1. The object moves on the x-axis under a conservative force in such a way that its speed and position satisfy $v = c_1\sqrt{c_2 - x^2}$ where c_1 and c_2 are positive constants.

   (A) The object executes S.H.M

   (B) The object does not change its direction

   (C) The kinetic energy of the object keeps on decreasing

   (D) The object can change its direction only once

2. The object moves on the x-axis in such a way that its velocity and displacement from the origin satisfy v = -kx where k is appositive constant

   (A) The object executes S.H.M

   (B) The object does not change its direction

   (C) The kinetic energy of the object keeps on decreasing

   (D) The object can change its direction only once

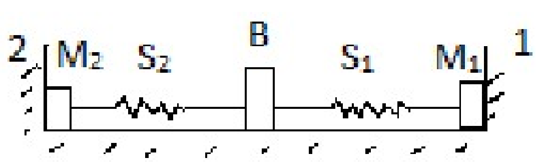
3. The object is attached to one end of a massless spring of a given spring constant. The other end of the spring is attached to the ceiling of an elevator. Initially everything is at rest. The elevator starts going upwards with constant acceleration 'a'. The motion of the object is observed from the elevator during the period it maintains this acceleration.

   (A) The object executes S.H.M

   (B) The object does not change its direction

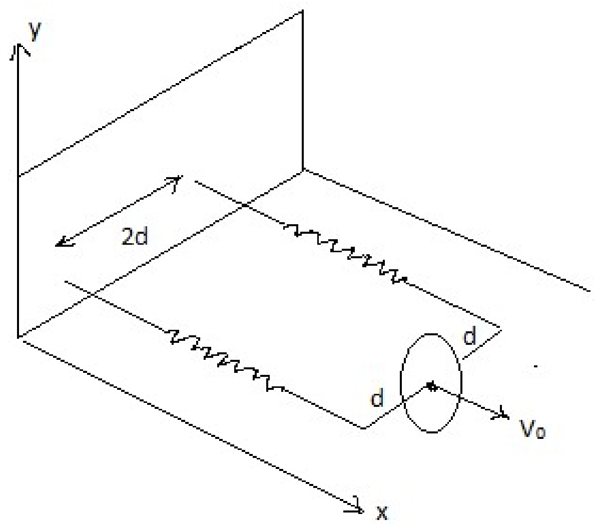
   (C) The kinetic energy of the object keeps on decreasing

   (D) The object can change its direction only once

4. 

The block B is attached to two unstretched springs S_1 and S_2 of spring constants k and 4k respectively. The other ends are attached to identical supports M_1 and M_2 not attached to the walls. The springs and the supports have negligible mass. There is no friction anywhere. The block B is displaced towards the wall 1 by a small distance x and released. The block returns and moves a maximum distance y towards the wall 2. Displacements x and y are measured with respect to the equilibrium position of the block B. Ratio y: x is

(A) 4 (B) 2 *(C) ½ (D) 1/4



5. A uniform thin cylindrical disc of mass m and radius R is attached to identical massless springs of constant k which are fixed to the wall as shown. The springs are attached to the axle of the disc symmetrically on either side at a distance d from its centre. The axle is massless and both the springs and the axle are in the horizontal plane. The unstretched length of each spring is L. The disc is initially in equilibrium with its centre of mass at a distance L from the wall. The disc rolls without slipping with a velocity $V_0\hat{i}$. The coefficient of friction is μ.

(I) the net external force on the disc when its centre of mass is at a displacement x from its equilibrium position is

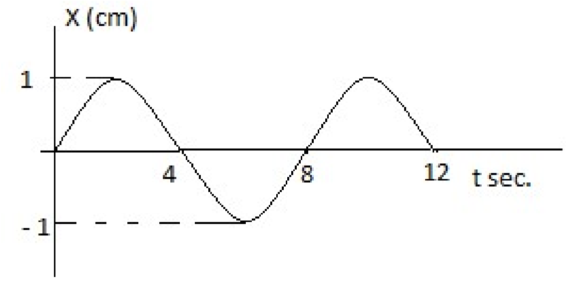
(A) – Kx (B) – 2kx (C) – 2kx/3 *(D) – 4kx/3

(II) The centre of mass of the disc undergoes S.H.M with angular frequency ω =

(A) $\sqrt{\frac{k}{m}}$ (B) $\sqrt{\frac{2k}{m}}$ (C) $\sqrt{\frac{2k}{3m}}$ *(D) $\sqrt{\frac{4k}{3m}}$

(III) The maximum value of V_0 for which the disc will roll without slipping is

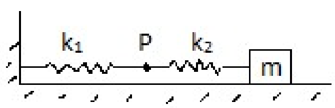
(A) $\mu g\sqrt{\frac{m}{k}}$ (B) $\mu g\sqrt{\frac{m}{2k}}$ *(C) $\mu g\sqrt{\frac{3m}{k}}$ (D) $\mu g\sqrt{\frac{5m}{2k}}$



6. The x-t graph of a particle undergoing S.H.M is shown below. The acceleration of the particle at t = 4/3 sec is

(A) $(\sqrt{3}/32)\pi^2$ cm/s^2 (B) $-\pi^2/32$ cm/s^2

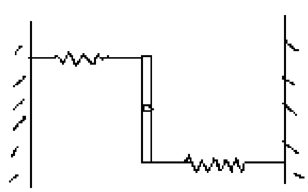
(C) $\pi^2/32$ cm/s^2 *(D) $-(\sqrt{3}/32)\pi^2$ cm/s^2



7. The mass m shown in the figure oscillates in S.H.M with amplitude A. The amplitude of the point P is

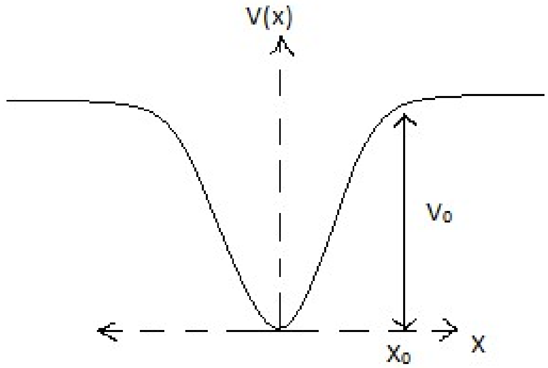
(A) k_1A/k_2 (B) k_2A/k_1

(C) $k_1A/(k_1 + k_2)$ *(D) $k_2A/(k_1 + k_2)$



8. A uniform rod of mass m and length L is pivoted at the centre. Its two ends are attached to two identical springs of constant k. The springs are fixed to two rigid supports and the rod is free to oscillate in the horizontal plane. The rod is gently pushed through a small angle θ on one side and released. The frequency of oscillation is

(A) $\frac{1}{2\pi}\sqrt{\frac{2k}{m}}$ (B) $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$ *(C) $\frac{1}{2\pi}\sqrt{\frac{6k}{m}}$ (D) $\frac{1}{2\pi}\sqrt{\frac{24k}{m}}$

9. 

When a particle of mass m moves on the x-axis in a potential of the form $V(x) = kx^2$ it performs S.H.M. The corresponding time period is proportional to $\sqrt{\frac{m}{k}}$ as can be seen using dimensional analysis. However the motion of the particle can be periodic even when its potential energy increases on both sides of $x = 0$ in a way different from kx^2 and its total energy is such that the particle does not escape to infinity. Consider a particle of mass m moving on the x-axis. Its potential energy is $V(x) = \alpha x^4$ ($\alpha > 0$) for $|x|$ near the origin and becomes a constant V_0 for $|x|$ greater than or equal to X_0 as shown.

(I) If the total energy of the particle is E, it will perform periodic motion only if

(A) $E < 0$ (B) $E > 0$ *(C) $V_0 > E > 0$ (D) $E > V_0$

(II) For periodic motion of small amplitude A the time period T of this particle is proportional to

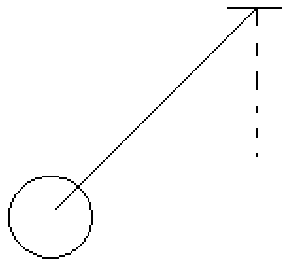
(A) $A\sqrt{(m/\alpha)}$ *(B) $(1/A)\sqrt{(m/\alpha)}$

(C) $A\sqrt{(\alpha/m)}$ (D) $(1/A)\sqrt{(\alpha/m)}$

(III) The acceleration of the particle for $|x| > X_0$ is

(A) Proportional to V_0 (B) proportional to V_0/mX_0

(C) Proportional to $\sqrt{(V_0/mX_0)}$ *(D) zero

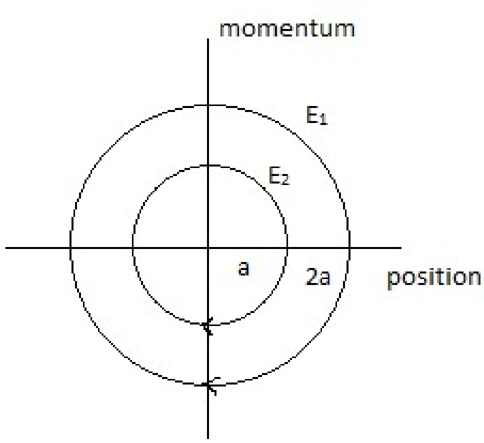
10.  A metal rod of length L and mass m is pivoted at one end. A thin disc of mass M and radius R < L is attached at its centre to the free end of the rod. Consider two ways the disc is attached. Case (a) the disc is not free to rotate about its centre Case (b) the disc is free to rotate about its centre. The rod disc system performs S.H.M in the vertical plane after being released from the same displaced position. Which of the following statements is/are true?

*(A) Restoring torque in case (a) = restoring torque in case (b)

(B) Restoring torque in case (a) < restoring torque in case (b)

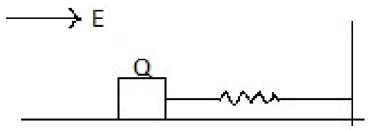
*(C) Angular frequency for case (a) > angular frequency for case (b)

(D) Angular frequency for case (a) < angular frequency for case (b)

11. 

The phase space diagram for S.H.M is a circle centred at the origin. In the figure the two circles represent the same oscillator but for different initial conditions, and E_1 and E_2 are the total mechanical energies respectively. Then,

(A) $E_1 = E_2\sqrt{2}$ (B) $E_1 = 2E_2$ *(C) $E_1 = 4E_2$ (D) $E_1 = 16E_2$

12. 

A wooden block performs S.H.M on a smooth surface with frequency f_0. The block carries a charge Q on its surface. If a uniform electric field E is now switched on, the S.H.M of the block will now be

*(A) of the same frequency with shifted mean position.

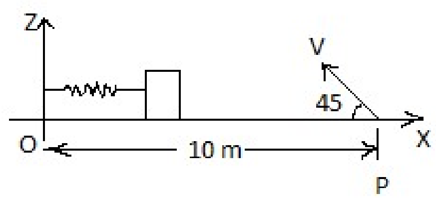
(B) Of the same frequency and same mean position

(C) Of changed frequency and shifted mean position

(D) Of changed frequency and same mean position

13. A point mass is subjected to two S.H.M's in the x-direction.
$X_1(t) = A\sin(\omega t)$ and $X_2(t) = A\sin(\omega t + 2\pi/3)$ Adding a third S.H.M with displacement $X_3(t) = B\sin(\omega t + \theta)$ brings the mass to a complete rest. The values of B and θ are

(A) $A\sqrt{2}, 3\pi/4$ *(B) $A, 4\pi/3$ (C) $A\sqrt{3}, 5\pi/6$ (D) $A, \pi/3$

14. 

A small block is connected to one end of a massless spring of unstretched length 4.9 m. The other end of the spring is fixed. The system lies on a frictionless horizontal surface. The spring is stretched by 0.2 m and released from rest at t = 0. It then executes S.H.M of angular frequency π/3 rad/sec. simultaneously at t = 0 a pebble is projected with speed v from the point P at an angle of 45^0 as shown. Point P is at a horizontal distance of 10 m from O. If the pebble hits the block at t = 1 sec then the value of v in m/s is ($g = 10\ ms^2$)

*(A) $\sqrt{50}$ (B) $\sqrt{51}$ (C) $\sqrt{52}$ (D) $\sqrt{53}$

15. The amplitude of a damped oscillator decreases to 0.9 times its original magnitude in 5 s. In another 10 s it decreases to α times its original magnitude, where αequals

(A) 0.7 (B) 0.81 *(C) 0.729 (D) 0.6

(For damped oscillations $A = A_0 e^{-kt}$ where t is the time and k is the damping constant.)

16. A particle executing S.H.M in a straight line moves a distance ‘a’ in the first t sec starting from rest and in the next t sec it travels a distance ‘2a’ in the same direction. Then

(A) Amplitude of motion is 4a

*(B) time period of oscillation is 6t

(C) Amplitude of motion is 3a

(D) time period of oscillation is 8t

17. A particle is performing S.H.M with amplitude A. Its speed is tripled at the instant it is at a distance 2A/3 from the equilibrium position. The new amplitude of motion is

(A) $(A/3)\sqrt{41}$ (B) 3A (C) $A\sqrt{3}$ *(D) 7A/3

18. A pendulum made of a uniform wire of cross sectional area A has a 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 the value of 1/Y is (take acceleration due to gravity as g)

*(A) $\left[\left(\frac{T_m}{T}\right)^2 - 1\right]\left(\frac{A}{mg}\right)$

(B) $\left[\left(\frac{T_m}{T}\right)^2 - 1\right]\left(\frac{mg}{A}\right)$

(C) $\left[1 - \left(\frac{T_m}{T}\right)^2\right]\left(\frac{A}{mg}\right)$

(D) $\left[1 - \left(\frac{T}{T_m}\right)^2\right]\left(\frac{A}{mg}\right)$