin\omega t - \frac{1}{\sqrt{v}}\cos\omega t$ is representing the equation of SHM then find the amplitude of motion.

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3. Potential energy of a particle is $\frac{1}{2}m\omega^2x^2$, where m and ω are constants. Prove that the motion of the particle is simple harmonic.

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4. What should be the displacement of a particle executing SHM from the position of equilibrium so that its acceleration becomes half of its maximum acceleration?

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5. For what displacement from the equilibrium position of a particle executing SHM, its velocity will be one fourth of its maximum velocity?

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6. At which points of its path, for a particle executing simple harmonic motion, will its velocity, acceleration, kinetic energy and potential energy be zero?

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7. What will be the change in the time period of a pendulum if (i) the diameter of the bob is increased (ii) the mass of the bob is increased keeping its diameter constant?

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8. Write the equation of motion of a particle executing simple harmonic motion, whose displacement is maximum at t = 0.

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9. The bob of a simple pendulum is a hollow sphere. If it is half-filled with water, what will be the effect on its frequency?

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Short Answer Type Questions Ii

1. Show whether the following equation are simple harmonic or not (i) $x = A\sin\omega t$ $(ii) x = A\cos(\omega t - \alpha)$

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2. A particle of mass m is executing simple harmonic motion with an amplitude A. If the mass of the particle is reduced by 50%, then what will be its (i) new frequency, (ii) new total energy?

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3. The phase difference between the displacement and the velocity of a particle executing SHM is 90°' - explain.

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4. Why are the displacement and the acceleration of a particle executing SHM always in opposite phase?

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5. Show that the equation $x = A\sin(\omega t - \alpha)$ is the mathematical representation of a simple harmonic motion. Find the time period and the maximum acceleration of the motion.

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6. If the displacement of a particle executing SHM is maximum at time t = 0, then write down its equation.

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7. Show that for a particle in linear SHM, the average kinetic energy over a period of oscillation equals the average potential energy over the same period.

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Problem Set I

1. The amplitude of a particle executing SHM is 0.1 m. The acceleration of the particle at a distance of 0.03 m from the equilibrium position is $0.12m \cdot s^{-2}$. What will be its velocity at a distance of 0.08 m from the position of equilibrium?

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2. The maximum acceleration of a particle executing simple harmonic motion is $0.296m \cdot s^{-2}$, its time period is 2s and the displacement from the equilibrium position at the beginning of its motion is 0.015m. Determine the equation of motion of the particle.

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3. What is the amplitude, frequency and initial phase of the SHM represented by the equation : $x = 2\sin\left(10\pi t + \frac{\pi}{6}\right)m$?

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4. Amplitude of a SHM is, A = 7 cm, its time period, T = 2s and initial phase, $\alpha = 30^\circ$. Establish the equation of this SHM.

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5. A particle executes SHM with an amplitude of 13 cm and its velocity at a distance of 5 cm from the equilibrium position is $36cm \cdot s^{-1}$. Determine the maximum value of the restoring force. (Mass of the particle = 2g).

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6. Equations of two SHMs are $y_1 = 10\sin\left(3\pi t + \frac{\pi}{4}\right)$ and $y_2 = 5\left(\sin 3\pi t + \sqrt{3}\cos 3\pi t\right)$. Determine the ratio of their amplitudes.

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7. When a particle executing SHM is at a distance of 0.03 m from the equilibrium position, its acceleration is $0.296 m \cdot s^{-2}$. What is the time period of oscillation of the particle?

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8. A particle executes SHM of period 1.2 s and amplitude 8 cm. Find the time it takes to travel 4 cm from the positive extremity of its oscillation.

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9. Time period and amplitude of a particle executing SHM are 2 s and 5 cm respectively. Determine its velocity and acceleration at a distacne of 3 cm from the equilibrium position.

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10. Time period of a particle executing SHM is T = 1 second and its amplitude of vibration is A = 0.04 m. Determine the maximum velocity and maximum acceleration of the particle.

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11. The maximum velocity of a particle executing SHM is $v_m = \pi cm \cdot s^{-1}$ and the maximum acceleration is $a_m = \pi^2 cm \cdot s^{-2}$. Determine the time period and the amplitude of motion of the particle.

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12. The equation of motion of a particle executing SHM is $3\frac{d^2x}{dt^2} = 27x = 0$, what will be the angular frequency of the SHM?

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13. A particle executing SHM starts from one end of its path. If the time period of the particle is T, then what will be the ratio of its kinetic energy and potential energy after a time of $\frac{T}{12}$?

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14. A particle of mass 5g is executing SHM. The velocity of the particle when it crosses the midpoint of its motion is $10cm \cdot s^{-1}$. What will be its total mechanical energy?

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15. The ratio of kinetic energy and potential energy of a particle executing SHM at a distance of 2 cm from its equilibrium position is 3 : 2. What is the amplitude of vibration of the particle?

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16. The bob of a simple pendulum of effective length 1 m is pulled through a distance of 2 cm horizontally from its equilibrium position and then released. Determine the equation of motion of the bob.

[Given, $\tan^{-1}\left(\frac{2}{100}\right) < 4^{\circ}$]

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17. The time period of a simple pendulum is 2 s. The mass of its bob is 10 g and the bob is oscillating with an amplitude of 4 cm. What is the total mechanical energy of the bob?

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18. What is the time period of a simple pendulum of effective length 60 cm? $g = 980cm \cdot s^{-2}$.

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19. A simple pendulum completes 20 oscillations in a minute. If the diameter of its bob is 3.28 cm, what will be the length of its thread?

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20. A particle executes SHM of period 8 s. After what time of its passing through the mean position will the energy be half kinetic and half potential?

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21. Due to shifting from one place to another, the time period of a simple pendulum increases by 0.1%. What will be the percentage difference of the acceleration due to gravity at the second place as compared to that at the first place?

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22. What will be the effective length of a seconds pendulum on the surface of the moon? The mass and the diameter of the earth are 80 times and 4 times the mass and the diameter respectively of the moon.

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23. If a simple pendulum of length 100 cm is used as a seconds pendulum, then how many seconds will it go slow or fast in a day?

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24. The effective length of a simple pendulum is 1 m. The pendulum completes 20 oscillations in 40 s. What is the value of acceleration due to gravity at that place?

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25. The time period of vibration of a massless elastic spring, with mass M attached to its end, increases n times when an additional mass m is attached. What is the ratio of m to M?

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26. Which of the following functions of time represent (i) simple harmonic, (ii) periodic but not simple harmonic, and (iii) non-periodic motion? Give period for each case of periodic motion (ω is any positive constant):

(a) $\sin \omega t - \cos \omega t$

(b) $\sin^3 \omega t$

(c) $3\cos(\pi/4 - 2\omega t)$

(d) $\cos\omega t + \cos 3\omega t + \cos 5\omega t$

(e) $\exp(-\omega^2 t^2)$

(f) $1 + \omega t + \omega^2 t^2$

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27. Two particles execute SHM of same amplitude along the same straight line. They cross each other when going in opposite directions, each time their displacement is half of their amplitude. Calculate the phase difference between them.

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Problem Set Ii

1. The displacement equation of a simple harmonic motion is $x = A\sin(\omega t + \phi)$. Show that the relation between velocity v and acceleration a of the motion is $\omega^2 v^2 + a^2 = \omega^4 A^2$.

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2. The equation $x = (\sin t + \cos t)$cm represents a simple harmonic motion along x-axis. Determine the amplitude, time period maximum velocity and maximum acceleration for the motion.

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3. The equation $x = (\sqrt{3}\sin \pi t + \cos \pi t)$cm represents a simple harmonic motion x-axis. Determine the amplitude, time period, maximum velocity and maximum acceleration for the motion.

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4. A particle is subjected to two SHMs in the same direction having equal amplitude and equal frequency. If the resultant amplitude is equal to the amplitude of individual motion. What is the phase difference between the motions?

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5. A simple harmonic motion has an amplitude of A and an angular frequency of ω. Determine the distance of the point from the equilibrium position where the magnitudes of velocity and acceleration of the motion are equal.

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6. Velocities of a particle executing SHM are u and v at distances x_1 and x_2 respectively from the mean position. Prove that the amplitude of the motion is

$$\left(\frac{v^2x_1^2 - u^2x_2^2}{v^2 - u^2}\right)^{1/2}$$

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7. Velocities of a particle executing SHM are $4m \cdot s^{-1}$ and $3m \cdot s^{-1}$ at distances 2 m and 3 m respectively from the position of equilibrium. Determine the amplitude and time period of the motion.

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8. A particle of mass 0.01 kg is executing simple harmonic motion along a straight line. Its time period is 2 s and amplitude is 0.1 m. Determine its kinetic

energy (i) at a distance 0.02 m and (ii) at a distance 0.05 m from the position of equilibrium.

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9. Total energy of a particle executing simple harmonic motion is 400 erg and the maximum force acting on the particle is 100 dyn. If the time period is 2 s and the initial phase is 30°, then write down the equation of motion. What is the mass of the particle?

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10. The ratio of the masses, time periods and amplitudes of vibration of two particles executing simple harmonic motion are 2 : 1, 2 : 3 and 1 : 2 respectively. Determine the ratio of their mechanical energies.

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11. A particle of mass m is executing oscillations about the origin of the x-axis with amplitude A. Its potential energy $U(x) = ax^4$, where a is a positive constant. What is the x - coordinate of the particle, where potential energy is one-third of the kinetic energy?

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12. The mass of the bob of a simple pendulum is 2 g. If the pendulum keeps oscillating with an angular amplitude of 4°, then what will be the maximum tension acting on the thread of the pendulum?

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13. A seconds pendulum goes slow by 1 min 40 s a day. What should be the change in its length so that it will give the correct time? $(g = 980cm.\ s^{-2})$

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14. A pendulum clock gives correct time at sea level. By how much time will the clock go show or fast in a town situated at an altitude of 741 m? Radius of the earth = 6400 km

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15. The time period of a simple pendulum is 1.96 s. Its time period increases by 0.1 s when its length is increased by 10 cm. From this observation, determine the value of the acceleration due to gravity.

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16. Calculate the percentage of charge of time period of a simple pendulum if its length is increased by 8%.

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17. Two simple harmonic motions are represented by the equations $y_1 = 0.1 \sin\left(100\pi t + \frac{\pi}{3}\right)$ and $y_2 = 0.1 \cos \pi t$. Find the initial phase difference of the velocity of particle 1, with respect to the velocity of particle 2.

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18. A particle at the end of a spring executes simple harmonic motion with a period t_1, while the corresponding period for another spring is t_2. If the period of oscillation with the two springs in series is T, then prove that $t_1^2 + t_2^2 = T^2$

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19. A spring balance has a scale that reads from 0 to 50 kg. The length of the scale is 20 cm. A body suspended from this balance, when displaced and released, oscillates with a period of 0.6 s. What is the weight of the body?

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20. If the angular frequency of a particle executing SHM is ω and its maximum velocity is v_m, then show that the relation between its velocity v and acceleration a is $a = -\omega\sqrt{v_m^2 - v^2}$.

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21. When a particle executing SHM reaches half of its amplitude, find ratio os its (i) velocity and maximum velocity, (ii) kinetic energy and maximum kinetic energy.

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22. The time period and the amplitude of vibration of a particle of mass 5 kg executing simple harmonic motion are 2 s and 5 m respectively. Determine the (i) total mechanical energy, (ii) restoring force acting on it at a distance of 2 m from the position of equilibrium and (iii) kinetic energy at that position.

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23. A lift is ascending with a retardation of $1.4 m \cdot s^{-2}$. If a seconds pendulum from the ground is brought inside that lift, what will be its time period?

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24. An aeroplane is descending with a retardation of $2m \cdot s^{-2}$ making an angle of 45° with the horizontal. What should be the time period of a simple pendulum of length 100 cm kept inside that aeroplane?

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25. The bob of a simple pendulum executes simple harmonic motion in water with a period T, while the period of oscillation of the bob is T_0 in air. Neglecting frictional force of water and given that the density of the bob is $\frac{4}{3} \times 10^3 kg \cdot m^{-3}$. Prove that, $T = 2T_0$.

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26. The time period of a simple pendulum is T. When the length is increased by 10 cm, its period is T_1. When the length is decreased by 10 cm, its period is T_2. Prove that the relation between T, T_1 and T_2 is $T_1^2 + T_2^2 = 2T^2$.

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27. A heavy brass sphere is hung from a weightless inelastic spring and as a simple pendulum its time period of oscillation is T. When the sphere is immersed in a non-viscous liquid of density $\frac{1}{10}$ that of brass, find the time period of oscillation of the pendulum.

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28. A clock run by a brass pendulum gives correct time at $25^{\circ}C$. By how many seconds the clock will go slow or fast per day at $0^{\circ}C$? Coefficient of linear expansion of brass = $19 \times 10^{-6}{}^{\circ}C^{-1}$.

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29. A pendulum clock performs 86405 half-oscillations per day. At the beginning of a day the clock goes fast, but at the end of the day it goes slow by 15 s. What is the difference in maximum and minimum temperatures

on that day? α for the material of the pendulum = $16 \times 10^{-6} {}^{\circ}C^{-1}$

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30. There are three iron rods and two brass rods in a compensated pendulum. Coefficients of linear expansion of iron and brass are $12 \times 10^{-6} {}^{\circ}C^{-1}$ and $19 \times 10^{-6} {}^{\circ}C^{-1}$ respectively. If the average length of each iron rod is 50 cm, then what is the average length of each brass rod?

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31. A body of mass 1 kg is suspended from a weightless spring having force constant $600N \cdot m^{-1}$. Another body of 0.5kg moving vertically upwards hits the suspended body with a velocity of $3m \cdot s^{-1}$ and gets embedded in it. Find the frequency of oscillations and amplitude of motion.

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32. A particle is executing SHM on x-axis starting from mean position. At time t and 2t respectively, position of the particle along x-axis are at x = M and x = N then

Show time period, $T = \dfrac{2\pi t}{\cos^{-1}\left(\frac{N}{2M}\right)}$

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Hots Numerical Problems

1. A particle of mass 10 g is placed in a potential field given by $v = (50x^2 + 100)$ erg/g. Calculate the frequency of oscillation.

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2. Two particles are executing simple harmonic motions with equal frequency and amplitude. When the displacements of the two particles are half of their amplitudes, they cross each other in mutually opposite directions. What is the phase differecne of their vibrations?

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3. A spring, suspended vertically, elongates by 0.02m when a mass of 0.08 kg is attached to it. An object of mass 0.6 kg is attached to its free end and it is displaced by 8 cm from its equilibrium position. Determine the energy of the system at this position. From the viewpoint of energy, determine the velocity of the body when it is at a distance of 0.04 m from the equilibrium position.

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4. A seconds pendulum gives correct reading on the earth's surface, but when it is taken inside a mine, it goes slow by 10 s in a day. What is the depth of the mine? (Radius of the earth = 6400 km)

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5. Effective length of a simple pendulum is 50 cm and mass of the bob suspended is 4 g. The bob is pulled to one side to make the string horizontal and then it is released. What will be the kinetic energy of the bob when it makes an angle 60° with the vertical?

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6. If the length of a simple pendulum is increased by x, then its time period increases from T_1 to T_2.

Prove that $g = \frac{4\pi^2 x}{T_2^2 - T_1^2}$.

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7. Two simple pendulums of length 0.24 m and 0.25 m respectively hang vertically, one in front of the other. If they are set in motion simultaneously, find the time taken for one to gain a complete oscillation on the other. $g = 9.81 m \cdot s^{-2}$

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8. If a mass of 10 g is hung from a suspended spring, it elongates by 2mm. If the spring is pulled a little downwards and then released, what will be the frequency of vibration of the spring?

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9. In a U-tube of diameter 1.4 cm, 837 g mercury is poured. If the density the time period of vertical oscillation of the mercury column.

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10. A wooden block of cross sectional area $10cm^2$ remains floating upright in water. The volume of the immersed part of the block is $200cm^3$. If the block is depressed slightly and then released, determine the time period of its oscillation.

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11. A mass M is hung from one end of an elastic thread. When the mass is pulled downwards slightly and released, it performs vertical oscillations. If an additional mass m is attached to the mass M, then the time period of the SHM changes in the ratio 5 : 4. Determine the ratio between m and M.

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12. To one end of a massless spring, a body of mass m is attached. Now the spring is divided into two equal parts and to one of the parts the same body of mass m is attached. Determine the ratio of the frequencies of vibration in the two cases.

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13. A point mass is subjected to two simultaneous sinusoidal displacement in x direction, $x_1(t) = A\sin\omega t$ and $x_2(t) = A\sin\left(\omega t + \frac{2\pi}{3}\right)$.

Adding a third sinusoidal displacement $x_3(t) = B\sin(\omega t + \phi)$ brings the mass to a complete rest. Find the values of B and ϕ.

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14. When a person of mass 60 kg gets into a car, the centre of gravity of the car descends by 0.3 cm. If the mass of the car is 1000 kg, then determine the frequency of vibration of the empty car.

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15. A mass of 0.5 kg is suspended with the help of a rubber cord of length 40 cm and radius 1 mm. If the Young's modulus of rubber is 0.3$kg \cdot mm^{-2}$, then determine the time period of vertical oscillation of the mass.

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16. When a spring is pulled with a force of 5×10^5 dyn, it elongates by 0.1 m. What mass should be attached to the end of the spring so that when pulled a little downwards and released, the mass can perform 2 complete oscillations per second? What will be the maximum velocity of the mass when the amplitude of vibration is 0.01 m?

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17. Two light springs of force constants k_1 and k_2 are connected one after another and suspended from a rigid support. A body of mass m is hung from the free end of the spring system. Determine the time period of vertical oscillation of the body.

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18. A small sphere is placed inside a concave glass vessel kept on a horizontal table. The radius of curvature of the concave vessel is 1.09 m. If the small sphere is displaced slightly from its position of equilibrium and then released, what will be the time period of the simple harmonic motion that the sphere would execute? $g = 9.81 m \cdot s^{-2}$

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19. A simple pendulum is formed by hanging a sphere of mass of 1 kg from a copper wire of length 5 m and of diameter, 0.08 cm and then the time period of this pendulum is measured. Now the sphere of mass 1 kg is replaced by another sphere of mass 10 kg. Determine the change in time period of the pendulum. [Y for copper = $12.4 \times 10^{10} N \cdot m^{-2}$]

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20. A mass attached to a spring is free to oscillate, with angular velocity ω, in a horizontal plane without friction or damping. It is pulled to a distance x_0 and pushed towards the centre with a velocity v_0 at time t = 0. Determine the amplitude of the resulting oscillations in terms of the parameters ω, x_0 and v_0. Hint : Start with the equation $x = a\cos(\omega t + \theta)$ and note that the initial velocity is negative.

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21. 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.

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22. A 0.1 kg mass is suspended from a wire of negligible mass. The length of the wire is 1m and its cross-sectional area is $4.9 \times 10^{-7} m^2$. If the mass is pulled a little in the vertically downward direction and released, it performs simple harmonic motion of angular frequency 140rad/s. If the Young's modulus of the material of the wire is $n \times 10^9 N \cdot m^{-2}$, then find out the value of n.

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Assertion Reason Type

1. Statement I : The total energy of a particle performing simple harmonic motion could be negative.

Statement II : Potential energy of a system could be negative.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: A

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2. Statement I : The spring constant of a spring is k. When it is divided into n equal parts, then spring constant of each piece is k/n.

Statement II : The spring constant is independent of material used for the spring.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: D

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3. Statement I : A particle performs a simple harmonic motion with amplitude A and angular frequency ω. To change the angular frequency of the simple harmonic motion to 3ω and amplitude to $\frac{A}{2}$, we have to supply an extra energy of $\left(\frac{5}{4}\right)m\omega^2A^2$, where m is the mass of the particle executing simple harmonic motion.

Statement II : Angular frequency of simple harmonic motion is independent of amplitude of oscillation.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: D

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Multiple Correct Answer Type

1. The displacement-time relation for a particle can be expressed as $x = 0.5\left[\cos^2(n\pi t) - \sin^2(n\pi t)\right]$. This relation shows that

A. the particle execute SHM with amplitude 0.5 m

B. the particle execute SHM with a frequency n times that of a second pendulum

C. the particle executes SHM and the velocity in its mean position is $(3.142n)m \cdot s^{-1}$

D. the particle does not execute SHM at all.

Answer: A::C

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2. The function, $x = A\sin^2\omega t + B\cos^2\omega t + C\sin\omega t\cos\omega t$ represents SHM

A. for any value of A, B and C (except C = 0)

B. if A = - B, C = 2B, amplitude = $\left|B\sqrt{2}\right|$

C. if A = B, C = 0

D. if A = B , C = 2B, amplitude = |B|

Answer: B::D

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3. Choose the correct statement (s).

A. The time period of spring-mass system will change when it is made to oscillate horizontally and vertically.

B. Natural frequency depends upon elastic properties and diamensions of the body.

C. At mean position, the energy is entirely KE and at extreme positions, the energy is entirely potential.

D. A pendulum having time period 2 seconds is called a second's pendulum.

Answer: B::C::D

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4. A rectangular block of mass m and area of cross-section A floats in a liquid of density ρ. If it is given a small vertical displacement from equilibrium, it undergoes oscillation with a time period T.

A. $T \propto \sqrt{m}$

B. $T \propto \sqrt{\rho}$

C. $T \propto \frac{1}{\sqrt{A}}$

D. $T \propto \frac{1}{\sqrt{\rho}}$

Answer: A::C::D

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5. 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 kinetic energy is 160 J

C. maximum potential energy is 100 J

D. maximum potential energy is 0

Answer: A::B

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6. 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

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 $t = \frac{5\pi}{3}\sqrt{\frac{m}{k}}$

Answer: A::D

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Comprehension Type

1. A particle suspended from a vertical spring oscillates 10 times per second. At the highest point of oscillation, the spring becomes unstretched. Take $g = \pi^2 m \cdot s^{-2}$ The maximum speed of the particle is

A. $5\pi cm \cdot s^{-1}$

B. $4\pi cm \cdot s^{-1}$

C. $3\pi cm \cdot s^{-1}$

D. $2\pi cm \cdot s^{-1}$

Answer: A

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2. A particle suspended from a vertical spring oscillates 10 times per second. At the highest point of oscillation, the spring becomes unstretched. Take $g = \pi^2 m \cdot s^{-2}$ The speed of the particle when the spring is stretched by 0.2 cm is

A. $15.4 cm \cdot s^{-1}$

B. $12.8 cm \cdot s^{-1}$

C. $10.8 cm \cdot s^{-1}$

D. $11.4 cm \cdot s^{-1}$

Answer: A

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3. A man has an antique pendulum clock of 1832 which bears the signature of the purchaser. He does not want to replace it in the fond memory of his great-grandparents. It ticks off one second in each side to side swing. It keeps correct time at $20^{\circ} C$. The pendulum shaft is made of steel and its mass can be ignored as compared to the mass of the bob. Linear expansion coefficient of steel is $1.2 \times 10^{-5 \circ} C^{-1}$ What is the fractional change in length if the shaft is cooled to $10^{\circ} C$?

A. 0.0001

B. $1.2 \times 10^{-2} \%$

C. $1.2 \times 10^{-3} \%$

D. $1.2 \times 10^{-4}\%$

Answer: B

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4. A man has an antique pendulum clock of 1832 which bears the signature of the purchaser. He does not want to replace it in the fond memory of his great-grandparents. It ticks off one second in each side to side swing. It keeps correct time at $20^{\circ}C$. The pendulum shaft is made of steel and its mass can be ignored as compared to the mass of the bob. Linear expansion coefficient of steel is $1.2 \times 10^{-5} {}^{\circ}C^{-1}$

How many seconds will the clock gain or lose in a day at $10^{\circ} C$?

A. gains 5.2 s

B. loses 5.2 s

C. gains 10.4 s

D. loses 10.4 s

Answer: A

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5. A man has an antique pendulum clock of 1832 which bears the signature of the purchaser. He does not want to replace it in the fond memory of his great-grandparents. It ticks off one second in each side to side swing. It keeps correct time at $20^{\circ} C$. The pendulum shaft is made of steel and its mass can be ignored as compared to the mass of the bob. Linear expansion coefficient of steel is $1.2 \times 10^{-5} {}^{\circ} C^{-1}$

How closely must the temperature be controlled so that it does not gain or lose more than a second in a day?

A. $\pm 0.2^{\circ} C$

B. $\pm 0.1^{\circ} C$

C. $\pm 1^{\circ} C$

D. $\pm 2^{\circ} C$

Answer: D

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6. A man has an antique pendulum clock of 1832 which bears the signature of the purchaser. He does not want to replace it in the fond memory of his great-grandparents. It ticks off one second in each side to side swing. It keeps correct time at $20^\circ C$. The pendulum shaft is made of steel and its mass can be ignored as compared to the mass of the bob. Linear expansion coefficient of steel is $1.2 \times 10^{-5} {}^\circ C^{-1}$

The pendulum mentioned in the paragraph is called ______ and its time period is ________.

A. seconds pendulum, 1s

B. seconds pendulum, 2s

C. 2 second pendulum, 2s

D. none

Answer: B

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Integer Answer Type

1. If the displacement (x) and velocity (v) of a particle executing SHM are related through the expression

$4v^2 = 25 - x^2$, what should be the value of (T/π)? [T is the time period (in second) of the SHM.]

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2. Starting from the origin, a body oscillates simple harmonically with a period of 2s. After a certain time (t) its kinetic energy will be 75% of the total energy. What should be the value of $\frac{1}{t}\left(\text{in } s^{-1}\right)$?

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3. A particle executing SHM can be expressed by the equation $x = 3\cos\omega t + 4\sin\omega t$. Find the amplitude of resultant SHM.

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4. Two pendulums of lengths 100 cm and 225 cm start oscillating in phase simultaneously. After how many oscillations will they again be in phase together ?

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5. At a certain temperature the pendulum of a clock keeps correct time. The coefficient of linear expansion for the pendulum material = $1.85 \times 10^{-5} K^{-1}$. How much will the clock gain or lose in 24 h if the ambient temperature is $10^{\circ} C$ higher?

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Wbchse

1. The kinetic energy (K) and potential energy (V) of a particle performing a simple harmonic motion are such that, always

A. $K > V$

B. $K < V$

C. K = V

D. K + V = constant

Answer: D

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2. A particle situated in a homogenous medium performs a simple harmonic oscillation of amplitude 3 cm and frequency 25 Hz. The velocity of the waves generated is $300 cm \cdot s^{-1}$. Find the equation of the waves propagating in the positive direction of x-axis.

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3. Show that the equation $x = a\cos^2 \omega t$ represents a simple harmonic motion. Find the (i) amplitude, (ii) time period and (iii) position of equilibrium of the particle.

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4. Can simple pendulum experiment be performed inside a satellite?

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5. The earth is revolving round the sun. Is it an example of a simple harmonic motion? Explain.

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6. A particle executes simple harmonic motion of amplitude A. The distance from the mean position where its kinetic energy is equal to its potential energy, is

A. 0.81 A

B. 0.71 A

C. 0.61 A

D. 0.51 A

Answer: B

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7. What is the displacement of a particle in SHM from its equilibrium position when its KE is half of its maximum kinetic energy?

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8. Show that the equation $x = a \sin \omega t + b \cos \omega t$ represents a simple harmonic motion.

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9. The equation of motion of a particle executing SHM is $x = a\sin\left(\omega t + \frac{\pi}{6}\right)$ with time period T. Find the time interval at which the velocity is being half of its maximum value.

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10. If the displacement and the restoring force acting on a particle executing simple harmonic motion are x and F respectively, then F = -kx. Here the negative sign on the right hand side indicates that

A. the restoring force is directed towards the equilibrium position

B. the restoring force is directly proportional to the displacement

C. the force constant is always negative

D. the restoring force is always negative

Answer: A

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11. What should be the displacement of a particle executing SHM so that its KE is equal to its PE?

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12. Show that in SHM the ratio of acceleration and displacement of a particle always remains unchanged.

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13. A particle executes a simple harmonic motion with frequency f. The frequency at which the kinetic energy of the particle changes is

A. $\frac{f}{2}$

B. f

C. 2f

D. 4f

Answer: C

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14. Show that the equation $x = a \sin \omega t + b \cos \omega t$ represents a simple harmonic motion.

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Wbjee

1. When a particle executing SHM oscillates with a frequency ν, then the kinetic energy of the particle

A. changes periodically with frequency ν

B. changes periodically with frequency 2ν

C. changes periodically with frequency $\frac{\nu}{2}$

D. remains constant

Answer: B

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2. A simple pendulum of length L swings in a vertical plane. The tension of the string when it makes an angle θ with the vertical and the bob of mass m moves with a speed v is (g is the gravitational acceleration)

A. mv^2/L

B. $mg\cos\theta + mv^2/L$

C. $mg\cos\theta - mv^2/L$

D. $mg\cos\theta$

Answer: B

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3. A particle vibrating simple harmonically has an acceleration of $16cm \cdot s^{-2}$ when it is at a distance of 4 cm from the mean position. Its time period is

A. 1 s

B. 2.572 s

C. 3.142 s

D. 6.028 s

Answer: C

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4. The velocity of a particle executing a simple harmonic motion is $13m \cdot s^{-1}$, when its distance from the equilibrium position (Q) is 3 m and its velocity is $12m \cdot s^{-1}$, when it is 5 m away from Q. The frequency of the simple harmonic motion is

A. $\frac{5\pi}{8}$

B. $\frac{5}{8\pi}$

C. $\frac{8\pi}{5}$

D. $\frac{8}{5\pi}$

Answer: B

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5. In case of a simple harmonic motion, if the velocity is plotted along the X-axis and the displacement (from the equilibrium position) is plotted along the Y-axis, the resultant curve happens to be an ellipse with the ratio

$$\frac{\text{major axis (along X)}}{\text{minor axis (along Y)}} = 20\pi$$

What is the frequency of the simple harmonic motion?

A. 100 Hz

B. 20 Hz

C. 10 Hz

D. $\frac{1}{10}$ Hz

Answer: C

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Jee Main

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

A. amplitude of motion is 3a

B. time period of oscillations is 8τ

C. amplitude of motion is 4a

D. time period of oscillation is 6τ

Answer: D

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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 frawn to scale)

A.

B.

C.

D.

Answer: B

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3. A pendulum made of a uniform wire of cross-sectional area A has time period T. When an additional mass M is added to its bob, the time period changes to T_M. If the Young's modulus of the material of the wire is Y, then $\frac{1}{Y}$ is equal to

(g = gravitational acceleration)

A. $\left[\left(\frac{T_M}{T}\right)^2 - 1\right]\frac{A}{Mg}$

B. $\left[\left(\frac{T_M}{T}\right)^2 - 1\right]\frac{Mg}{A}$

C. $\left[1 - \left(\frac{T_M}{T}\right)^2\right]\frac{A}{Mg}$

D. $\left[1 - \left(\frac{T}{T_M}\right)^2\right]\frac{A}{Mg}$

Answer: A

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4. A particle performs simple harmonic motion with amplitude A. Its speed is trebled at the instant that it is at a distance $\frac{2A}{3}$ from equilibrium position. The new amplitude of the motion is

A. $\frac{A}{3}\sqrt{41}$

B. $3A$

C. $A\sqrt{3}$

D. $\frac{7A}{3}$

Answer: D

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5. A particle is executing simple harmonic motion with a time period T. At time t = 0, it is at its position of equilibrium. The kinetic energy-time graph of the particle will lock like.

A.

B.

C.

D.

Answer: D

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6. A silver atom in a solid oscillates in simple harmonic motion in some direction with a frequency of $10^{12} s^{-1}$. What is the force constant of the bonds connecting one atom with the other? (Mole wt. of Silver = 108 and Avogadro number = $6.02 \times 10^{23} g \cdot mol^{-1}$)

A. 2.2 N/m

B. 5.5 N/m

C. 6.4 N/m

D. 7.1 N/m

Answer: D

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1. The oscillation of a body on a smooth horizontal surface is represented by the equation, $x = A\cos\omega t$, where x = displacement at time t, ω = frequency of oscillation.

Which one of the following graphs shows correctly the variation a with t ?

Here, a = acceleration at time t and T = time period.

A.

B.

C.

D.

Answer: C

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2. Two similar springs P and Q have spring constants K_P and K_Q, such that $K_P > K_Q$. They are stretched, first by the same amount (case a), then by the same force (case b). The work done by the springs W_P and W_Q are related as, in case (a) and case (b), respectively

A. $W_P = W_Q, W_P > W_Q$

B. $W_P = W_Q, W_P = W_Q$

C. $W_P > W_Q, W_Q > W_P$

D. $W_P < W_Q, W_Q < W_P$

Answer: C

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3. When two displacements represented by $y_1 = a\sin(\omega t)$ and $y_2 = b\cos(\omega t)$ are superimposed, the motion is

A. not a simple harmonic

B. simple harmonic with amplitude $\frac{a}{b}$

C. simple harmonic with amplitude $\sqrt{a^2 + b^2}$

D. simple harmonic with amplitude $\frac{(a+b)}{2}$

Answer: C

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4. A particle is executing SHM along a straight line. Its velocities at distances x_1 and x_2 from the mean position are V_1 and V_2, respectively. Its time period is

A. $2\pi\sqrt{\dfrac{x_1^2+x_2^2}{V_1^2+V_2^2}}$

B. $2\pi\sqrt{\dfrac{x_1^2-x_2^2}{V_1^2-V_2^2}}$

C. $2\pi\sqrt{\dfrac{V_1^2+V_2^2}{x_1^2+x_2^2}}$

D. $2\pi\sqrt{\dfrac{V_1^2-V_2^2}{x_1^2-x_2^2}}$

Answer: B

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Neet

1. A particle moves so that its position vector is given by $\overrightarrow{r} = \cos \omega t \widehat{x} + \sin \omega t \hat{y}$, where ω is a constant. Which of the following is true?

A. Velocity and acceleration both are paralled to $\overrightarrow{r}$

B. Velocity is perpendicular to $\overrightarrow{r}$ and acceleration is directed towards the origin

C. Velocity is perpendicular to $\vec{r}$ and acceleration is directed away from the origin

D. Velocity and acceleration both are perpendicular to $\vec{r}$

Answer: B

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2. A pendulum is hung from the roof of a sufficiently high building and is moving freely to and fro like a simple harmonic oscillator. The acceleration of the bob of the pendulum is $20m/s^2$ at a distance of 5 m from the mean position. The time period of oscillation is

A. 2s

B. πs

C. $2\pi s$

D. 1s

Answer: B

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1. Explain the relation in phase between displacement velocity and acceleration in SHM, graphically as well as theoretically.

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2. A particle is in linear simple harmonic motion between two points A and B, 10 cm apart. Take the direction from A to B, as positive direction and give the signs of velocity and acceleration on the particle when it is (i) at the end B, (ii) at 3 cm away from A going towards B.

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3. Time period of a particle in SHM depends on the force constant k and mass m of the particle as follows:

$$T = 2\pi\sqrt{\frac{m}{k}}.$$

A simple pendulum executes SHM approximately, why then is the time period of a simple pendulum independent of the mass of the pendulum?

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4. One end of U-tube containing mercury is connected to a suction pump and the other end to atmosphere. A small pressure difference is maintained between the two columns. Show that, when the suction pump is removed, the column of mercury in the U-tube executes simple harmonic motion.

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5. A simple harmonic motion is described by a = -16x where a is acceleration and x is the displacement in meter. What is the time period?

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6. Derive an expression for the total energy of a particle undergoing simple harmonic motion.

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7. For a particle executing simple harmonic motion, find the distance from the mean position at which its potential and kinetic energies are equal.

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8. Write the phase difference between the velocity and acceleration of a particle undergoing a simple harmonic motion.

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9. A simple pendulum of length l and having a bob of mass M is suspended in a car. The car is moving on a circular track of radius R with a uniform speed V. If the pendulum makes small oscillation in a radial direction about its equilibrium position, what will be its time period?

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10. What will be the change in time period of a loaded spring, when taken to moon?

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11. Find the expression for kinetic energy, potential energy and total energy in simple harmonic motion. Show the variation of kinetic energy, potential energy

and total energy with (i) time and (ii) displacement graphically.

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12. How will the time period of a simple pendulum change when its length is doubled?

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13. Two identical springs of spring constant k are attached to a black of mass m and to fixed supports in the Fig. 1.45. Show that the mass executes simple harmonic motion when displaced from its rest position on either side.

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14. $y(t) = (\sin \omega t - \cos \omega t)$ represents simple harmonic motion, determine the period of SHM.

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15. Derive an expression for the time period and frequency of a simple pendulum.

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16. At what displacement (i) the PE and (ii) KE of a simple harmonic oscillator is maximum?

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