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India's Number 1 Education App

## PHYSICS

## BOOKS - HC VERMA

## SIMPLE HARMONIC MOTION

## Example

1. The resultant force acting on a particle executing simple harmonic motion is 4 N when it
is 5 cm 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
$F=-\left(50 \mathrm{Nm}^{-1}\right) x$. If it crosses the centre of oscillation with a speed of $10 \mathrm{~ms}^{-1}$, find the amplitude of the motion.

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

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4. A particle executes simple harmonic motion of amplitude A along the X -axis. At $\mathrm{t}=0$ the position of the particle is $x=\frac{A}{2}$ and it moves along the positive x -direction. Find the phase constant $\delta$ 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 $\frac{\pi}{10} \mathrm{rad}$ and time period 0.5 s . If the body is at a displacement $\theta=\frac{\pi}{10}$ rad at $\mathrm{t}=0$,
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 $\pi^{2} m s^{-2}$.

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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.
10. A uniform disc of radius 5.0 cm and mass 200 g 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 0.20 s , find the torsional constant of the wire.

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

$$
\begin{aligned}
& x_{1}=(2.0 \mathrm{~cm}) \sin \omega t \\
& \quad \text { and } x_{2}=(2.0 \mathrm{~cm}) \sin \left(\omega t+\frac{\pi}{3}\right)
\end{aligned}
$$

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## Worked Out Examples

1. The equation of a particle executing simple harmonic motion
$x=(5 m) \sin \left[\left(\pi s^{-1}\right) t+\frac{\pi}{3}\right]$. Write down the amplitude time period and maximum speed. Also
find the velocity at $\mathrm{t}=1 \mathrm{~s}$.
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 $6.28 s^{-1}$ and amplitude

10 cm . Find $(a)$ the time period, $(b)$ the maximum speed, $(c)$ the maximum acceleration.

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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.
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 $g=\pi^{2} m s^{-2}$

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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. Find the blanks:

| Linear <br> Polynomial | Zero of the polynomial |
| :---: | :---: |
| $x+a$ | $-a$ |
| $x-a$ | $-\cdots$ |
| $a x+b$ | $\frac{b}{a}$ |

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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.

$$
\xrightarrow{\stackrel{\mathrm{V}}{\longrightarrow}} \stackrel{\mathrm{~m}}{\stackrel{\mathrm{k}}{\longrightarrow}}
$$

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 $X o$ 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.

## (D) Watch Video Solution

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.

## (D) Watch Video Solution

15. A simple pendulum having a bob of mass $m$ under goes small oscillations with amplitude $\theta_{0}$

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 $1.0 m$. 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 $I$, 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 $0.2 k g-m^{2}$. It oscillates with a period of 2 s .

Asnother disc is placed over the first one and time period of the system becomes 2.5 s . 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 I is suspended through a light wire of length I and torsional constant $k$ as shown in figure. Find the
time period of the system makes small oscillations in the vertical plane about the suspension point .

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 the maximum speed of the particle and 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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## 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?
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?

## (D) Watch Video Solution

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?
4. A particle executes simple harmonic motion with a frequency $v$. The frequency with which the kinetic energy oscillates is

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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 with an amplitude of 10 cm . At what distance
from the mean position are the kinetic and potential energies equal?

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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. It is proposed to move a particle in simple harmionic motion on a rough horizontal surface by applying an external force along the line of motion. Sketch the graph of the applied force agains the position of the particle. Note that the applied force has two values for a given position depending on whether the particle is moving in positive or negative direction.

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9. 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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10. 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.

## D Watch Video Solution

11. The aplitude is increased because the energy is increased.

## (D) Watch Video Solution

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

## (D) Watch Video Solution

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

## (D) Watch Video Solution

14. Write down the time period of simple pendulum.
15. 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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16. 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?

## D Watch Video Solution

17. The force acting on a particle moving along $X$ axis is $F=-k\left(x-v_{0} t\right)$ 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?

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 $S H M$ takes time equal to $T$ (time period of $S H M$ ) 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

## (D) Watch Video Solution

3. A particle executing linear $S H M$. 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. $v_{\text {max }}$
B. 0
C. between 0 and $v_{\text {max }}$
D. between and 0 and $-v_{\text {max }}$

Answer: A
(D) Watch Video Solution
4. The displacement of a particle in simple harmonic motion in one time period is
A. A
B. 2A
C. 4 A
D. zero

## Answer: D

5. The distance moved by a particle in simple harmonic motion in one time period is
A. A
B. 2A
C. 4 A
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

8. The displacement of a particle is given by
$\vec{r}=A(\vec{i} \cos \omega t+\vec{j} \sin \omega t)$. 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. a) amplitude
B. b) frequency
C. c) phase
D. d) maximum velocity

Answer: C
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 $2 E$
B. becoem $\frac{E}{2}$
C. becoem $\sqrt{2} E$
D. remain E

Answer: D

## D Watch Video Solution

12. The average energy in one time period in simple harmonic motion is
A. $\frac{1}{2} m \omega^{2} A^{2}$
B. $\frac{1}{4} m \omega^{2} A^{2}$
C. $m \omega^{2} A^{2}$
D. zero

Answer: A

## - Watch Video Solution

13. A particle executes simple harmonic motion with a frequency. (f). The frequency with which its kinetic energy oscillates is.
A. $\frac{f}{2}$
B. f
C. 2 f
D. zero

Answer: C

## D Watch Video Solution

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

## (D) Watch Video Solution

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

## D Watch Video Solution

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

## (D) Watch Video Solution

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

## D Watch Video Solution

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

## D Watch Video Solution

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
(D) Watch Video Solution
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
21. What is the use of gear box?
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) A simple harmonic motion is necessarily periodic
B. b) a simple harmonic motion is necessarily oscillatory
C.c) an oscillatory motion is necessery periodic

# D. d) a periodic motion is necessarily 

 oscillatoryAnswer: A::B

## (D) Watch Video Solution

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

## D Watch Video Solution

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

## D Watch Video Solution

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

## D Watch Video Solution

## 5. The motion of a torsional pendulum is

A. periodic
B. oscillatory
C. simple harmonic
D. angular simple harmonic

Answer: A::B::D

## D Watch Video Solution

6. Which of the following quantities are always
negative in a simple harmonic motion?
A. $\vec{F} \cdot \vec{a}$.
B. $\vec{v} \cdot \vec{r}$
C. $\vec{a} \cdot \vec{r}$
D. $\vec{F} \cdot \vec{r}$

## Answer: C::D

## D Watch Video Solution

7. Which of the following quantities are always positive in a simple harmonic motion?
A. $\vec{F} \cdot \vec{a}$.
B. $\vec{v} \cdot \vec{r}$
C. $\vec{a} \cdot \vec{r}$
D. $\vec{F} \cdot \vec{r}$

Answer: A

## D Watch Video Solution

8. Which of the following quantities are always
zero in a simple harmonic motion?
A. $\vec{F} \times \vec{a}$.
B. $\vec{v} \times \vec{r}$
C. $\vec{a} \times \vec{r}$
D. $\vec{F} \times \vec{r}$

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

## D Watch Video Solution

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

## D Watch Video Solution

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

## D Watch Video Solution

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

## (D) Watch Video Solution

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 $2 x_{0}$
C. with time period $\frac{2 \pi}{\omega}$
D. with time period $\frac{\pi}{\omega}$

## Answer: D

## D Watch Video Solution

13. In a simple harmonic motion
A. the potential energy is always equal to the kinetic energy
B. the potential energy of is never equal to
the kinetic energy
C. the average potential energy in any time interval is equal to the average kinetic
energy in that time interval
D. the average potential energy is one time period is equal to the averge energy is this period

## Answer: D

## (D) Watch Video Solution

14. In a simple harmonic motion
A. the maximum kinetic energy equals the maximum potential energy
B. the minimum kinetic energy equals the minimum potential energy
C. the minimum potential energy equals the
maximum kinetic energy
D. the maximum potential energy equals the minimum kinetic energy.

Answer: A::B
15. 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

## D Watch Video Solution

16. 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 6 s . At $\mathrm{t}=0$ it is at position $\mathrm{x}=5 \mathrm{~cm}$ 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 $\mathrm{t}=4 \mathrm{~s}$.
2. The position velocity and acceleration of a particle executing simple harmonic motion are found to have magnitudes $2 \mathrm{~cm}, 1 \mathrm{~ms}^{\wedge}-1$ and $10 \mathrm{~ms}^{\wedge}-2$ at a certain instant. Find the amplitude and the time period of the motion.

## ( Watch Video Solution

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?

## (D) Watch Video Solution

4. The maximum speed and acceleration of a particle executing simple harmonic motion are 10 $\mathrm{cm} \mathrm{s} \mathrm{s}^{\wedge}-1$ and $50 \mathrm{cms}^{\wedge}-2$. Find the position of the particle when the speed is $8 \mathrm{cms}^{\wedge}-1$.
5. A particle having mass 10 g oscillates according to the equation
$x=(2.0 \mathrm{~cm}) \sin \left[\left(100 s^{-1}\right) t+\frac{\pi}{6}\right]$. Find the amplitude the time period and the spring constant

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6. The equation of motion of a particle started at
$\mathrm{t}=0$ is given by $x=5 \sin \left(20 t+\frac{\pi}{3}\right)$, 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?

## (D) Watch Video Solution

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

## (D) Watch Video Solution

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 0.314 s . 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 4 s . If the oscillations are stopped and the body hangs in equillibrium, find the potential energy stored in the spring.

## D Watch Video Solution

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. 0.16 kg
B. 1.6 kg
C. 16 kg
D. 0.016 kg

## Answer: C

## (D) Watch Video Solution

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?

15. The block of mass $m_{1}$ shown in figure is
fastened to the spring and the block of mass $m_{2}$
is placed as against it. Find the compression of the spring in the equilibrium position.

16. In figure, $k=100 \mathrm{~N} / m, M=1 \mathrm{~kg}$ and $F=10 N$

(a) Find the compression of the spring in the equilibrium position
(b) A sharp blow by some external agent imparts a speed of $2 m / s$ 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.

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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?

(a)

(b)

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

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19. A particle of mass $m$ is attached to three springs $A, B$ and $C$ of equal force constants $k$ as
shown in figure. If 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 $120^{\circ}$ 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.

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.

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

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.

## (D) Watch Video Solution

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 1 kg block is executing simple harmonic motion of amplitude 0.1 m on a smooth horizontal surface under the restoring force of a
spring constant $100 \mathrm{Nm}^{-1}$. A block of mass 3 kg is gently placed on it at the instant it passes through the mean position. Assuming that the two blocks move together, find the frequency.


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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.


## D Watch Video Solution

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.


## ( Watch Video Solution

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 $\mu$. Find the time period of oscilationof the pate if it is slightly displaced along its length and released.


## D Watch Video Solution

32. Find the length of seconds pendulum at a place where $\mathrm{g}=10 \frac{\mathrm{~m}}{\mathrm{~s}^{2}}$.

## D Watch Video Solution

33. State the laws of simple pendulum.

## - Watch Video Solution

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

## - Watch Video Solution

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

## (D) Watch Video Solution

36. A simple pendulum is constructed by hanging a heavy ball by a 5.0 m 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 $1.67 \mathrm{~ms}^{-2} ?$

## - Watch Video Solution

37. The maximum tension in the string of an oscillating pendulum is double of the minimum tension. Find the angular amplitude.
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.

## (D) Watch Video Solution

39. A spherical ball of mass $m$ and radius $r$ rolls without slipping on a rough concave surface of large radius R . It makes small oscillations about the lowest point. Find the time period.
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 $=6400 \mathrm{~km}$.

## (D) Watch Video Solution

41. Assume that a tunnel is dug across the earth
(radius=R) passing through its centre. Find the time a particle 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 relased from a height R above the tunnel (c ) it is thrown vertically upward along the length of tunnel with a speed of $\sqrt{g R}$.

## D Watch Video Solution

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.

## D Watch Video Solution

43. A simple pendulum of length $I$ 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.

## - Watch Video Solution

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

## $\pi$

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

## D Watch Video Solution

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, Ithe time period changes to 3.99 seconds. Making an approximate analysis,
find the acceleration of the car.

## D Watch Video Solution

46. A simple pendulum of length $I$ 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.

## D Watch Video Solution

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 $4 m s^{-1}$ in a circle of radius 2 m .
find the time period of small oscillation of the ear
ring.


## (D) Watch Video Solution

48. Find the time period of small oscillations of the following system. $a$. A meter stick suspended
through the 20 cm mark. $b \mathrm{~A}$ ring of mas m and radius $r$ suspended through a point on it periphery. $c \mathrm{~A}$ 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.

## - Watch Video Solution

49. A uniform rod of length $I$ 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.

## D Watch Video Solution

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?
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?

## ( Watch Video Solution

52. A closed circular wire hung on a nail in a wall undergoes small oscillations of amplitude $2^{\circ}$ and
time period 2 s . 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 $g=\pi^{2} s m s^{-2}$

## D Watch Video Solution

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?
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 $\theta_{0}$ and released.

Find the tension in the rod as the system passes
through the mean position.


## D Watch Video Solution

55. 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.

## (D) Watch Video Solution

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 $60^{\circ}$ ahead of the first and the phase of the third motion is $60^{\circ}$ ahead of the second.

Find the amplitude of the resultant motion.

## D Watch Video Solution

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 $a . t=0.0125, b$. $\mathrm{t}=0.025$.

## D Watch Video Solution

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 $45^{\circ}$ with the X -axis. The
two motions are given by

$$
x=x_{0} \sin \omega t \text { and } s=s_{0} \sin \omega t
$$

find the amplitude of the resultant motion.

D Watch Video Solution

