PHYSICS

BOOKS - HC VERMA PHYSICS (ENGLISH)

SIMPLE HARMONIC MOTION

Example

1. The resultant force acting on a particle executing simple harmonic motion is 4N when it is 5cm away from the centre of oscillation. Find the spring constant.

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2. A particle of mass 0.50 kg executes a simple harmonic motion under a force $F = -(50Nm^{-1})x$. If it crosses the centre of oscillation with a speed of $10ms^{-1}$, find the amplitude of the motion.

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3. A particle of mass $200g$ executes a simple harmonic motion. The restoring force is provided by a spring of spring constant $80N/m$. Find the time period.

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4. A particle executes simple harmonic motion of amplitude A along the X-axis. At t=0 the position of the particle is $x = \frac{A}{2}$ and it moves along the positive x-direction. Find the phase constant δ if the equation is written as $x = A\sin(\omega t + \delta)$

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5. A particle of mass 40 g executes a simple harmonic motion of amplitude 2.0 cm. If the time period is 0.20 s, find the total mechanical energy of the system.

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6. A body makes angular simple harmonic motion of amplitude $\frac{\pi}{10} rad$ and time period 0.5s. If the body is at a displacement $\theta = \frac{\pi}{10}$ rad at t=0, write the equation giving the angular displacement as a function of time.

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7. Calculate the time period of a simple pendulum of length one meter. The acceleration due to gravity at the place is $\pi^2 ms^{-2}$.

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8. In a laboratory experiment with simple pendulum it was found it took 36 s to complete

20 oscillations when the effective length was kept that 80 cm. Calculate the acceleration due to gravity from these data.

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9. A uniform rod of length 1.00 m is suspended through an end and is set into oscillation with small amplitude under gravity. Find the time period of oscillation.

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10. A uniform disc of radius 5.0 cm and mass 200g is fixed at its centre to a metal wire, the other end of which is fixed with a clamp. The hanging disc is rotated about the wire through an angle and is released. If the disc makes torsional oscillations with time period 0.20s, find the torsional constant of the wire.

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11. Find the amplitude of the simple harmonic motion obtasined by combining the motions

$x_1 = (2.0cm)\sin\omega t$

and $x_2 = (2.0cm)\sin\left(\omega t + \frac{\pi}{3}\right)$

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Worked Out Examples

1. The equation of a particle executing simple harmonic motion is $x = (5m)\sin\left[\left(\pi s^{-1}\right)t + \frac{\pi}{3}\right]$. Write down the amplitude time period and maximum speed. Also find the velocity at t=1s.

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2. A block of mass 5 kg executes simple harmonic motion under the restoring force of a spring. The amplitude and the time period of the motion are 0.1 m and 3.14 s respectively. Find the maximum force exerted by the spring on the block.

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3. A particle executing simple harmonic motion has angular frequency $6.28s^{-1}$ and amplitude $10cm$. Find (a) the time period, (b) the maximum speed, (c) the maximum acceleration, (d) the speed when the displacement is $6cm$ from the mean position, (e) the speed at $t = 1/6s$ assuming that the motion starts from rest at $t = 0$.

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4. A particle executes a simple harmonic motion of time period T. Find the time taken by the particle to go directly from its mean position to half the amplitude.

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5. A block of mass m hangs from a vertical spring of spring constant k. If it is displaced from its equilibrium position, find the time period of oscillations.

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6. A particle suspended from a vertical spring oscillates 10 times per second. At the highest point of oscillation the spring becomes unstretched. A. Find the maximum speed of the block. B. Find the speed when the spring is stretched by 0.20 cm. Take $g = \pi^2 ms^{-2}$

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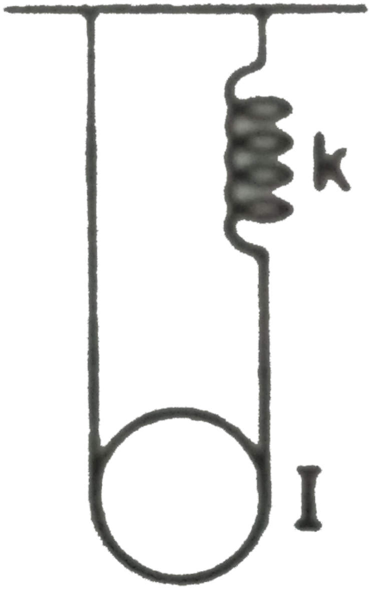
7. The pulley shown in figure has a moment of inertias I about its axis and mass m. find the time period of vertical oscillation of its centre of mass. The spring has spring constant k and the string does not slip over the pulley.



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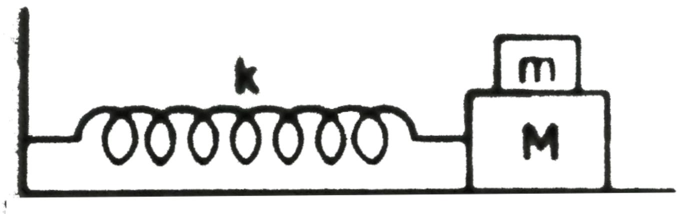
8. The friction coefficient between the two blocks shown in figure is μ and the horizontal plane is smooth. A. If the system is slightly diplaced and released find the time period. B. find the magnitude of the frictional force between the blocks when the displacement from the mean position is x. c. What can be the maximum amplitude if the upper block does not slip relative to the lower block?



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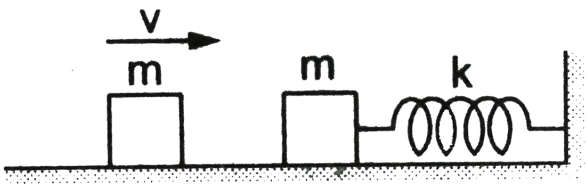
9. The left block in filgure collides inelastically with the right block and sticks to it. Find the amplitude of the resulting simple harmonic motion.



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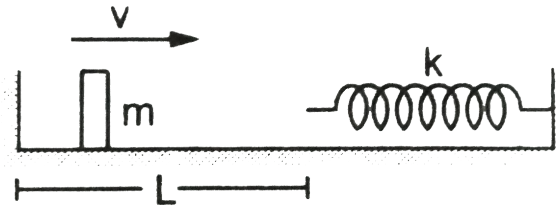
10. Describe the motion of the mass m shown in figure. The walls and the block are elastic.



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11. A block of mass m is suspended from the ceiling of a stationary standig elevator through a spring of spring constant k. Suddenly, the cable breaks and the elevator starts falling freely. Show that the bklock now executes a simple harmonic motion of amplitude $m\frac{g}{k}$ in the elevator

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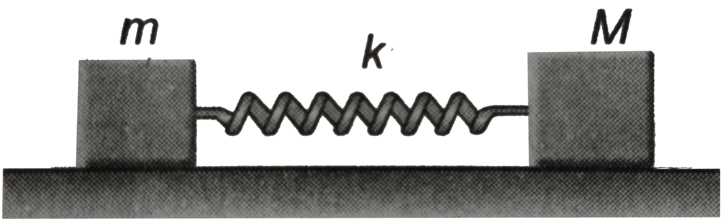
12. The spring as shown in figure is kept in a stretched position with extension Xo when the system is released. Assuming the horizontal surface to be frictionless, the frequency of oscillation is



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13. Assume that as narrow tunnel is dug between two diametrically opposite points of the earth. Treat the earth as a solid sphere of uniform density. Show that if a particle is released in this tunnel, it will execute a simple harmonic motion. Calculate the time period of this motion.

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14. A simple pendulum of length 40 cm oscillates with an angular amplitude of 0.04 rad. Find a. the time period b. the linear amplitude of the bob, c.

The speed of the bob when the string makes 0.02 rad with the vertical and d. the angular acceleration when the bob is in momentarily rest. Take $g = 10ms^{-2}$.

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15. A simple pendulum having a bob of mass m under goes small oscillations with amplitude θ_0 Find the tension in the string as a function of the angle made by the string with the vertical. When in this tension maximum, and when is it minimum?

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16. A simple pendulum is taken at a place where its separation from the earth's surface is equal to the radius of the earth. Calculate the time period of small oscillation if the length of the string is $1.0m$. Take $g = \pi^2 m / s^2$ at the surface of the earth.

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17. A simple pendulum is suspended from the ceiling a car accelerating uniformly on a horizontal road. If the acceleration is a_0 and the length of the pendulum is l, find the time period of small oscillations about the mean position.

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18. A uniform meter stick is suspended through a small pin hole at the 10 cm mark. Find the time period of small oscillation about the point of suspension.

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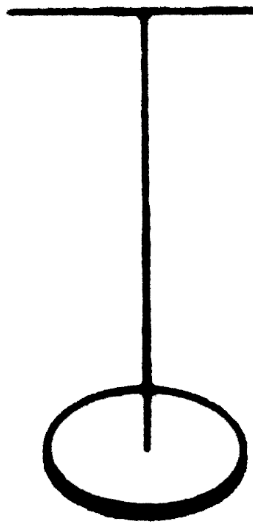
19. The moment of inertia of the disc used in a torsional pendulum about the suspension wire is $0.2kg - m^2$. It oscillates with a period of 2s. Asnother disc is placed over the first one and time period of the system becomes 2.5s. Find the moment of inertia of the second disc about the wire.



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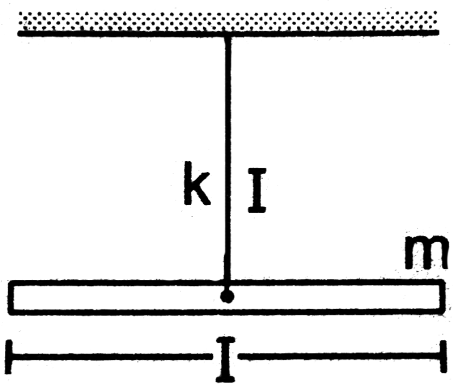
20. A uniform rod of mass m and length l is suspended through a light wire of length l and torsional constant k as shown in figure. Find the time perid iof the system makes a. small oscillations in the vertical plane about the suspension point and b. angular oscillations in the horizontal plane about the centre of the rod.



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21. A particle is subjected to two simple harmonic motions

$x_1 = A_1 \sin \omega t$

and $x_2 = A_2 \sin\left(\omega t + \frac{\pi}{3}\right)$

Find a the displacement at t=0, b. the maxmum speed of the particle and c. the maximum acceleration of the particle

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22. A particle is subjected to two simple harmonic motions in the same direction having equal amplitudes and equal frequency. If the resultant amplitude is equal to the amplitude of the individual motions, find the phase difference between the individual motions.

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Objective 1

1. A student says that he had applied a force $F = -k\sqrt{x}$ on a particle and the particle moved in simple harmonic motion. He refuses to tell whether k is a constant or not. Assume that he has worked only with positive x and no other force acted on the particle

A. As x increases k increaes

B. As x inceases k decreases

C. As x increases k remains constant

D. The motion cannot be simple harmonic

Answer: A

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2. A particle performing SHM takes time equal to T (time period of SHM) in consecutive appearances at a perticular point. This point is :

A. the mean position

B. an extreme position

C. between the mean position and the positie extreme

D. between the mean position and the negative extreme.

Answer: B

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3. A particle executing linear SHM. Its time period is equal to the smallest time interval in which paricle acquires a particular velcity $\vec{v}$, the magnitude of $\vec{v}$ may be :

A. $v_{\max}$

B. 0

C. between 0 and $v_{\max}$

D. between and 0 and $-v_{\max}$

Answer: A

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4. The displacement of a particle in simple harmonic motion in one time period is

A. A

B. 2A

C. 4A

D. zero

Answer: D

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5. The distance moved by a particle in simple harmonic motion in one time period is

A. A

B. 2A

C. 4A

D. zero

Answer: C

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6. The average acceleration in one time period in a simple harmonic motion is

A. $A\omega^2$

B. $A\frac{\omega^2}{2}$

C. $A\frac{\omega^2}{\sqrt{2}}$

D. zero

Answer: D

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7. The motion of a particle is given by $x = A \sin \omega t + B \cos \omega t$. The motion of the particle is

A. not simple harmonic

B. simple harmonic with amplitude $A + B$

C. simple harmonic with amplitude $\frac{A + B}{2}$

D. simple harminic with amplitude $\sqrt{A^2 + B^2}$

Answer: D

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8. The displacement of a particle is given by $\vec{r} = A\left(\vec{i}\cos\omega t + \vec{j}\sin\omega t\right)$. The motion of the particle is

A. simple harmonic

B. on a straight line

C. on a circle

D. with constant acceleration

Answer: C

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9. A particle moves on the X-axis according to the equation $x = A + B \sin \omega t$. Let motion is simple harmonic with amplitude

A. A

B. B

C. $A + B$

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

Answer: B

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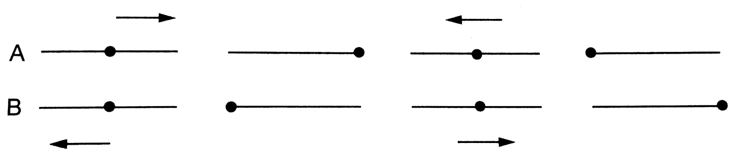
10. Figure represents two simple harmonic motions the parameter which has different value in the two motion is



A. amplitude

B. frequency

C. phase

D. maximum velocity

Answer: C

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11. The total mechanical energy of a spring mass system in simple harmonic motion is $E = \frac{1}{2}m\omega^2 A^2$. Suppose the oscillating particle is replaced by another particle of double the mass while the amplitude A remains the same. The new mechanical energy will

A. become $2E$

B. becoem $\frac{E}{2}$

C. becoem $\sqrt{2}E$

D. remain E

Answer: D

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12. The average energy in one time period in simple harmonic motion is

A. $\frac{1}{2}m\omega^2A^2$

B. $\frac{1}{4}m\omega^2 A^2$

C. $m\omega^2 A^2$

D. zero

Answer: A

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13. A particle executes simple harmonic motion with a frequency. (f). The frequency with which its kinetic energy oscillates is.

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

B. v

C. 2v

D. zero

Answer: C

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14. A particle executes simple harmonic motion under the restoring force provided by a spring. The time period is T. If the spring is divided in two equal parts and one part is used to continue the simple harmonic motion, the time period will

A. remain T

B. become 2T

C. become T/2

D. become $\frac{T}{\sqrt{2}}$

Answer: D

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15. Two bodies A and B of equal mass are suspended from two separate massless springs of spring constant k_1 and k_2 respectively. If the bodies Oscillate vertically such that their maximum velocities are equal, the ratio of the amplitude of A to that of B is

A. $\frac{k_1}{k_2}$

B. $\sqrt{\frac{k_1}{k_2}}$

C. $\frac{k_2}{k_1}$

D. $\sqrt{\frac{k_2}{k_1}}$

Answer: D

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16. A spring mass system oscillates with a frequency v. If it is taken in an elavator slowly accelerating upward, the frequency will

A. increases

B. decreases

C. remain same

D. become zero

Answer: C

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17. A spring mass system oscillates in a car. If the car accelerates on a horizontal road, the frequency of oscillation will

A. increases

B. decreases

C. remain same

D. become zero

Answer: C

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18. A pendulum clock that keeps the correct time on the earth is taken to the moon. It will run

A. at correct rate

B. 6 times faster

C. $\sqrt{6}$ times faster

D. $\sqrt{6}$ slower

Answer: D

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19. A wall clock uses a vertical spring mass system to measure the time. Each time the mass reaches an extreme position, the clock advances by a second. The clock gives correct time at the equator. If the clock is taken to the poles it will

A. run slow

B. run fast

C. stop working

D. give correct time

Answer: D

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20. A pendulum clock keeping correct time is taken to high altitudes

A. it will keep correct time

B. its length should be increased to keep correct time

C. its length should be decresed to keep correct time

D. it cannot keep correct time even if the length is changed

Answer: C

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21. The free end of a simple pendulum is attached to the ceiling of a box. The box is taken to a height and the pendulum is oscillated. When the bob is at its lowest point the box is released to fall freely. As seen from the box during this period the bob will

A. continue its oscillation as before

B. stop

C. will go in a circular path

D. move on a straight line

Answer: C

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Objective 2

1. Select the correct statements

A. A simple harmonic motion is necessarily periodic

B. a simple harmonic motion is necessarily oscillatory

C. an oscillatory motion is necessrily periodic

D. a periodic motion is necessarily oscillatory

Answer: A::B

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2. A particle moves in a circular path with a uniform speed. Its motion is

A. periodic

B. oscillatory

C. simple harmonic

D. angular simple harmonic

Answer: A

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3. A particle is fastened at the end of a string and whirled in a vertical circle with the other end of the string being fixed. The motion of the particle is

A. periodic

B. oscillatory

C. simple harmonic

D. with simple harmonic

Answer: A

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4. A particle moves in a circular path with a continuously increasing speed. Its motion is

A. periodic

B. oscillatory

C. simple harmonic

D. none of these

Answer: D

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5. The motion of a torsional pendulum is

A. periodic

B. oscillatory

C. simple harmonic

D. angular simple harmonic

Answer: A::B::D

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6. Which of the following quantities are always negative in a simple harmonic motion?

A. $\vec{F}.\vec{a}$.

B. $\vec{v}.\vec{r}$

C. $\vec{a}.\vec{r}$

D. $\vec{F}.\vec{r}$

Answer: C::D

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7. Which of the following quantities are always positive in a simple harmonic motion?

A. $\vec{F}.\vec{a}$.

B. $\vec{v}.\vec{r}$

C. $\vec{a}.\vec{r}$

D. $\vec{F}.\vec{r}$

Answer: A

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8. Which of the following quantities are always zero in a simple harmonic motion?

A. $\overrightarrow{F} \times \overrightarrow{a}$.

B. $\overrightarrow{v} \times \overrightarrow{r}$

C. $\overrightarrow{a} \times \overrightarrow{r}$

D. $\overrightarrow{F} \times \overrightarrow{r}$

Answer: A::B::C::D

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9. Suppose a tunnel is dug along a diameter of the earth. A particle is dropped from a point at a distance h directly above the tunnel. The motion of the particle as seen from the earth is

A. simple harmonic

B. parabolic

C. on a straight line

D. periodic

Answer: C::D

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10. For a particle executing simple harmonic motion, the acceleration is proportional to

A. displacement from the mean position

B. distnce from the mean position

C. distance travellled since t=0

D. speed

Answer: A

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11. A particle moves in the $x - y$ plane , accoding to the equation, $r = (\hat{i} + 2\hat{j}) A \cos \omega t$. The motion of the particle is

A. on a straight line

B. on an ellipse

C. periodic

D. simple harmonic

Answer: A::C::D

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12. A particle moves on the X-axis according to the equation $x = x_0 \sin^2 \omega t$. The motion simple harmonic

A. with amplitude x_0

B. with amplitude $2x_0$

C. with time period $\frac{2\pi}{\omega}$

D. with time period $\frac{\pi}{\omega}$

Answer: D

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13. In a simple harmonic motion

A. the maximum potential energy equals the maximum kinetic energy

B. the minimum potential energy equals the minimum kinetic energy

C. the minimum potential energy equals the maximum kinetic energy

D. the maximum potential energy equals the minimum kinetic energy.

Answer: A::B

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14. An object is released from rest. The time it takes to fall through as distance h and the speed of the object as it falls through this distance are measured with a pendulum clock. The entire apparatus is taken on the moon and the experiment is repeated

A. the measured times are same

B. the measured speeds are same

C. the actual times in the fall are equal

D. the actual speeds are equal

Answer: A::B

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15. Which of the following will change the time period as they are taken to moon?

A. A simple pendulum

B. A Physical pendulum

C. A torsional pendulum

D. A spring mass system

Answer: A::B

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Exercises

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

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2. The position velocity and acceleration of a particle executing simple harmonic motion are found to have magnitudes 2cm, $1ms^{-1}$ and $10ms^{-2}$ at a certain instant. Find the amplitude and the time period of the motion.

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3. A particle executes simple harmonic motion with an amplitude of 10 cm. At what distance from the mean position are the kinetic and potential energies equal?

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4. The maximum speed and acceleration of a particle executing simple harmonic motion are 10 cm s^-1 and 50 cms^-2. Find the position of the particle when the speed is 8cms^-1.

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5. A particle having mass 10 g oscillates according to the equation $x = (2.0cm)\sin\left[\left(100s^{-1}\right)t + \frac{\pi}{6}\right]$. Find a the amplitude the time period and the spring constant b. the position, the velocity and the acceleration at t=0.

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6. The equation of motion of a particle started at t=0 is given by $x = 5\sin\left(20t + \frac{\pi}{3}\right)$, where x is in centimetre and t in second. When does the particle

a. first come rest

b. first have zero acceleration

c. first have maximum speed?

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7. Consider a particle moving in simple harmonic motion according to the equation

$$x = 2.0 \cos\left(50\pi t + \tan^{-1} 0.75\right)$$

where x is in centimetre and t in second. The motion is started at t=0. a. When does the particle come to rest for the first time? B. When does the acceleration have its maximum magnitude for the first time? c. When does the particle comes to rest for the second time?

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8. Consider a simple harmonic motion of time period T. Calculate the time taken for the displacement of change value from half the amplitude to the amplitude.

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9. The pendulum of a clock is replaced by a spring mass system with the spring having spring constant $0.1Nm^{-1}$. What mass should be attached to the spring?

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10. A block suspended from a vertical spring is in equilibrium. Show that the extension of the spring equals the length of an equivalent simple pendulum, i.e., a pendulum having frequency same as that of the block.

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11. A block of mass 0.5 kg hanging from a vertical spring executes simple harmonic motion of amplitude 0.1 m and time period 0.314s. Find the maximum fore exerted by the spring on the blockl.

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12. A body of mass 2 kg suspended through a vertical spring executes simple harmonic motionof period 4s. If the oscillations are stopped and the body hangs in equillibrium, find the potential energy stored in the spring.

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

A. $0.16kg$

B. $1.6kg$

C. $16kg$

D. $0.016kg$

Answer: C

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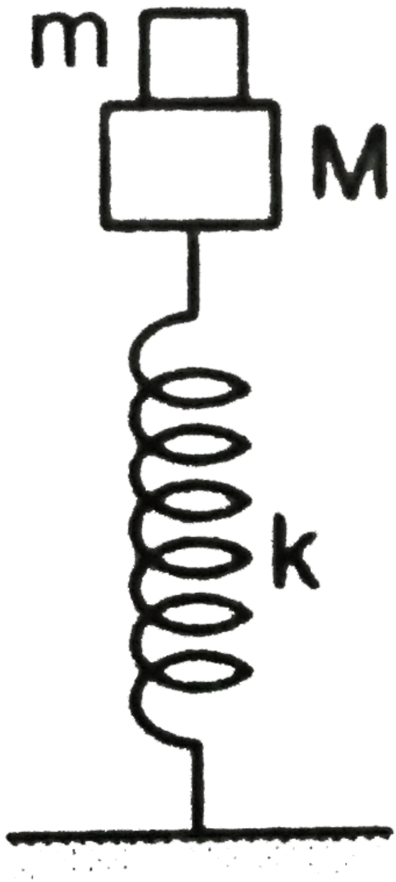
14. A small block of mass m is kept on a bigger block of mass M which is attached to a vertical spring of spring constant k as shown in the figure. The system oscilates verticaly. a.Find the resultant force on the smaller block when it is displaced through a distance x above its equilibrium position. b. find the normal force on the smaller blok at this position. When is this force smallest smaller block at this position. When is this force smallest in magnitude? c. What can be the maximum amplitude with which the two blocks may oscillate together?



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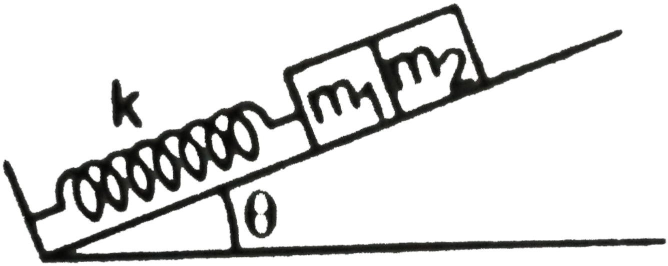
15. The block of mass m_1 shown in figure is fastened to the spring and the block of mass m_2 is placed asgainst ilt. A. Find the compression of the spring in the equilibrium position. b.The blocks are pushed a further distance $\left(\frac{2}{k}\right)(m_1 + m_2)g\sin\theta$ against the spring and released. Find the position where the two blocks separate. c. What is the common speed of blocks at the time of separation?



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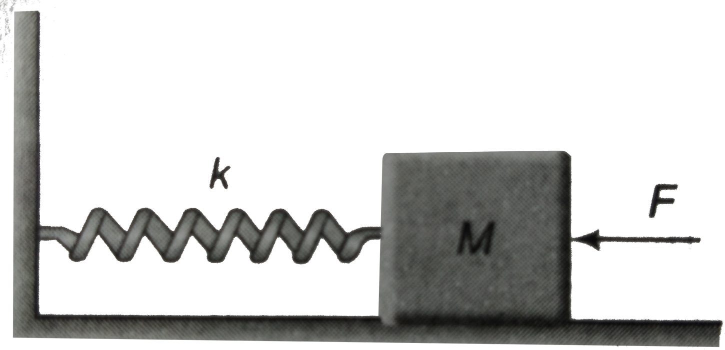
16. In figure, $k = 100N / m, M = 1kg$ and

$F = 10N$



(a) Find the compression of the spring in the equilibrium position

(b) A sharp blow by some external agent imparts a speed of $2m/s$ to the block towards left. Find the sum of the potential energy of the spring and the kinetic energy of the block at this instant.

(c) Find the time period of the resulting simple harmonic motion.

(d) Find the amplitude.

(e) Write the potential energy of the spring when the block is at the left estreme.

(f) Write the potential energy of the spring when the block is at the right extreme.

The answers of (b), (e) and (f) are different. Explain why this does not violate the principle of conservation of energy ?

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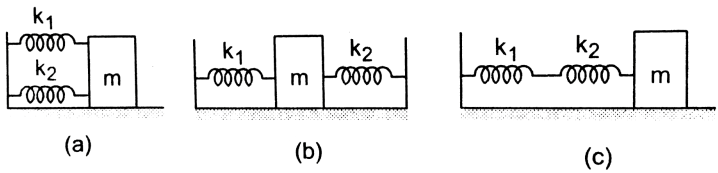
17. Find the time period of the oscillation of mass m in figure a,b,c what is the equivalent spring constant of the pair oif springs in each case?



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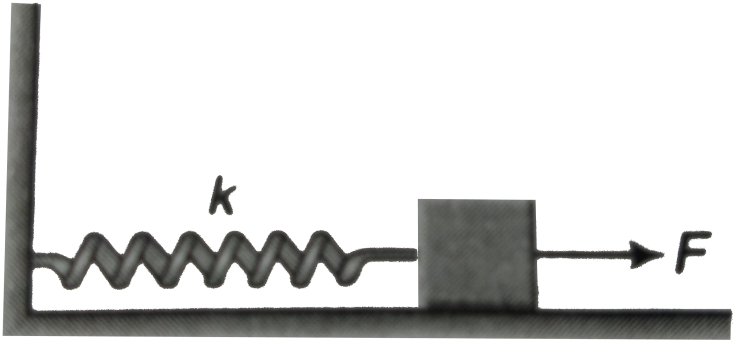
18. The spring shown in figure is unstretched when a man starts pulling on the cord. The mass of the block is M. If the man exerts a constant force F, find



(a) the amplitude and the time period of the motion of the block,

(b) the energy stored in the spring when the block passes through the equilibrium position and

(c) the kinetic energy of the block at this position.

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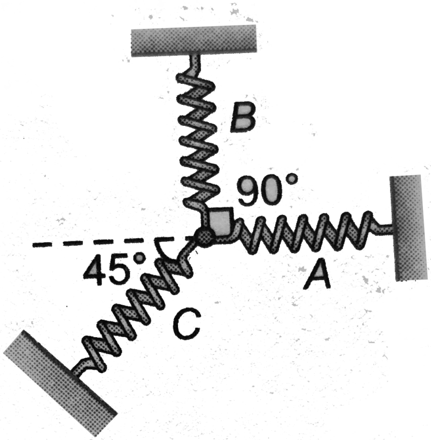
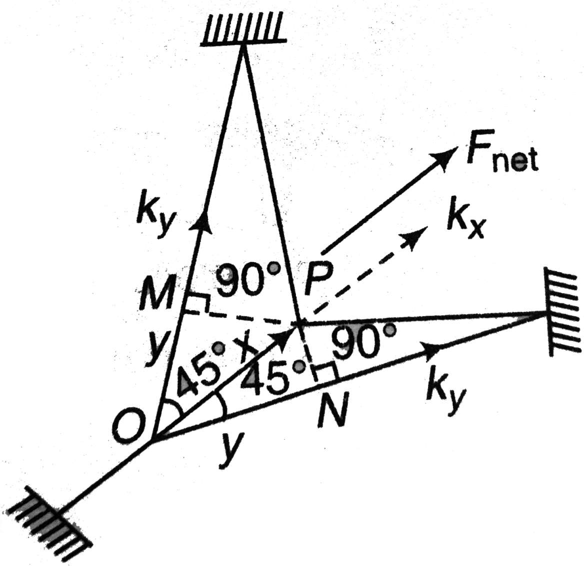
19. A particle of mass m is attached with three springs A, B and C of equal force constancts k as shown in figure. The particle is pushed slightly against the spring C and released. Find the time period of oscillation.





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20. Repeat the previous exercise if the angle between each pair of springs is 120° initially.

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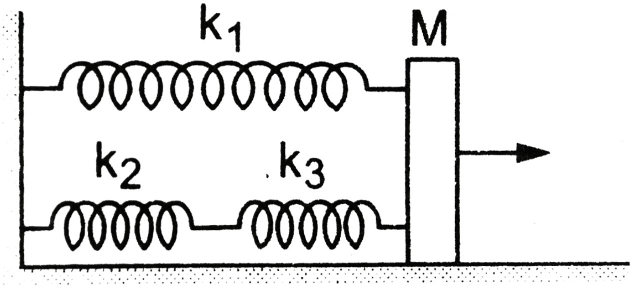
21. The springs shown in the figure are all unstretched in the beginning when a man starts pulling the block. The man exerts a constant force F on the blcok. Find the amplitude and the frequency of the motion of the block.



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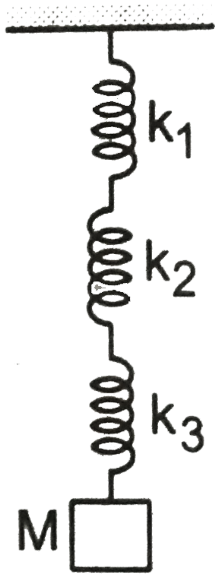
22. Find the elastic potential energy stored in each spring shown in figure, when the block is in equilibrium. Also find the time period of vertical oscillation of the block.



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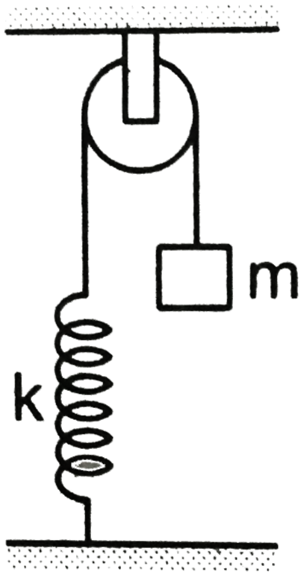
23. The string the spring and the puley shown in figure are light. Find the time period of the mass m.



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24. Solve the previous problem if the pulley has a moment of inertia I about its axis and the string does not slip over it.

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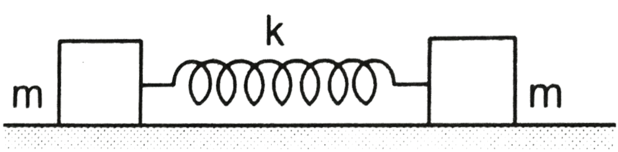
25. Consider the situastion shown in figure. Show that if that blocks are displaced slightly in opposite directions and released, they will execute simple harmonic motion. Calculate the time period.



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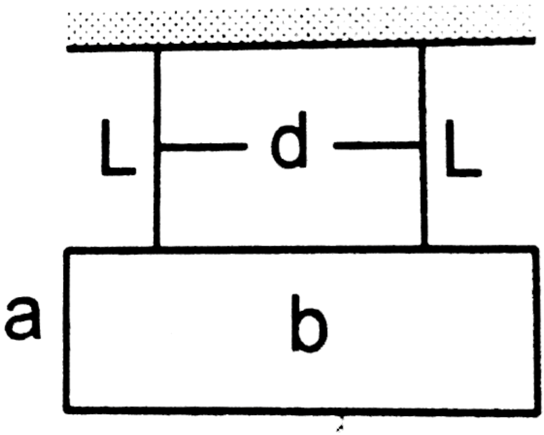
26. A rectangular plate of sides a and b is suspended from a ceiling by two parallel strings of length L each in the figure. The separation between the strings is d. The plate is displaced slightly in its plane keeping the strings tight. Show that it will execute harmonic motion. Find the time period.



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

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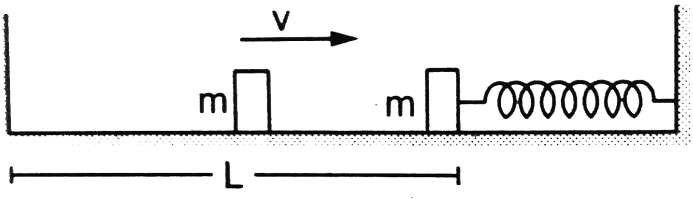
28. The left block in figure moves at a speed v towards the right block placed in equilibrium. All collisions to take place are elastic and the surfaces are frictionless. Show that motion of the two blocks are periodic. Find the time period of these periodic motions. Neglect the widths of the blocks.



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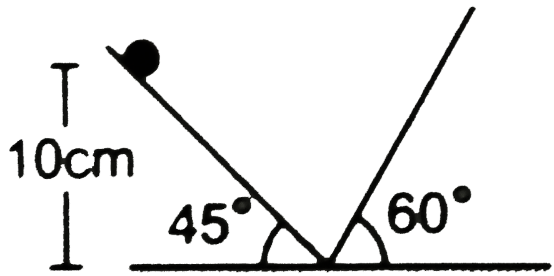
29. Find the time period of the motion of the particle shown in figure. Neglected small effect of the bend near the bottom.



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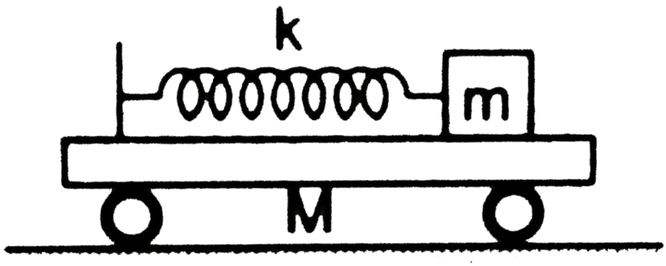
30. All the surfaces shown in figure are frictionless. The mass of the car is M, that of the block is mk and the spring has spring constant. Initialy the car and the block are at rest and the spring is stretched through a length x_0 when the system is released. a. Find the amplitude of the simple harmonic motion of the blocks and of the car as seen from the road. b. Find the time periods of the two simple harmonic motions.



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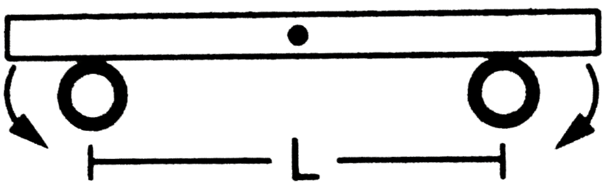
31. A uniform table of mas M stays horizontally and symmetrically on two wheels rotatig in opposite directions figure. The separsation between the wheels is L. The friction coefficeint between each whee, and the plate is μ. Find the time period of oscilationof the pate if it is slightly displaced along its length and released.



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32. Find the length of seconds pendulum at a place where $g = \pi^2 m / s^2$.

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33. The angle made by the string of a simple pendulum with the vertical depends on time as $\theta = \frac{\pi}{90}\sin\left[\left(\pi s^{-1}\right)t\right]$. Find the length of the pendulum if $g = \pi^2 ms^{-2}$

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34. The pendulum of certain clock has time period 2.04 s. How fast or slow does the clock run during 24 hours?

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35. A pendulum clock giving correct time at a place where `g=9.800 ms^-2 is taken to another place where it loses 2 seconds during 24 hours. Find the value of g at this new place.

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36. A simple pendulum is constructed by hanging a heavy ball by a 5.0 long string. It undergoes small oscillation. a. How many oscillations does it make per second? b. What will be the frequency if the system is taken on the moon where acceleration due to gravitation of the moon is $1.67 ms^{-2}$?

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37. The maximum tension in the string of a pendulum is two times the minimum tension. Let

θ_0 is then what is angular amplitude

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38. A small block oscillates back and forth on as smooth concave surface of radius R in figure. Find the time period of small oscillation.

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39. A sphere of mass m and radius r radius without slipping on a rough concave surface of large radius R. It makes small oscillations about the lowest point. Find the time period.

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40. The simple pendulum of length 40 cm is taken inside a deep mine. Assume for the time being that the mine is 1600 km deep. Calculate the time period of the pendulum there. Radius of the earth =6400 km.

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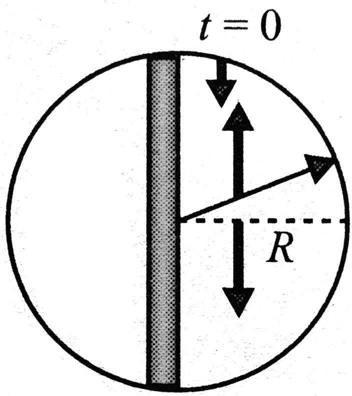
41. Assume that a tunnel is dug across the earth (radius = R) passing through its centre . Find the time a partical takes to cover the length of the tunnel if

a. it is projected into the tunnel with a speed of

$\sqrt{g}R$

b. it is released from a being R above the tunnel

c. it is thrown vertical upwards along the tunnel with a speed of $\sqrt{g}R$



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42. Assume that a tunnel ils dug along a chord of the earth, at a perpendicular distance R/2 from the earth's centre where R is the radius of the earth. The wall of the tunnel is frictionless. a. Find the gravitational force exerted by the earth on a particle of mass m placed in the tunnel at a distance x from the centre of the tunnel. b. Find the component of this fore along the tunnel and perpendicular to the tunnel. c. Find the normal force exerted by the wall on the particle. d. Find the resultant force on the particle. e.Show that the motion of the particle in the tunnel is simple harmonic and find the time period.

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43. A simple pendulum of length l is suspended through the ceiling of an elevator. Find the time period of small oscillations if the elevator a. is going up with an acceleration a_0. b. is going down with an acceleration a_0 and c. is moving with a uniform velocity.

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44. A simple pendulum of length 1 feet suspended from the ceiling of an elevator takes

$\frac{\pi}{3}$ seconds to complete one oscilation. Find the acceleration of the elevator.

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45. A simple pendulum fixed in a car has a time period of 4 seconds when the car is moving uniformly on a horizontal road. When the accelerator is pressed, lthe time period changes to 3.99 seconds. Making an approximate analysis, find the acceleration of the car.

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46. A simple pendulum of length l is suspended from the ceilling of a car moving with a speed v on a circular horizontal road of radius r. a. Find the tension in the string when it is at rest with respect to the car. b.Find the time period of small oscillation.

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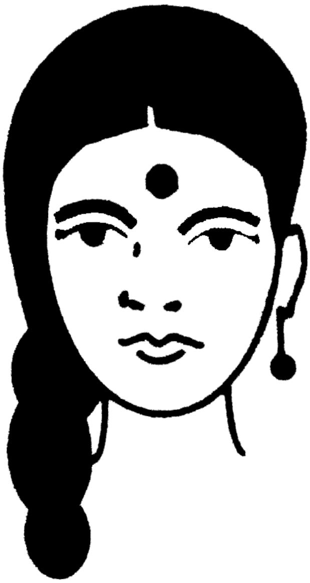
47. The ear ring of a lady shown in figure has a 3 cm long light suspension wire. A. Find the time period of small oscillations if the lady is standing on the ground. b. The lady now sits in a merry go round moving at $4ms^{-1}$ in a circle of radius 2 m. find the time period of small oscillation of the ear ring.



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48. Find the time period of small oscillations of the following system. a. A meter stick suspended through the $20cm$ mark. b A ring of mas m and radius r suspended through a point on it periphery. c A uniform square plate of edge a suspended through a corner. d. A uniform disc of mass m and radius r suspended through a point $\frac{r}{2}$ away from the center.

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49. A uniform rod of length l is suspended by end and is made to undego small oscillations. Find the length of the simple pendulum having the time period equal to that of the rod.

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

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51. A hollow sphere of radius 2 cm is attached to an 18 cm long thread to make a pendulum. Find the time period of oscillation of this pendulum . How does it differ from the time period calculated using the formula for a simple pendulum?

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52. A closed circular wire hung on a nail in a wall undergoes small oscillations of amplitude 2° and time period 2s. Find a the radius of the circular wire. b. the speed of the particle farthest away from the point of suspension as it goes though its mean position c. the aceleration of this particle as ilt goes through its mean position and extreme position. Take $g = \pi^2 sms^{-2}$

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53. A uniform disc of mass m and radius r is suspended through a wire attached to its Centre. If the time period of the torsional oscillations be T, what is the torsional constant of the wire?

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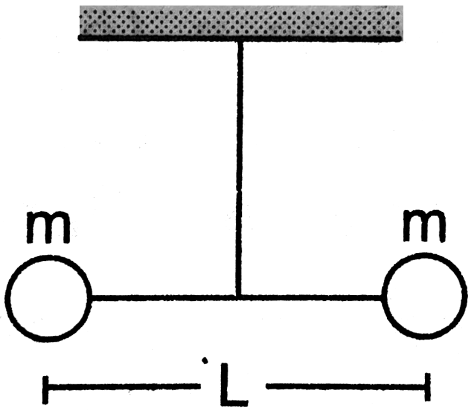
54. Two small balls, each of mass m are connected by a light rigid rod of length L. The system is suspended from its centre by a thin wire of torsional constant k. The rod is rotated about the wire through an angle θ_0 and released. Find the tension in the rod as the system passes through the mean position.



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55. A particle is subjected to two simple harmonic motions of same time period in the same direction. The amplitude of the first motion is 3.0 cm and that of the second is 4.0 cm. Find the resultant amplitude if the phase difference between the motion is a. 0°, $b.\ 60^\circ$, $c.\ 90^\circ$

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56. Three simple harmonic motions of equal amplitudes A and equal time periods in the same direction combine. The phase of the second motion is 60° ahead of the first and the phase of the third motion is 60° ahead of the second. Find the amplitude of the resultant motion.

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57. A particle is subjected to two simple harmonic motions given by

$x_1 = 2.0\sin(100\pi t)$ and $x_2 = 2.0\sin\left(120\pi t + \frac{\pi}{3}\right)$

, where x is in centimeter and t in second. Find the displacement of the particle at a. t=0.0125, b. t= 0.025.

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58. A particle is subjected to two simple harmonic motions, one along the X-axis and the other on a line making an angle of 45° with the X-axis. The two motions are given by

$x = x_0 \sin \omega t$ and $s = s_0 \sin \omega t$.

find the amplitude of the resultant motion.

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Question For Short Answer

1. A person goes to bed at shasrp 10.00 pm every day. Is it an example of periodic motion? If yes, what is the time period? If no why?

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2. A particle executing simple harmonic motion comes to rest at the extreme positions. Is the resultant force on the particle zero at these positions according to Newton's first law?

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3. Can simple harmonic motion take place in a non inertial frame? If yes, should the ratio of the force applied with the displacement be constant?

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4. A particle executes simple harmonic motion. If you are told that its veocity at this instant is Zero can you say what is its displacement? If you are told that its velocity at this instant is maximum, can you say what is its displacement?

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5. A small creature moves with constant speed in a vertical circle on a bright day. Does its shadow formed by the sun on horizontal plane move in a simple harmonic motion?

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6. A particle executes simple harmonic motion. Let P be a point near the mean position and Q be a point near an extreme. The speed of the particle at P is larger than the speed at Q. Still the particle crosses P and Q equal number of times in a given time interval. Does it make you unhappy?

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7. In measuring time period of a pendulum, it is advised to measure the time between consecutive passage through the mean position in the same direction. This is said to result in better accuracy than measuring time between consecutive passage through an extreme position. Explain.

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8. Can the potential energy in a Simple harmonic motion be negative ? will it be so if we choose zero potential energy at some point other than the mean position?

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9. The energy of a system in simple harmonic motion is given by $E = \frac{1}{2} m\omega^2 A^2$. Which of the following two statements is more appropriate? (A). the energy is increased because the amplitude is increased. (B) . The amplitude is increased because the energy is increased.

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10. A pendulum clock gives correct Time at the equator, Wil it gain time or loose time as it is taken to the poles?

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11. Can a pendulum clock be used in an earth satellite?

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12. A hollow sphere filled with water is used as the bob of a pendulum. Assume that the equation for simple pendulum is valid with the distance between the point of suspension and centre of mass of the bob acting as the effective length of the pendulum. If water slowly leaks out of the bob, how will the time period vary?

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13. A block of known mass is suspended from a fixed support through a ligh spring. Can you find the time period of vertical oscillation only by measuring the extension of the spring when the block is in equilibrium?

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14. A platoon of soldiers marches on a road in steps accoridng to the sound of a marching band The band iS stopPed and the soldiers are ordered to break the steps while crossing the bridge. Why?

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15. The force acting on a particle moving along X-axis is $F = -k(x - v_0 t)$ where k is a positive constant. An observer moving at a constant velocity v_0 along the X-axis looks the particle . What kind of motion does he find for the particle?

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