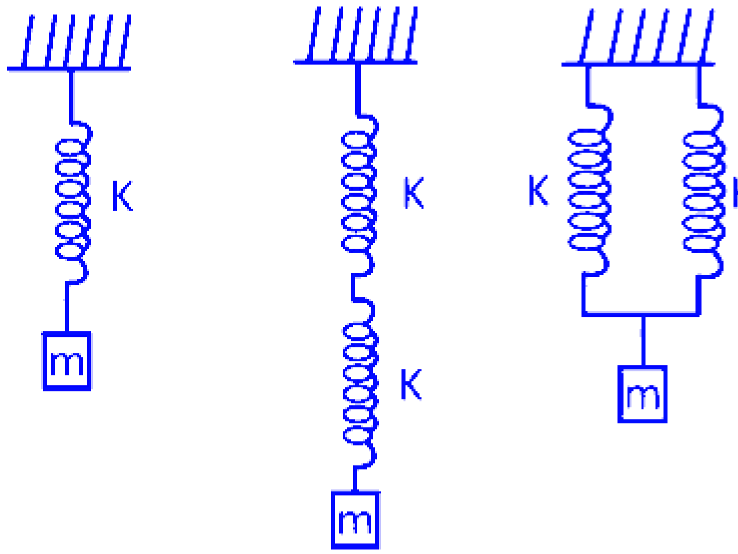
Question1

All the springs in fig. (a), (b) and (c) are identical, each having force constant K each. Mass m is attached to each system. If T_a, T_b and T_c are the time periods of oscillations of the three systems in fig. (a), (b) and (c) respectively, then



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Options:

A.

$\mathrm{T_a} = \sqrt{2}\,\mathrm{T_b}$

B.

$\mathrm{T_a} = \frac{\mathrm{T_c}}{\sqrt{2}}$

C.

$\mathrm{T_b} = 2\,\mathrm{T_a}$

D.

$T_b = 2\ T_c$

Answer: D

Solution:

Finding the Time Periods

For any spring-mass system, the time period is $T = 2\pi\sqrt{\frac{m}{K'}}$, where m is the mass and K' is the effective spring constant of the setup.

Figure (a):

There is only one spring with constant K. The time period is:
$T_a = 2\pi\sqrt{\frac{m}{K}}$

Figure (b):

Two springs are attached in parallel. The effective spring constant adds up:
$K' = K + K = 2K$
The time period is:
$T_b = 2\pi\sqrt{\frac{m}{2K}}$

Simplify this:
$T_b = 2\pi\sqrt{\frac{m}{2K}} = 2\pi\frac{1}{\sqrt{2}}\sqrt{\frac{m}{K}} = \frac{T_a}{\sqrt{2}}$

Figure (c):

Two springs are in series. Effective spring constant is:
$\frac{1}{K'} = \frac{1}{K} + \frac{1}{K} = \frac{2}{K}$, so $K' = \frac{K}{2}$
Time period is:
$T_c = 2\pi\sqrt{\frac{m}{K/2}} = 2\pi\sqrt{\frac{2m}{K}} = \sqrt{2}T_a$

Shortest and Longest Time Period

T_b (parallel springs) is the shortest, and T_c (series springs) is the longest.

Relating the Time Periods

From above, we have:
$T_a = \frac{T_c}{\sqrt{2}}$ and $T_a = \sqrt{2}T_b$

We can also write:
$T_b = \frac{T_a}{\sqrt{2}}$ and $T_c = \sqrt{2}T_a$

So, T_c is twice T_b:
$T_c = 2T_b$

Question2

A point particle of mass 200 gram is executing S.H.M. of amplitude 0.2 m . When the particle passes through the mean position, its kinetic energy is 16×10^{-3} J. The equation of motion of this particle is (Initial phase of oscillation $= 0^{\circ}$)

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Options:

A.

$\mathrm{Y}=0.2 \sin (4 \mathrm{t})$

B.

$\mathrm{Y}=0.2 \sin \left(\frac{\mathrm{t}}{4}\right)$

C.

$\mathrm{Y}=0.2 \sin \left(\frac{\mathrm{t}}{2}\right)$

D.

$\mathrm{Y}=0.2 \sin (2 \mathrm{t})$

Answer: D

Solution:

At the mean position kinetic energy is maximum which is also equal to the total energy of the S.H.M.

$$
\begin{aligned}
\therefore \quad & \frac{1}{2} \mathrm{m} \omega^2 \mathrm{~A}^2=16 \times 10^{-3} \\
\Rightarrow \quad & \frac{1}{2} \times 0.2 \times \omega^2 \times(0.2)^2=16 \times 10^{-3} \\
\Rightarrow \quad & \omega^2=\frac{16 \times 10^{-3}}{0.004}=4 \\
\Rightarrow \quad & \omega=2 \mathrm{rad} / \mathrm{s} \\
& y=A \sin \omega t \\
\Rightarrow \quad & y=0.2 \sin (2 t)
\end{aligned}
$$

Question3

A simple pendulum starts oscillating simple harmonically from its mean position ($\mathrm{x}=0$) with amplitude ' a ' and periodic time ' T '. The magnitude of velocity of pendulum at $x=\frac{a}{2}$ is

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Options:

A.

$\frac{3\pi^2 a}{T}$

B.

$\frac{\sqrt{3}\pi a}{2T}$

C.

$\frac{\pi a}{T}$

D.

$\frac{\sqrt{3}\pi \mathrm{a}}{\mathrm{T}}$

Answer: D

Solution:

Step 1: Standard expression for velocity in SHM

For SHM:

$x(t)=a\sin(\omega t)$

or equivalently,

$v=\frac{dx}{dt}=\omega\sqrt{a^2-x^2}$,

where $\omega=\frac{2\pi}{T}$.

Step 2: Put $x=\frac{a}{2}$

$v=\omega\sqrt{a^2-\left(\frac{a}{2}\right)^2}=\omega\sqrt{a^2-\frac{a^2}{4}}=\omega\sqrt{\frac{3a^2}{4}}$.

$v=\omega\cdot\frac{\sqrt{3}}{2}a$.

Step 3: Express ω in terms of T

$\omega = \frac{2\pi}{T}$.

So:

$v = \frac{2\pi}{T} \cdot \frac{\sqrt{3}}{2} a = \frac{\sqrt{3}\pi a}{T}$.

Step 4: Compare with options

This matches **Option D**:

$$\boxed{\frac{\sqrt{3}\pi a}{T}}$$

Question4

A simple pendulum is suspended from ceiling of a lift when lift is at rest its period is ' T '. With what acceleration ' a ' should lift be accelerated upward in order to reduce the period to ' T '? (take ' g ' as acceleration due to gravity)

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Options:

A.

2 g

B.

3 g

C.

4 g

D.

g

Answer: B

Solution:

Step 1: Understand how period depends on gravity

The formula for the time period of a simple pendulum is: $T = 2\pi\sqrt{\frac{L}{g}}$. This means the time period T gets smaller when gravity g is bigger. We can write: $T \propto \frac{1}{\sqrt{g}}$.

Step 2: Set up the ratio for periods and gravity

We compare the old period T to the new period T' when gravity changes: $\frac{T}{T'} = \sqrt{\frac{g'}{g}}$ where g' is the new effective gravity.

Step 3: When the lift moves upward

If the lift goes up with acceleration a, the new gravity felt (effective gravity) becomes $g' = g + a$. We are told we want the new period to be half as long: $T' = T/2$.

Step 4: Put the values into the ratio

Substitute these values into our ratio formula: $\frac{T}{T/2} = \sqrt{\frac{g+a}{g}}$ This simplifies to $2 = \sqrt{1 + \frac{a}{g}}$.

Step 5: Solve for acceleration a

Square both sides: $2^2 = 1 + \frac{a}{g}$, so $4 = 1 + \frac{a}{g}$.

Solve for a: $4 - 1 = \frac{a}{g}$, so $\frac{a}{g} = 3$.

Therefore, $a = 3g$.

Question5

A particle is performing S.H.M. starting from extreme position. Graphical representation shows that between displacement and acceleration, there is a phase difference of

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Options:

A.

πrad

B.

$\frac{\pi}{2}$rad

C.

$\frac{\pi}{4}$rad

D.

0 rad

Answer: A

Solution:

Step 1: Recall the SHM relations

For a particle in SHM,

$x(t) = A\cos(\omega t + \phi)$

where:

- $x(t)$ = displacement
- A = amplitude
- ω = angular frequency
- ϕ = phase constant

The acceleration is related to displacement by:

$a(t) = \ddot{x}(t) = -\omega^2 x(t)$

Step 2: Relationship between $x(t)$ and $a(t)$

From the expression:

$a(t) = -\omega^2 x(t)$

This shows that **acceleration is directly proportional to displacement, but opposite in direction.**

Step 3: Phase difference

- Both $a(t)$ and $x(t)$ vary sinusoidally with the **same frequency**.
- However, $a(t)$ has a **negative sign** compared to displacement.
- This corresponds to a **phase difference of π radians (180°).**

✅ **Final Answer:**

Phase difference $= \pi$ rad

Correct option: A. π rad

Question6

A mass ' M ' attached to a horizontal spring executes S.H.M. of amplitude A_1. When the mass M passes through its mean position, then a smaller mass ' m ' is placed over it and both of them move together with amplitude A_2. The ratio $\left(\frac{A_1}{A_2}\right)$ is

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Options:

A.

$\frac{M+m}{M}$

B.

$\frac{\mathrm{M}}{\mathrm{M}+\mathrm{m}}$

C.

$\left(\frac{M+m}{M}\right)^{\frac{1}{2}}$

D.

$\left(\frac{M}{M+m}\right)^{\frac{1}{2}}$

Answer: C

Solution:

Step 1: Conservation of Momentum at Mean Position

At the mean position, the net force (F_{net}) is zero. This means the total momentum before and after adding mass must stay the same.

Step 2: Setting Up the Momentum Equation

Before the smaller mass m is placed, only mass M moves, so its momentum is Mv_1. After adding m, both move together, so their momentum is $(M+m)v_2$.

$Mv_1 = (M+m)v_2$

Step 3: Express Velocity in Terms of Amplitude and Angular Frequency

The velocity at mean position for a mass in S.H.M. is $V = A\omega$. For A_1 and mass M, $v_1 = A_1\omega_1$. For A_2 and mass $(M+m)$, $v_2 = A_2\omega_2$.

$$M\omega_1 A_1 = (M+m)\omega_2 A_2$$

Step 4: Find Angular Frequencies for Both Cases

The angular frequency $\omega = \sqrt{\frac{k}{m}}$, where k is the spring constant and m is the mass.

$$\omega_1 = \sqrt{\frac{k}{M}} \quad \text{and} \quad \omega_2 = \sqrt{\frac{k}{M+m}}$$

Step 5: Substitute and Solve for the Ratio $\frac{A_1}{A_2}$

Replace ω_1 and ω_2 in the momentum equation:

$$M\sqrt{\frac{k}{M}}A_1 = (M+m)\sqrt{\frac{k}{M+m}}A_2$$

Step 6: Simplify the Equation

Simplifying both sides, we get:

$$\frac{A_1}{A_2} = \sqrt{\frac{M+m}{M}}$$

Question7

At a place, the length of the oscillating simple pendulum is made $\frac{1}{4}$ times keeping amplitude same then the total energy will be

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Options:

A. 2 times

B. 4 times

C. 8 times

D. 16 times

Answer: B

Solution:

Total energy of simple pendulum

$E=\frac{1}{2} m \omega^2 A^2$

Where, angular frequency $\omega=\sqrt{\frac{g}{l}}$

$$
\begin{aligned}
\text{ new length } & =1/4 \\
\therefore \omega_{\text{new}} & =\sqrt{\frac{g}{l} / 4}=\sqrt{\frac{4 g}{l}}=2 \omega \\
\therefore E_{\text{new}} & =\frac{1}{2} m(2 \omega)^2 A^2 \quad(\because \text{A is same}) \\
& =4\left(\frac{1}{2} m \omega^2 A^2\right) \\
& =4 \times E
\end{aligned}
$$

$\therefore$ Total energy becomes 4 times

Question8

A spring executes S.H.M. with mass 1 kg attached to it. The force constant of the spring is $4 \mathrm{~N} / \mathrm{m}$. If at any instant its velocity is $20 \mathrm{~cm} / \mathrm{s}$, the displacement at that instant is (Amplitude of S.H.M. is 0.4 m)

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Options:

A. $\sqrt{0.11} \mathrm{~m}$

B. $\sqrt{0.15} \mathrm{~m}$

C. $\sqrt{0.17} \mathrm{~m}$

D. $\sqrt{0.19} \mathrm{~m}$

Answer: B

Solution:

We are given:

- Mass $m = 1\,\text{kg}$
- Spring constant $k = 4\,\text{N/m}$
- Velocity at some instant $v = 20\,\text{cm/s} = 0.2\,\text{m/s}$
- Amplitude $A = 0.4\,\text{m}$

We need the displacement x at that instant.

Step 1: Angular frequency

$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{4}{1}} = 2\,\text{rad/s}$

Step 2: Energy conservation in SHM

Total energy (constant):

$E = \frac{1}{2}kA^2 = \frac{1}{2}m\omega^2 A^2$

At displacement x and velocity v:

$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

Step 3: Equate energies

$\frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$

Substitute values:

$\frac{1}{2}(1)(0.2^2) + \frac{1}{2}(4)x^2 = \frac{1}{2}(4)(0.4^2)$

$0.5 \times 0.04 + 2x^2 = 2 \times 0.16$

$0.02 + 2x^2 = 0.32$

$2x^2 = 0.30$

$x^2 = 0.15$

$x = \sqrt{0.15}\,\text{m}$

✅ Final Answer:

The displacement is

Option B: $\sqrt{0.15}\,\text{m}$

Question9

The ratio of the frequencies of two simple pendulums is $4:3$ at the same place. The ratio of their respective lengths is

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Options:

A. 3 : 4

B. 4 : 3

C. 9 : 16

D. 16 : 9

Answer: C

Solution:

Period of simple pendulum,

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$$

$$\Rightarrow \quad f \propto \frac{1}{\sqrt{L}}$$

$$\therefore \quad \frac{f_1}{f_2} = \sqrt{\frac{L_2}{L_1}}$$

$$\therefore \quad \frac{L_2}{L_1} = \left(\frac{f_1}{f_2}\right)^2 = \left(\frac{4}{3}\right)^2 = \frac{16}{9}$$

$$\therefore \quad \frac{L_1}{L_2} = \frac{9}{16}$$

Question10

Two simple pendulums have first (A) bob of mass ' M_1 ' and length ' L_1 ', second (B) of mass ' M_2 ' and length ' L_2 '. $M_1 = M_2$ and $L_1 = 2L_2$. If their total energies are same then the correct statement is

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Options:

A. amplitude of B is greater than amplitude of A.

B. amplitude of B is smaller than amplitude of A.

C. amplitude of both will be same.

D. amplitude of B is twice that of A .

Answer: B

Solution:

Total energy of a simple pendulum,

$E=\frac{1}{2} M \omega^2 A^2$

For a simple pendulum,

$\omega=\sqrt{g / L}$

For pendulum A:

$E_A=\frac{1}{2} M_1\left(\frac{g}{L}\right) A_1^2$

For pendulum B :

$E_B=\frac{1}{2} M_2\left(\frac{g}{L}\right) A_2^2$

Given:

$$
\begin{aligned}
& E_A=E_B \\
& \frac{1}{2} M_1\left(\frac{g}{L_1}\right) A_1^2=\frac{1}{2} M_2\left(\frac{g}{L_2}\right) A_2^2 \\
\therefore \quad & \frac{A_1^2}{A_2^2}=\frac{L_1}{L_2} \quad \ldots \ldots .\left(M_1=M_2\right)
\end{aligned}
$$

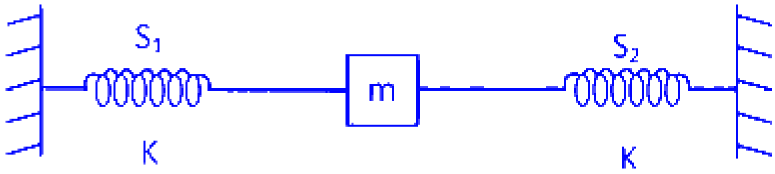
$\therefore \quad \mathrm{A}_1^2=2 \mathrm{~A}_2^2 \quad \ldots \ldots\left(\mathrm{~L}_1=2 \mathrm{~L}_2\right)$

$\therefore \quad \mathrm{A}_1>\mathrm{A}_2$

$\therefore$ Amplitude of B is smaller than amplitude of A

Question11

As shown in the figure, S_1 and S_2 are identical springs with spring constant K each. The oscillation frequency of the mass ' m ' is ' f '. If the spring S_2 is removed, the oscillation frequency will become



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Options:

A. f

B. 2 f

C. $\frac{\mathrm{f}}{\sqrt{2}}$

D. $\sqrt{2} \cdot \mathrm{f}$

Answer: C

Solution:

Case 1: With both springs $S_1 \& S_2$

Effective spring constant: $K_{\text{eff}} \quad : K+K=2K$

Oscillation frequency: $f=\frac{1}{2\pi}\sqrt{\frac{K_{\text{eff}}}{m}}=\frac{1}{2\pi}\sqrt{\frac{2K}{m}}$

Case II: After removing S_2

Now only one spring with spring constant K

New frequency: $\mathrm{f}'=\frac{1}{2\pi}\sqrt{\frac{\mathrm{K}}{\mathrm{m}}}$

Divide both cases: $\frac{F'}{F}=\frac{\sqrt{\frac{K}{m}}}{\sqrt{\frac{2K}{m}}}$

$\Rightarrow \quad \frac{F'}{F}=\frac{1}{\sqrt{2}}$

$\therefore \quad F'=\frac{F}{\sqrt{2}}$

Question12

A particle starts oscillating simple harmonically from its mean position with time period ' T '. At time $\mathrm{t}=\frac{\mathrm{T}}{6}$, the ratio of the potential energy to kinetic energy of the particle is

$$\left[\sin 30^{\circ}=\cos 60^{\circ}=0 \cdot 5, \cos 30^{\circ}=\sin 60^{\circ}=\sqrt{3} / 2\right]$$

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Options:

A. 1 : 2

B. 1 : 3

C. 2 : 1

D. 3 : 1

Answer: D

Solution:

For SHM,

$$\text{P.E.} =\frac{1}{2} m \omega^2 x^2 \qquad \ldots(i)$$

$$\text{and K.E.} =\frac{1}{2} m \omega^2\left(A^2-x^2\right) \qquad \ldots(ii)$$

$$\text{Given } t=\frac{T}{6}$$

$$\therefore \quad x=A \sin \omega t=A \sin \frac{2 \pi}{T} \cdot t$$

$$\therefore \quad x=A \sin \frac{2 \pi}{T} \times \frac{T}{6}$$

$$=A \sin \left(\frac{\pi}{3}\right)$$

$$=\frac{\sqrt{3} A}{2} \qquad \ldots(iii)$$

Substituting equation (iii) in equation (i),

$$\text{P.E.} =\frac{1}{2} m \omega^2\left(\frac{3 \mathrm{~A}^2}{4}\right)$$

$$=\frac{3 m \omega^2 \mathrm{~A}^2}{8}$$

Substituting equation (iii) in equation (ii),

$$\begin{aligned} \text{K.E. } &= \frac{1}{2} m\omega^2\left(A^2-\frac{3A^2}{4}\right) \\ &= \frac{1}{2} m\omega^2\left(\frac{A^2}{4}\right) \end{aligned}$$

$$\therefore \quad \frac{\text{P.E.}}{\text{K.E.}} = \frac{\frac{1}{2} m\omega^2 A^2 \times \frac{3}{4}}{\frac{1}{2} m\omega^2 A^2 \times \frac{1}{4}} = \frac{3}{1}$$

Question13

Two particles ' A ' and ' B ' execute SHMs of periods ' T ' and $\frac{3T}{2}$. If they start from the mean position then the phase difference between them, when the particle ' A ' completes two oscillations will be

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Options:

A. $\frac{\pi}{3}$

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

C. $\frac{4\pi}{3}$

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

Answer: C

Solution:

Phase difference,

$$\Delta\phi = \left(\frac{2\pi}{\mathrm{T}_1}-\frac{2\pi}{\mathrm{T}_2}\right)\mathrm{t} = \left(\frac{2\pi}{\mathrm{T}}-\frac{2\pi}{\frac{3}{2}\mathrm{T}}\right)\mathrm{t}$$

At $\mathrm{t}=2\mathrm{~T}$

$$\Delta\phi = \left(2\pi-\frac{4\pi}{3}\right)\frac{2\mathrm{~T}}{\mathrm{T}} = \frac{4\pi}{3}\mathrm{rad}$$

$$\Delta\phi = \frac{4\pi}{3}\mathrm{rad}$$

Question14

A small sphere oscillates simple harmonically in a watch glass whose radius of curvature is 1.6 m . The period of oscillation of the sphere is (acceleration due to gravity $\mathrm{g}=10 \mathrm{~m} / \mathrm{s}^2$)

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Options:

A. 0.2π s

B. 0.4π s

C. 0.6π s

D. 0.8π s

Answer: D

Solution:

Step 1: Recall the situation

A small sphere (or particle) oscillates in a spherical surface of large radius R. If displaced slightly from equilibrium, the restoring force comes from component of gravity along the surface.

For small oscillations, the motion approximates simple harmonic motion with period:

$T=2 \pi \sqrt{\frac{R}{g}}$

where R is the radius of curvature of the spherical surface.

Step 2: Substitute values

Here $R=1.6 \mathrm{~m}$, $g=10 \mathrm{~m/s}^2$.

$T=2 \pi \sqrt{\frac{1.6}{10}}$

$T=2 \pi \sqrt{0.16}$

$T=2 \pi(0.4)=0.8 \pi \mathrm{~s}$.

Step 3: Final Answer

So the correct option is:

Option D: 0.8π s ✅

Question15

The displacement of particle in S.H.M. is $\mathrm{x} = \mathrm{A}\cos(\omega \mathrm{t} + \pi/6)$. Its speed will be maximum at time $(\sin 90^{\circ} = 1)$

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Options:

A. $\frac{\pi}{3\omega}$ s

B. $\frac{\pi}{2\omega}$ s

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

D. $\frac{\pi}{4\omega}$ s

Answer: A

Solution:

Displacement:

$x = A\cos(\omega t + \frac{\pi}{6})$

We want the time when **speed is maximum**.

Step 1: Velocity in SHM

$v = \frac{dx}{dt} = -A\omega\sin(\omega t + \frac{\pi}{6})$

So:

$v^2 = A^2\omega^2\sin^2(\omega t + \frac{\pi}{6})$

Maximum speed:

$v_{\max} = A\omega$

occurs when

$|\sin(\omega t + \frac{\pi}{6})| = 1$

i.e.

$\sin(\omega t + \frac{\pi}{6}) = \pm 1$

Step 2: Condition for maximum

So:

$\omega t + \frac{\pi}{6} = \frac{\pi}{2}, \frac{3\pi}{2}, \ldots$

Choose the smallest positive time. First solution:

$\omega t + \frac{\pi}{6} = \frac{\pi}{2}$

$\omega t = \frac{\pi}{2} - \frac{\pi}{6} = \frac{3\pi - \pi}{6} = \frac{2\pi}{6} = \frac{\pi}{3}$

$t = \frac{\pi}{3\omega}$

This is the **first time** when speed is maximum.

Step 3: Match with options

Correct option:

A) $\frac{\pi}{3\omega}$

✅ Final Answer:

$\boxed{\frac{\pi}{3\omega}}$

Question16

An object of mass 0.2 kg executes simple harmonic oscillations along the x -axis with frequency of $\left(\frac{25}{\pi}\right)\mathrm{Hz}$. At the position $x = 0.04\ \mathrm{m}$, the object has kinetic energy 1 J and potential energy 0.6 J . The amplitude of oscillation is

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Options:

A. 0.06 m

B. 0.6 m

C. 0.08 m

D. 0.8 m

Answer: C

Solution:

Total energy $= K.E. + P.E. = K + P = \frac{1}{2} m\omega^2 A^2$

$$A^2 = \frac{2(K+P)}{m\omega^2}$$

$$A = \frac{1}{\omega}\sqrt{\frac{2(K+P)}{m}} = \frac{1}{2\pi n}\sqrt{\frac{2(K+P)}{m}} = \frac{1}{\pi n}\sqrt{\frac{K+P}{2m}}$$

Substituting the values,

$$A = \frac{1}{\pi} \times \frac{\pi}{25}\sqrt{\frac{1+0.6}{2 \times 0.2}} = 0.08 \text{ m}$$

Question17

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

The motion of the particle is

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Options:

A. simple harmonic with amplitude $(A + B)$

B. simple harmonic with amplitude $(A - B)$

C. simple harmonic with amplitude $\left(A^2 + B^2\right)^{\frac{1}{2}}$

D. not simple harmonic

Answer: C

Solution:

Motion of the particle is given by

$x = A \sin \omega t + B \cos \omega t = A \sin \omega t + B \sin(\omega t + \pi/2)$

Resultant amplitude of a particle performing S.H.M. represented by the following equation is given by -

$$\begin{aligned} & \mathrm{R} = \sqrt{\mathrm{A}_1^2 + \mathrm{A}_2^2 + 2\,\mathrm{A}_1\,\mathrm{A}_2 \cos\left(\phi_1 - \phi_2\right)} \\ \therefore\quad & \mathrm{R} = \sqrt{\mathrm{A}^2 + \mathrm{B}^2} \quad \ldots.\left(\because \phi_1 - \phi_2 = -\frac{\pi}{2}\right) \end{aligned}$$

Question18

A particle is executing S.H.M. of amplitude ' A '. When the potential energy of the particle is half of its maximum value during the oscillation, its displacement from the equilibrium position is

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Options:

A. $\pm \frac{\mathrm{A}}{4}$

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

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

D.

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

Answer: D

Solution:

The potential energy in simple harmonic motion is given by $P = \frac{1}{2} k x^2$.

The maximum potential energy happens when the particle is at the farthest point from the center. This value is $P_{\max} = \frac{1}{2} k A^2$.

We are told that the current potential energy is half of this maximum value. So, $\frac{1}{2} k x^2 = \frac{1}{2}\left(\frac{1}{2} k A^2\right)$

If we simplify both sides, we get: $x^2 = \frac{A^2}{2}$ So the displacement from the center is: $x = \pm \frac{A}{\sqrt{2}}$

Question19

A particle is executing linear S.H.M. starting from mean position. The ratio of the kinetic energy to the potential energy of the particle at a point of half the amplitude is

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Options:

A. 2 : 1

B. 3 : 1

C. 4 : 1

D. 8 : 1

Answer: B

Solution:

K.E. at half the amplitude position $\left(x=\frac{A}{2}\right)$

$=\frac{1}{2} m \omega^2\left(A^2-\frac{A^2}{4}\right)=\frac{3}{8} m \omega^2 A^2$

P.E. at $x=\frac{A}{2}=\frac{1}{2} m \omega^2\left(\frac{A}{2}\right)^2=\frac{1}{8} m \omega^2 A^2$

$\therefore$ The required ratio

$\frac{\text{K.E.}}{\text{P.E.}}=\frac{\left(\frac{3}{8} m \omega^2 A^2\right)}{\left(\frac{1}{8} m \omega^2 A^2\right)}=\frac{3}{1}$

Question20

The amplitude of a damped oscillator becomes $\left(\frac{1}{3}\right)^{\text{rd}}$ of original amplitude in 2 seconds. If its amplitude after 6 second become $\left(\frac{1}{n}\right)$ times the original amplitude, the value of n is (n is non zero integer)

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Options:

A. 9

B. 3

C. 81

D. 27

Answer: D

Solution:

Step 1: Write amplitude decay relation

In general, for damped oscillation, amplitude decays exponentially:

$A(t) = A_0 e^{-\gamma t}$

where γ is the damping constant.

Step 2: Use given condition at $t = 2s$

It is given that amplitude becomes $\frac{1}{3}$ of original (that's what "$\left(\frac{1}{3}\right)^{\text{rd}}$" must mean: one–third).

$A(2) = \frac{A_0}{3} = A_0 e^{-2\gamma}$

Cancel A_0:

$e^{-2\gamma} = \frac{1}{3}$

So,

$\gamma = \frac{1}{2}\ln(3)$

Step 3: Condition at $t = 6s$

$A(6) = A_0 e^{-6\gamma}$

Substitute $\gamma = \frac{1}{2}\ln 3$:

$A(6) = A_0 e^{-6\cdot\frac{1}{2}\ln(3)} = A_0 e^{-3\ln(3)} = A_0 \cdot e^{\ln(3^{-3})} = A_0 \cdot \frac{1}{27}$

Step 4: Express as $\frac{1}{n}$

So,

$\frac{A(6)}{A_0} = \frac{1}{27}$

Thus $n = 27$.

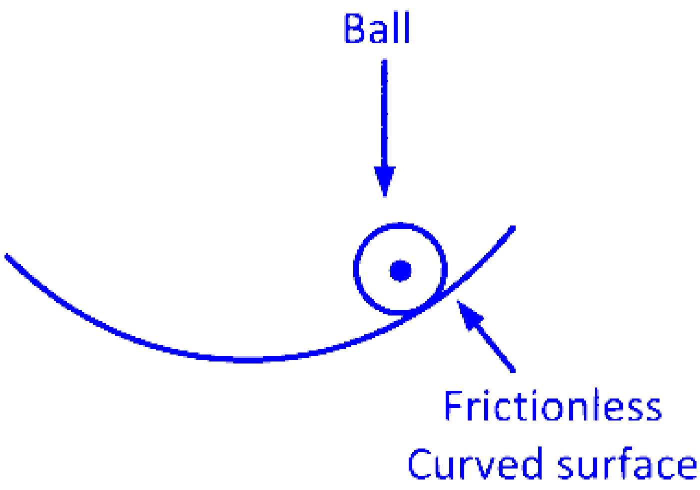
Final Answer:

$\boxed{27}$

✓ Correct Option: **D (27)**

Question21

A small spherical ball of radius ' r ' is rolling on a curved surface which is frictionless and has a radius of curvature ' R '. Its motion is simple harmonic. Then its tine period of oscillation is proportional to (g $=$ acceleration due to gravity)



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Options:

A. $\sqrt{\frac{R}{g}}$

B. $\sqrt{\frac{r}{g}}$

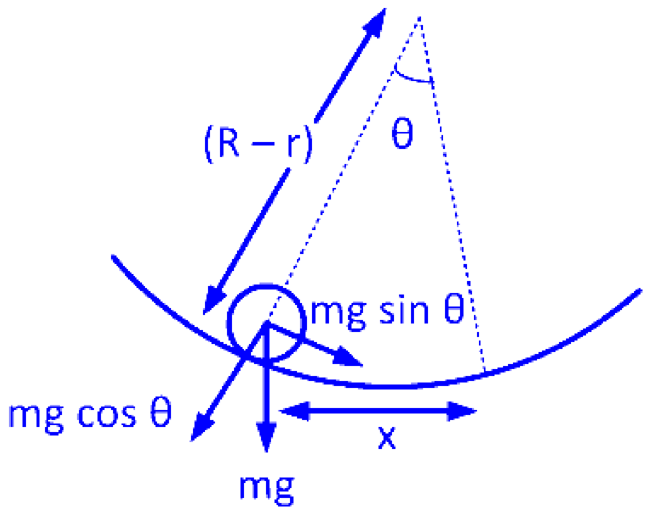
C. $\sqrt{\frac{R-r}{g}}$

D. $\sqrt{\frac{R+r}{g}}$

Answer: C

Solution:

From the figure,



Restoring force $\mathrm{F}=-\mathrm{mg} \sin \theta$

$\sin \theta=\theta=\frac{x}{R-x}$

$\therefore \quad F=-m g\left(\frac{x}{R-r}\right) \quad \Rightarrow F=-\left(\frac{m g}{R-r}\right) x$

$\therefore \quad K=\frac{m g}{R-r}$

$\therefore \quad m \omega^2=\frac{m g}{R-r}$

$\therefore \quad \omega=\sqrt{\frac{g}{R-r}}$

$\therefore \quad T=\frac{2 \pi}{\omega}=2 \pi \sqrt{\frac{R-r}{g}}$

Question22

A particle executes S.H.M. starting from the mean position. Its amplitude is ' a ' and its periodic time is ' T '. At a certain instant, its speed ' u ' is half that of maximum speed $\mathrm{V}_{\max}$. The displacement of the particle at that instant is

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Options:

A. $\frac{2a}{\sqrt{3}}$

B. $\frac{\sqrt{2}a}{3}$

C. $\frac{3a}{\sqrt{2}}$

D. $\frac{\sqrt{3}a}{2}$

Answer: D

Solution:

Speed at displacement x

$u = \omega\sqrt{a^2 - x^2}$

Speed of particle at a certain instant is half that of maximum speed V_{max}

$$\therefore \quad u = \frac{V_{max}}{2} = \frac{\omega a}{2}$$
$$\therefore \quad \frac{\omega a}{2} = \omega\sqrt{a^2 - x^2}$$
$$a^2 - x^2 = \frac{a^2}{4}$$
$$x^2 = \frac{3}{4}a^2$$
$$x = \frac{\sqrt{3}}{2}a$$

Question23

A particle performing linear S.H.M. has period 8 seconds. At time $t = 0$, it is in the mean position. The ratio of the distances travelled by the particle in the 1^{st} and 2^{nd} second is $\left(\cos 45^\circ = 1/\sqrt{2}\right)$

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Options:

A. $1 : (\sqrt{2} - 1)$

B. $1 : 2$

C. $2 : 1$

D. $1 : (\sqrt{2} + 1)$

Answer: A

Solution:

Step 1: Understand the motion

- Time period: $T = 8\,\text{s}$.
- Therefore, angular frequency:

$\omega = \frac{2\pi}{T} = \frac{2\pi}{8} = \frac{\pi}{4}$ rad/s.

- At $t = 0$, the particle is at the mean position.

So displacement function:

$x(t) = A \sin(\omega t)$.

- Velocity: $v(t) = \frac{dx}{dt} = A\omega \cos(\omega t)$.

Step 2: Distance travelled in 1st second (0 to 1s)

Distance travelled = integral of $|v|$.

For $t = 0$ to small values, $\cos(\omega t) > 0$ (since $\omega = \pi/4$, in 1 second $\omega t = \pi/4 \approx 45^\circ$, still positive). So velocity doesn't change sign in this interval $\rightarrow$ monotonic increase of x.

Hence distance travelled = displacement magnitude:

$s_1 = x(1) - x(0) = A \sin\left(\frac{\pi}{4} \cdot 1\right) - 0 = A \sin\frac{\pi}{4} = \frac{A}{\sqrt{2}}$.

Step 3: Distance travelled in 2nd second (1 to 2s)

Check velocity sign between $t = 1$s and $t = 2$s.

At $t = 1$, $\omega t = \pi/4$, cos positive. At $t = 2$, $\omega t = \pi/2$, cos zero. So velocity gradually reduces to zero without changing sign. So again monotonic increase in displacement.

Thus distance = displacement change:

$s_2 = x(2) - x(1)$.

$x(2) = A \sin\left(\frac{\pi}{4} \cdot 2\right) = A \sin\frac{\pi}{2} = A$.

So

$s_2 = A - \frac{A}{\sqrt{2}} = A\left(1 - \frac{1}{\sqrt{2}}\right)$.

Step 4: Ratio $s_1 : s_2$

$$\frac{s_1}{s_2} = \frac{\frac{A}{\sqrt{2}}}{A\left(1-\frac{1}{\sqrt{2}}\right)} = \frac{\frac{1}{\sqrt{2}}}{1-\frac{1}{\sqrt{2}}}.$$

Simplify denominator: $1 - \frac{1}{\sqrt{2}} = \frac{\sqrt{2}-1}{\sqrt{2}}$.

So:

$$\frac{s_1}{s_2} = \frac{\frac{1}{\sqrt{2}}}{\frac{\sqrt{2}-1}{\sqrt{2}}} = \frac{1}{\sqrt{2}-1}.$$

Multiply numerator and denominator:

$$\frac{1}{\sqrt{2}-1} = \sqrt{2}+1.$$

Thus ratio:

$$s_1 : s_2 = (\sqrt{2}+1) : 1.$$

Step 5: Match with options

They ask ratio of distances in 1st and 2nd second = $1 : (\sqrt{2}-1)$ or $2 : 1$ etc.

We got $(\sqrt{2}+1) : 1$.

So equivalently $1 : (\sqrt{2}-1)$? Let's check:

$(\sqrt{2}+1) : 1$ = multiply numerator and denominator by $(\sqrt{2}-1)$:

$(\sqrt{2}+1) : 1 = 1 : (\sqrt{2}-1)$.

Yes, same.

✅ **Final Answer:**

$$\boxed{1 : (\sqrt{2}-1)}$$

Option A

Question24

For a particle performing S.H.M.; the total energy is ' n ' times the kinetic energy, when the displacement of a particle from mean position is $\frac{\sqrt{3}}{2}$ A, where A is the amplitude of S.H.M. The value of ' n ' is

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Options:

A. 2

B. 3

C. 4

D. 6

Answer: C

Solution:

We know

K.E. $=\frac{1}{2} m \omega^2\left(A^2-x^2\right)$ and T.E. $=\frac{1}{2} m \omega^2 A^2$

Given: T.E. $=$ n$\times$ K.E.

$$\frac{1}{2} m \omega^2 A^2=n \times \frac{1}{2} m \omega^2\left(A^2-x^2\right)$$
$$\frac{1}{2} m \omega^2 A^2=n \times \frac{1}{2} m \omega^2 A^2\left(1-\frac{3}{4}\right) \ldots\left(\text{given } x=\frac{\sqrt{3}}{2} A\right)$$

$\Rightarrow \quad 1=\mathrm{n}\left(1-\frac{3}{4}\right)$
$\therefore \quad \mathrm{n}=4$

Question25

The length of the simple pendulum is made 3 times the original length. If ' T ' is its original time period, then the new time period will be

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Options:

A. 3 T

B. $\sqrt{3}$ T

C. $\frac{\text{T}}{\sqrt{3}}$

D. $\frac{\text{T}}{3}$

Answer: B

Solution:

We know, for a simple pendulum the time period is:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

where L = length of pendulum and g = acceleration due to gravity.

Step 1: Write the new time period

If the new length is $L' = 3L$, then the new time period is

$$T' = 2\pi\sqrt{\frac{L'}{g}} = 2\pi\sqrt{\frac{3L}{g}}$$

Step 2: Compare with the original period

The original time period is

$$T = 2\pi\sqrt{\frac{L}{g}}.$$

So,

$$T' = 2\pi\sqrt{\frac{3L}{g}} = 2\pi\sqrt{3}\sqrt{\frac{L}{g}} = \sqrt{3}T$$

✅ **Final Answer:**

The new time period is

Option B: $\sqrt{3}T$

Question26

Two simple harmonic motions of angular frequency 300rad/s and 3000rad/s have same amplitude. The ratio of their maximum accelerations is

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Options:

A. 1 : 10

B. $1 : 10^2$

C. $1 : 10^3$

D. $1 : 10^4$

Answer: B

Solution:

Let amplitude of both oscillations be A.

Let angular frequencies be

$\omega_1 = 300$ rad/s

$\omega_2 = 3000$ rad/s

For a simple harmonic motion, maximum acceleration is given by:

$a_{\max} = \omega^2 A$

Maximum acceleration for each:

- First motion:

  $a_{1,\max} = \omega_1^2 A = (300)^2 A = 90000A$

- Second motion:

  $a_{2,\max} = \omega_2^2 A = (3000)^2 A = 9000000A$

Ratio of maximum accelerations:

$\frac{a_{1,\max}}{a_{2,\max}} = \frac{90000A}{9000000A} = \frac{1}{100}$

Therefore,

$a_{1,\max} : a_{2,\max} = 1 : 100$

So, the correct answer is:

Option B: $1 : 10^2$

Question27

A mass m is suspended from a spring of negligible mass. The spring is pulled a little and then released, so that mass executes S.H.M. of time period T. If the mass is increased by m_0, the periodic time becomes $\frac{5\,\mathrm{T}}{4}$. The ratio $\frac{\mathrm{m}_0}{\mathrm{M}}$

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Options:

A. $\frac{3}{4}$

B. $\frac{4}{3}$

C. $\frac{9}{16}$

D. $\frac{16}{9}$

Answer: C

Solution:

Let

- m = original mass
- m_0 = extra mass added
- T = original time period
- T' = new time period = $\frac{5T}{4}$

Time period of a mass-spring system:

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

where k is the spring constant.

With the new mass $m + m_0$:

$T' = 2\pi\sqrt{\frac{m+m_0}{k}}$

Given:

$T' = \frac{5T}{4}$

Step 1: Write the ratio $\frac{T'}{T}$

$$\frac{T'}{T} = \frac{2\pi\sqrt{\frac{m+m_0}{k}}}{2\pi\sqrt{\frac{m}{k}}} = \sqrt{\frac{m+m_0}{m}}$$

$$\frac{T'}{T} = \sqrt{1+\frac{m_0}{m}}$$

Step 2: Substitute the given value

$$\frac{5}{4} = \sqrt{1+\frac{m_0}{m}}$$

Step 3: Square both sides

$$\left(\frac{5}{4}\right)^2 = 1+\frac{m_0}{m}$$

$$\frac{25}{16} = 1+\frac{m_0}{m}$$

Step 4: Solve for $\frac{m_0}{m}$

$$\frac{25}{16} - 1 = \frac{m_0}{m}$$

$$\frac{25-16}{16} = \frac{m_0}{m}$$

$$\frac{9}{16} = \frac{m_0}{m}$$

Step 5: Answer

Ratio $\frac{m_0}{m} = \frac{9}{16}$

Correct option: Option C

Question28

A simple pendulum has time period ' T_1 '. The point of suspension is now moved upward according to equation $\mathrm{y}=\mathrm{kt}^2$ where $\mathrm{k}=1\ \mathrm{m}/\mathrm{s}^2$. If new time period is ' T_2 ' then $\mathrm{T}_1^2/\mathrm{T}_2^2$ will be ($\mathrm{g}=10\ \mathrm{m}/\mathrm{s}^2$)

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Options:

A. $2/3$

B. $5/6$

C. $6/5$

D. $3/2$

Answer: C

Solution:

Step 1: Original Time Period

The time period of a simple pendulum (with no acceleration of suspension point) is

$$T_1 = 2\pi\sqrt{\frac{l}{g}}$$

Step 2: Acceleration of the Suspension Point

The suspension point moves upward as $y = kt^2$ with $k = 1\ \text{m/s}^2$.

Differentiate twice to get acceleration:

$$y = kt^2 \implies \frac{dy}{dt} = 2kt \implies \frac{d^2y}{dt^2} = 2k$$

So, upward acceleration $a = 2k = 2 \times 1 = 2\ \text{m/s}^2$

Step 3: Effective Acceleration Due to Gravity

When the point of suspension is given an upward acceleration a, the effective gravity becomes:

$$g' = g + a$$

Here,

$$g' = 10 + 2 = 12\ \text{m/s}^2$$

Step 4: New Time Period

The new time period is

$$T_2 = 2\pi\sqrt{\frac{l}{g'}} = 2\pi\sqrt{\frac{l}{12}}$$

Step 5: Ratio of the Squares of Time Periods

$$\frac{T_1^2}{T_2^2} = \frac{\left(2\pi\sqrt{\frac{l}{g}}\right)^2}{\left(2\pi\sqrt{\frac{l}{g'}}\right)^2} = \frac{\frac{l}{g}}{\frac{l}{g'}} = \frac{g'}{g} = \frac{12}{10} = \frac{6}{5}$$

Final Answer:

Option C

$$\boxed{\frac{6}{5}}$$

Question29

A mass attached to a spring performs S.H.M. whose displacement is $x = 3 \times 10^{-3} \cos 2\pi t$ metre. The time taken to obtain maximum speed for the first time is

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Options:

A. $\frac{1}{12}$ s

B. $\frac{1}{8}$ s

C. $\frac{1}{4}$ s

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

Answer: C

Solution:

As the equation of displacement is given in terms of cosine, the particle starts from the extreme position.

Comparing the given equation with,

$$x = A\cos(\omega t),$$
$$\omega = 2\pi$$
$$\therefore \quad \frac{2\pi}{T} = 2\pi$$
$$\therefore \quad T = 1s.$$

Now, velocity of the particle performing S.H.M. is maximum at the mean position. Thus, starting from extreme position, the time taken to reach the mean position for the first time is $\frac{T}{4}$.

i.e., $\frac{1}{4}$ seconds.

Question30

A particle executes a linear S.H.M. In two of its positions the velocities are $V_1,\ V_2$ and accelerations are a_1 and a_2 respectively

$\left(0
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Options:

A. $\frac{V_1^2-V_2^2}{a_1-a_2}$

B. $\frac{V_2^2-V_1^2}{a_1-a_2}$

C. $\frac{V_1^2-V_2^2}{a_1+a_2}$

D. $\frac{v_2^2-v_1^2}{\left(a_1^2+a_2^2\right)}$

Answer: C

Solution:

When velocity is V_1 and acceleration is a_1, let the position of particle be x_1.

When velocity is V_2 and acceleration is a_2, let the position of particle be x_2.

If ω is the angular frequency then,

$a_1=\omega^2 x_1$

and $\mathrm{a}_2=\omega^2 \mathrm{x}_2$.

$\therefore \quad \mathrm{a}_1+\mathrm{a}_2=\omega^2\left(\mathrm{x}_1+\mathrm{x}_2\right) \qquad \ldots(i)$

Also, velocity of particle at particular instant can be given as,

$V_1^2=\omega^2 A^2-\omega^2 x_1^2$

and $V_2{}^2=\omega^2 A^2-\omega^2 x_2^2$

i.e., $V_2{}^2-V_1{}^2=\omega^2\left(x_1^2-x_2^2\right)$

$V_2^2-V_1^2=\omega^2\left(x_1-x_2\right)\left(x_1+x_2\right) \qquad \ldots(ii)$

from equation (i) we get

$$V_2^2-V_1^2=\left(x_1-x_2\right)\left(a_1+a_2\right)$$

$$\therefore \quad x_1-x_2=\frac{V_2^2-V_1^2}{a_1+a_2}$$

$$\text{or } x_2-x_1=\frac{V_1^2-V_2^2}{a_1+a_2}$$

Question31

A mass x gram is suspended from a light spring. It is pulled in downward direction and released so that mass performs S.H.M. of period T. If mass is increased by Y gram, the period becomes $\frac{4\text{ T}}{3}$. The ratio of Y/x is

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Options:

A. 7 : 9

B. 5 : 4

C. 3 : 2

D. 8 : 7

Answer: A

Solution:

Let the force constant (spring constant) be k.

Step 1: Write the formula for the time period of S.H.M.:

For a mass m attached to a spring of force constant k,

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

Given:

- Initial mass $=x$ grams
- New mass $=x+Y$ grams
- Initial period $=T$
- New period $=\frac{4T}{3}$

Step 2: Express both situations using the time period formula.

1. When mass is x grams:

   $T = 2\pi\sqrt{\frac{x}{k}}$

2. When mass is $x + Y$ grams:

$$\frac{4T}{3} = 2\pi\sqrt{\frac{x+Y}{k}}$$

Step 3: Divide the two equations.

$$\frac{\frac{4T}{3}}{T} = \frac{2\pi\sqrt{\frac{x+Y}{k}}}{2\pi\sqrt{\frac{x}{k}}}$$

$$\frac{4}{3} = \sqrt{\frac{x+Y}{x}}$$

Step 4: Square both sides to remove the square root.

$$\left(\frac{4}{3}\right)^2 = \frac{x+Y}{x}$$

$$\frac{16}{9} = \frac{x+Y}{x}$$

Step 5: Rearranging to find Y/x.

$$x + Y = \frac{16}{9}x$$

$$Y = \frac{16}{9}x - x$$

$$Y = \left(\frac{16}{9} - 1\right)x = \frac{7}{9}x$$

$$\frac{Y}{x} = \frac{7}{9}$$

Step 6: Final answer

The required ratio is

$$\boxed{7:9}$$

Correct option: A

Question32

The period of S. H.M. of a particle is 16 second. The phase difference between the positions at $\mathrm{t} = 2\ \mathrm{s}$ and $\mathrm{t} = 4\ \mathrm{s}$ will be

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Options:

A. π

B. $\frac{\pi}{2}$

C. $\frac{\pi}{4}$

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

Answer: C

Solution:

Given:

- Period of SHM, $T = 16$ seconds
- Times: $t_1 = 2$ s and $t_2 = 4$ s

Step 1: Find the angular frequency ω

The formula is:

$\omega = \frac{2\pi}{T}$

Substituting $T = 16$ s:

$\omega = \frac{2\pi}{16} = \frac{\pi}{8}$ rad/s

Step 2: Calculate the phase at t_1 and t_2

The general phase at time t (ignoring initial phase, as only difference is required):

Phase at $t = \omega t$

So,

- At $t_1 = 2$ s, phase $= \omega \times 2 = \frac{\pi}{8} \times 2 = \frac{\pi}{4}$
- At $t_2 = 4$ s, phase $= \omega \times 4 = \frac{\pi}{8} \times 4 = \frac{\pi}{2}$

Step 3: Find the phase difference

Phase difference $= \left|\frac{\pi}{2} - \frac{\pi}{4}\right| = \frac{\pi}{4}$

Final Answer:

Option C: $\boxed{\frac{\pi}{4}}$

Question33

If the period of a oscillation of mass ' m ' suspended from a spring is 2 s , then the period of suspended mass ' 4 m ' with the same spring

will be

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Options:

A. 1 s

B. 3 s

C. 2 s

D. 4 s

Answer: D

Solution:

The time period T of a mass-spring system is given by:

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

where

$m =$ mass suspended from the spring

$k =$ spring constant

Given:

For m, $T_1 = 2$ s

Now, for mass $4m$, the new period T_2 will be:

$T_2 = 2\pi\sqrt{\frac{4m}{k}}$

$= 2\pi\sqrt{4}\sqrt{\frac{m}{k}}$

$= 2\pi \times 2\sqrt{\frac{m}{k}}$

$= 2 \times \left(2\pi\sqrt{\frac{m}{k}}\right)$

But $2\pi\sqrt{\frac{m}{k}} = T_1 = 2$ s

So,

$T_2 = 2 \times 2 = 4$ s

Answer: Option D (4 s)

Question34

A particle oscillates in straight line simple harmonically with period 8 second and amplitude $4\sqrt{2}$ m. Particle starts from mean position. The ratio of the distance travelled by it in 1^{st} second of its motion to that in 2^{nd} second is $\left(\sin 45^{\circ}=1/\sqrt{2}, \sin \frac{\pi}{2}=1\right)$

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Options:

A. $1:8$

B. $1:4$

C. $1:2$

D. $1:(\sqrt{2}-1)$

Answer: D

Solution:

For a particle executing SHM from mean position,

$$\begin{aligned} x & =A \sin \omega t \\ At \quad & t=1 s \\ x_1 & =A \sin \left(\frac{2 \pi}{T} t\right)=A \sin \left(\frac{2 \pi}{8} \times 1\right) \\ & =A \sin 45^{\circ}=\frac{A}{\sqrt{2}} \\ t & =2 s \\ x_2 & =A \sin \left(\frac{2 \pi}{T} t\right)=A \sin \left(\frac{2 \pi}{8} \times 2\right) \\ & =A \sin 90^{\circ}=A \end{aligned}$$

$\therefore$ Distance covered in 2^{nd} second,

$$x=x_2-x_1=A-\frac{A}{\sqrt{2}}=A\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$$

$\therefore$ Required ratio,

$$\frac{x_1}{x}=\frac{A/\sqrt{2}}{A\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)}=\frac{4\sqrt{2}/\sqrt{2}}{4\sqrt{2}\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)}=\frac{1}{\sqrt{2}-1}$$

Question35

A vertical spring oscillates with period 6 second with mass m is suspended from it. When the mass is at rest, the spring is stretched through a distance of (Take, acceleration due to gravity, $\mathrm{g}=\pi^2=10 \mathrm{~m} / \mathrm{s}^2$)

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Options:

A. 10 m

B. 3 m

C. 6 m

D. 9 m

Answer: D

Solution:

Given:

- Period of oscillation, $T=6$ s
- Mass suspended, m
- Acceleration due to gravity, $g=\pi^2=10 \mathrm{~m/s}^2$

Let the extension in the spring at equilibrium (rest position) be x.

Step 1: Relation between period and spring constant

The period for a spring-mass system:

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

where k is the spring constant.

Step 2: Express k in terms of m and T

Squaring both sides and rearranging for k,

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

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

$\Rightarrow \left(\frac{T}{2\pi}\right)^2 = \frac{m}{k}$

$\Rightarrow k = \frac{m}{\left(\frac{T}{2\pi}\right)^2}$

Step 3: Extension at equilibrium

At rest,

$mg = kx$

$\Rightarrow x = \frac{mg}{k}$

Step 4: Substitute value of k

From above,

$x = \frac{mg}{k}$

$= mg \times \frac{\left(\frac{T}{2\pi}\right)^2}{m}$

$= g\left(\frac{T}{2\pi}\right)^2$

Step 5: Plug the values

Given $T = 6$ s and $g = \pi^2 = 10$,

$x = 10\left(\frac{6}{2\pi}\right)^2$

$= 10\left(\frac{3}{\pi}\right)^2$

$= 10 \times \frac{9}{\pi^2}$

But $\pi^2 = 10$, so:

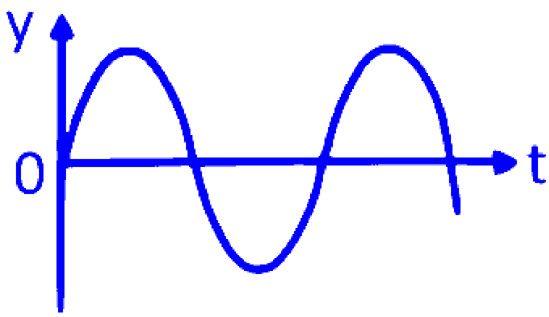
$x = 10 \times \frac{9}{10} = 9$ m

Final Answer:

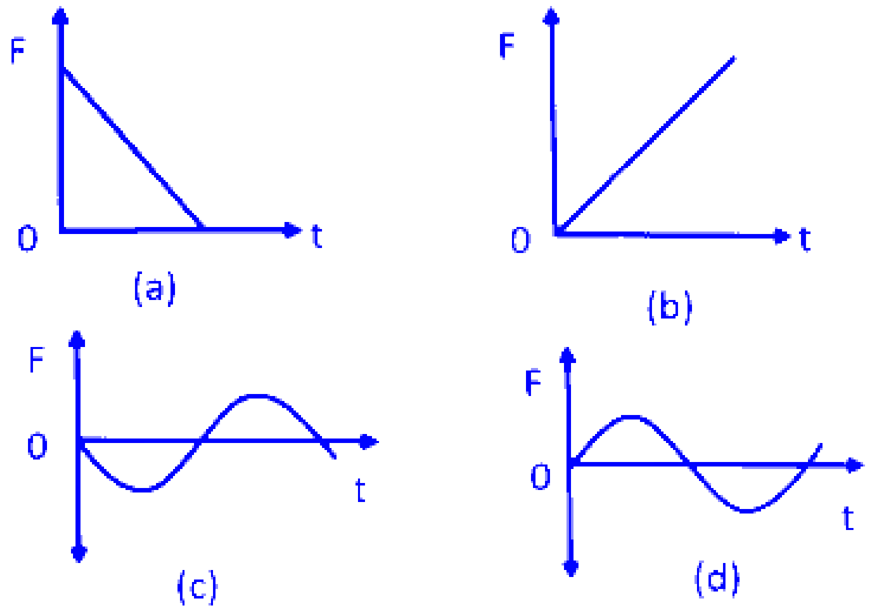
Option D: 9 m

Question36

For a particle performing; S.H.M. the displacement - time graph is shown.



For that particle the force - time graph is correctly shown in graph



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Options:

A. (a)

B. (b)

C. (c)

D. (d)

Answer: C

Solution:

Displacement and force (ma) are out of phase ($\Delta\alpha = \pi$) in S.H.M. Therefore, the correct graph will be graph (c).

Question37

If the length of the oscillating simple pendulum is made $\frac{1}{3}$ times the original keeping amplitude same then increase in its total energy at a place will be

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Options:

A. 3 times

B. 2 times

C. 9 times

D. 5 times

Answer: B

Solution:

Given:

The length of the pendulum is reduced to $\frac{1}{3}$ of the original.

Let the original length be l.

Step 1: Expression for Total Energy

The total energy E of a simple pendulum (for small amplitudes) is given by:

$E = \frac{1}{2} m\omega^2 A^2$

where

- m = mass of bob
- ω = angular frequency
- A = amplitude (linear)

Step 2: Angular Frequency for Simple Pendulum

$\omega = \sqrt{\frac{g}{l}}$

Step 3: Calculate Initial and Final Energy

Let E_1 = initial energy (length $= l$)

Let E_2 = final energy (length $= \frac{l}{3}$)

Initial:

$$E_1 = \frac{1}{2}m(\sqrt{\frac{g}{l}})^2 A^2 = \frac{1}{2}m\frac{g}{l}A^2$$

Final:

$$E_2 = \frac{1}{2}m\left(\sqrt{\frac{g}{l/3}}\right)^2 A^2 = \frac{1}{2}m\left(\frac{g}{l/3}\right)A^2 = \frac{1}{2}m\frac{3g}{l}A^2$$

Step 4: Find Ratio and Increase

$$\frac{E_2}{E_1} = \frac{\frac{1}{2}m\frac{3g}{l}A^2}{\frac{1}{2}m\frac{g}{l}A^2} = \frac{3g}{g} = 3$$

Increase in energy = $E_2 - E_1 = 3E_1 - E_1 = 2E_1$

So, **increase is 2 times the original energy.**

Correct answer:

Option B: 2 times

Question38

The time period of a simple pendulum inside a stationary lift is $\sqrt{3}$ second. When the lift moves upwards with an acceleration $g/3$, the time period will be ($\mathrm{g} =$ acceleration due to gravity)

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Options:

A. 1.5 s

B. 2 s

C. $\sqrt{3}$ s

D. 3 s

Answer: A

Solution:

Given:

- Time period in stationary lift, $T_1 = \sqrt{3}$ s
- Acceleration due to gravity = g
- Lift moves upwards with acceleration $a = \frac{g}{3}$

Step 1: Time period formula for a simple pendulum

In general,

$$T = 2\pi\sqrt{\frac{l}{g_{\text{eff}}}}$$

where g_{eff} is the effective acceleration due to gravity.

Step 2: Effective gravity in the stationary case

When the lift is stationary, $g_{\text{eff}} = g$

So,

$$T_1 = 2\pi\sqrt{\frac{l}{g}}$$

Step 3: Effective gravity when lift moves upward

When lift accelerates upwards with a,

$$g_{\text{eff}} = g + a = g + \frac{g}{3} = \frac{4g}{3}$$

Step 4: New time period

The new time period is

$$T_2 = 2\pi\sqrt{\frac{l}{g_{\text{eff}}}} = 2\pi\sqrt{\frac{l}{\frac{4g}{3}}}$$

$$T_2 = 2\pi\sqrt{\frac{3l}{4g}}$$

Express l in terms of T_1:

$$T_1 = 2\pi\sqrt{\frac{l}{g}}$$

Square both sides:

$$T_1^2 = 4\pi^2\frac{l}{g} \implies l = \frac{gT_1^2}{4\pi^2}$$

Now, substitute l into T_2:

$$T_2 = 2\pi\sqrt{\frac{3}{4g} \cdot \frac{gT_1^2}{4\pi^2}}$$

$$T_2 = 2\pi\sqrt{\frac{3T_1^2}{16\pi^2}}$$

$$T_2 = 2\pi \cdot \frac{T_1}{4\pi}\sqrt{3}$$

$T_2 = \frac{T_1}{2}\sqrt{3}$

Step 5: Substitute $T_1 = \sqrt{3}$ s

$T_2 = \frac{\sqrt{3}}{2} \times \sqrt{3} = \frac{3}{2} = 1.5$ seconds

Final Answer:

Option **A) 1.5 s**

Question39

A mass suspended from a vertical spring performs S.H.M. of period 0.1 second. The spring is unstretched at the highest point of suspension. Maximum speed of the mass is (Gravitational acceleration $\mathrm{g} = 10\ \mathrm{m/s^2}$)

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Options:

A. $\frac{1}{2\pi}\ \mathrm{m/s}$

B. $\frac{1}{\pi}\ \mathrm{m/s}$

C. $\frac{2}{\pi}\ \mathrm{m/s}$

D. $\pi \mathrm{m/s}$

Answer: A

Solution:

Given:

- Time for one complete swing (period) $T = 0.1$ seconds
- The spring is **not stretched** when the mass is at its highest point (this is the farthest point from the middle position).
- Gravitational acceleration, $g = 10\,\mathrm{m/s}^2$

Let's find the answer step by step.

Step 1: Formula for Maximum Speed in S.H.M.

In simple harmonic motion, the highest speed is given by:

$v_{max} = A\omega$

Where:

- A is the amplitude (the maximum distance from the center position)
- ω is the angular frequency (tells us how fast the object goes in a circle or swings back and forth)

Step 2: Find Angular Frequency ω

The formula connecting period and angular frequency is:

$\omega = \frac{2\pi}{T}$

Plug in $T = 0.1$:

$\omega = \frac{2\pi}{0.1} = 20\pi$

Step 3: Find Amplitude A

At the highest position, the spring is just relaxed (not stretched). This point is A distance from the mean (middle) position.

- At the middle (mean position), gravity balances the pull of the spring: $mg = kx_0$, where x_0 is the stretch from natural length.
- At highest point: extension is 0 (spring just relaxed). This distance from the middle to the top is our amplitude A.
- So, $A = x_0$.

Thus, to find A we find x_0.

From $mg = kx_0$:

$x_0 = \frac{mg}{k}$

Step 4: Connect k and m to ω

For a spring and mass, angular frequency is:

$\omega = \sqrt{\frac{k}{m}}$

This means $\frac{k}{m} = \omega^2$.

So, substitute into earlier expression for x_0:

$x_0 = \frac{mg}{k} = \frac{g}{k/m} = \frac{g}{\omega^2}$

Step 5: Plug Amplitude into the Speed Formula

Recall:

$v_{max} = A\omega$

Since $A = x_0 = \frac{g}{\omega^2}$, then:

$v_{max} = \frac{g}{\omega^2} \cdot \omega = \frac{g}{\omega}$

Step 6: Substitute the Values

- $g = 10$
- $\omega = 20\pi$

Now calculate maximum speed:

$v_{max} = \frac{10}{20\pi} = \frac{1}{2\pi}$ m/s

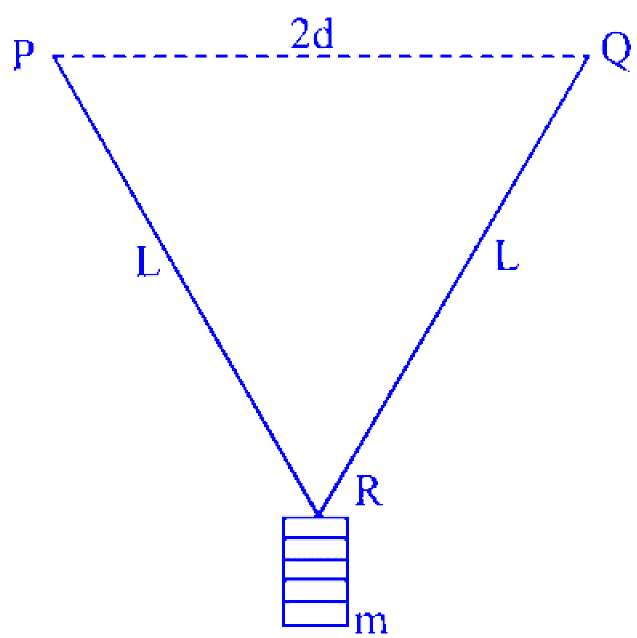
Step 7: Final Answer

The correct answer is:

$$\boxed{\frac{1}{2\pi}\ \mathrm{m/s}}$$

Question40

' P ' and ' Q ' are fixed points in same plane and mass ' m ' is tied by string as shown in figure. If the mass is displaced slightly out of this plane and released, it will oscillate with time period $(\mathrm{PQ} = 2\ \mathrm{d}, \mathrm{PR} = \mathrm{QR} = \mathrm{L})(\mathrm{g} =$ gravitational acceleration)



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Options:

A. $2\pi\sqrt{\frac{L}{g}}$

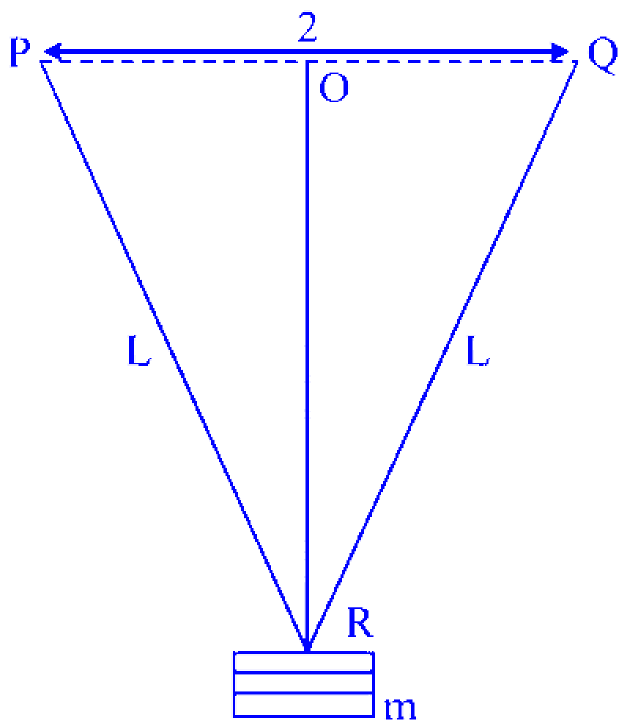
B. $2\pi\sqrt{\frac{L^2}{g}}$

C. $2\pi\sqrt{\frac{(L^2-d^2)^{1/2}}{g}}$

D. $2\pi\sqrt{\frac{(L^2+d^2)^{1/2}}{g}}$

Answer: C

Solution:



The motion of mass ' m ' is defined as a simple harmonic motion (S.H.M) with its length equal to OR:

From figure, $OR = \sqrt{L^2 - d^2}$

$\therefore$ Time period, $T = 2\pi\sqrt{\frac{\left(L^2-d^2\right)^{1/2}}{g}}$

Question41

The bob of a pendulum of length ' l ' is pulled aside from its equilibrium position through an angle ' θ ' and then released. The bob will then pass through its equilibrium position with speed ' v ', where ' v ' equal to ($g=$ acceleration due to gravity)

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Options:

A. $\sqrt{2gl(1-\cos\theta)}$

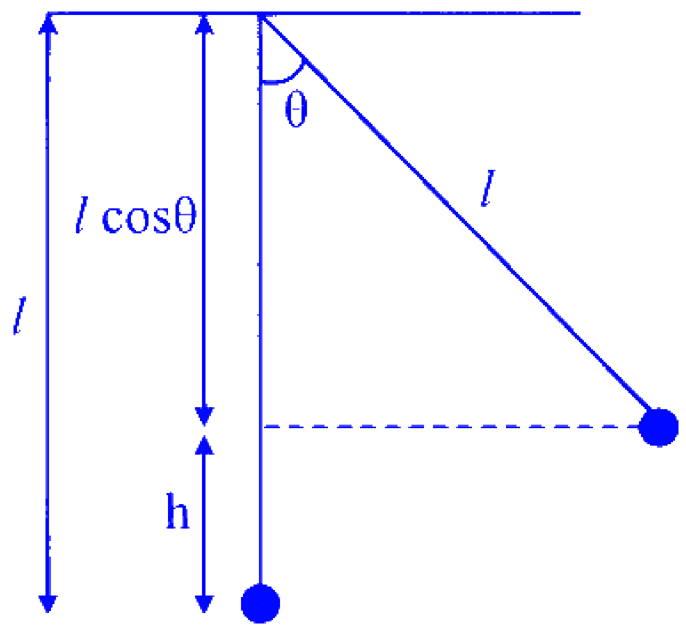
B. $\sqrt{2\ \mathrm{g}l(1+\sin\theta)}$

C. $\sqrt{2gl(1-\sin\theta)}$

D. $\sqrt{2\ \mathrm{g}l(1+\cos\theta)}$

Answer: A

Solution:



When bob of a pendulum rises up a height ' h ' potential energy at extreme position becomes kinetic energy of mean position.

$$\mathrm{mgh} = \frac{1}{2}\mathrm{mv}_{\max}^2$$

$$\therefore \quad \mathrm{v}_{\max} = \sqrt{2\mathrm{gh}}$$

$$l = \mathrm{h} + l\cos\theta$$

$$\therefore \quad \mathrm{h} = l(1-\cos\theta)$$

$$\therefore \quad \mathrm{v}_{\max} = \sqrt{2\mathrm{gl}(1-\cos\theta)}$$

Question42

The kinetic energy of a particle, executing simple harmonic motion is 16 J when it is in mean position. If amplitude of motion is 25 cm and the mass of the particle is 5.12 kg , the period of oscillation is

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Options:

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

B. 2π s

C. 20π s

D. 5π s

Answer: A

Solution:

Given:

Kinetic Energy (K.E.) at mean position = 16 J

Amplitude (A) = 25 cm = 0.25 m

Mass (m) = 5.12 kg

The kinetic energy at the mean position is equal to the total energy of the particle in simple harmonic motion. Therefore, we have:

Total energy $E = \frac{1}{2}m\omega^2 A^2 = 16$

To find the angular frequency ω, we rearrange the equation:

$\omega^2 = \frac{16\times2}{5.12\times(0.25)^2} = 10^2$

Thus, the angular frequency is:

$\omega = 10$

The period T of oscillation is given by:

$T = \frac{2\pi}{\omega} = \frac{2\pi}{10} = \frac{\pi}{5}$ s

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Question43

A particle performs linear S.H.M. At a particular instant, velocity of the particle is ' u ' and acceleration is ' α ' while at another instant, velocity is ' v ' and acceleration is ' β ' $(0 < \alpha < \beta)$. The distance between the two positions is

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Options:

A. $\frac{u^2-v^2}{\alpha+\beta}$

B. $\frac{u^2+v^2}{\alpha+\beta}$

C. $\frac{u^2-v^2}{\alpha-\beta}$

D. $\frac{u^2+v^2}{\alpha-\beta}$

Answer: A

Solution:

When velocity is u and acceleration is α, let the position of particle be x_1.When velocity is v and acceleration is β, let the position of particle be x_2.

If ω is the angular frequency then,

$$\alpha = \omega^2 x_1$$
$$\text{and } \beta = \omega^2 x_2$$
$$\therefore \quad \alpha + \beta = \omega^2 (x_1 + x_2) \quad \text{.... (i)}$$

Also, velocity of particle at particular instant can be given as,

$u^2 = \omega^2 A^2 - \omega^2 x_1^2$

and $v^2 = \omega^2 A^2 - \omega^2 x_2^2$

i.e., $v^2 - u^2 = \omega^2 \left(x_1^2 - x_2^2\right)$

$v^2 - u^2 = \omega^2 \left(x_1 - x_2\right)\left(x_1 + x_2\right)$ .... (ii)

from equation (i) we get

$v^2 - u^2 = (x_1 - x_2)(\alpha + \beta)$

$\therefore \quad \mathrm{x}_1 - \mathrm{x}_2 = \frac{\mathrm{v}^2 - \mathrm{u}^2}{\alpha + \beta}$

or $x_2 - x_1 = \frac{u^2 - v^2}{\alpha + \beta}$

Question44

A particle executing S.H.M. has velocities ' V_1 ' and ' V_2 ' at distances ' x_1 ' and ' x_2 ' respectively, from the mean position. Its frequency is

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Options:

A. $\frac{1}{2\pi}\sqrt{\frac{V_1^2 - V_2^2}{x_1^2 - x_2^2}}$

B. $2\pi\sqrt{\frac{x_1^2 - x_2^2}{v_1^2 - V_2^2}}$

C. $\frac{1}{2\pi}\sqrt{\frac{V_2^2 - V_1^2}{x_1^2 - x_2^2}}$

D. $2\pi\sqrt{\frac{\mathrm{x}_1^2 - \mathrm{x}_2^2}{\mathrm{V}_2^2 - \mathrm{V}_1^2}}$

Answer: C

Solution:

Particle velocities are

$$V_1^2 = \omega^2 \left(A^2 - x_1^2\right) \quad .... \text{(i)}$$
$$V_2^2 = \omega^2 \left(A^2 - x_2^2\right) \quad .... \text{(ii)}$$

Subtracting (i) from (ii),

$$V_2^2 - V_1^2 = \omega^2 \left(x_1^2 - x_2^2\right)$$
$$\omega = \sqrt{\frac{V_2^2 - V_1^2}{x_1^2 - x_2^2}}$$

As $\omega = 2\pi f$ we get,

$$\mathrm{f} = \frac{1}{2\pi}\sqrt{\frac{\mathrm{V}_2^2 - \mathrm{V}_1^2}{\mathrm{x}_1^2 - \mathrm{x}_2^2}}$$

Question45

For a particle executing S.H.M. having amplitude A, the speed of the article is $\left(\frac{1}{3}\right)^{\text{rd}}$ of its maximum speed when the displacement from the mean position is

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Options:

A. $\frac{3\text{ A}}{\sqrt{2}}$

B. $\frac{2\text{ A}}{3}$

C. $\frac{2\sqrt{2}}{3}\text{ A}$

D. $\frac{\sqrt{2}}{3}\text{ A}$

Answer: C

Solution:

$V=\omega\sqrt{A^2-x^2}$ .... (i)

$V_{\max}=\omega A$

$V=\frac{V_{\max}}{3}=\frac{\omega a}{3}$

$\frac{\omega A}{3}=\omega\sqrt{A^2-x^2}$ ... [From (i)]

$\frac{A^2}{9}=\left(A^2-x^2\right)$

$x^2=A^2-\frac{A^2}{9}$

$x=\sqrt{\frac{8}{9}A^2}$

$x=\frac{2\sqrt{2}}{3}A$

Question46

The motion of a particle is described by the equation $a=-bx$ where ' a ' is the acceleration, x is the displacement from the equilibrium position and b is a constant. The periodic time will be

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Options:

A. $\frac{2\pi}{\mathrm{b}}$

B. $\frac{2\pi}{\sqrt{b}}$

C. $2\pi\sqrt{b}$

D. $2\sqrt{\frac{\pi}{b}}$

Answer: B

Solution:

Given, $\mathrm{a}=-\mathrm{bx}$

But, $a=-\omega^2 x$

$\therefore \quad \omega=\sqrt{b} \quad .... (i)$

$$T=\frac{2\pi}{\omega}$$

$$=\frac{2\pi}{\sqrt{b}} \quad ...[From(i)]$$

Question47

A horizontal platform with a small object placed on it executes a linear S.H.M. in the vertical direction. The amplitude of oscillation is 40 cm . What should be the least period of these oscillations, so that the object is not detached from the platform? [Take $g=10 \mathrm{~m/s^2}$]

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Options:

A. 0.2π s

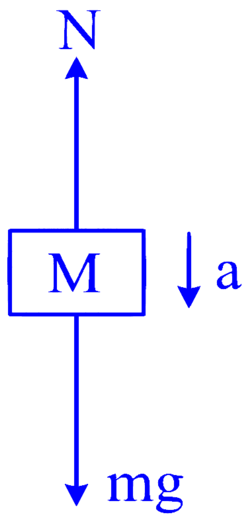
B. 0.3π s

C. 0.4π s

D. 0.5π s

Answer: C

Solution:



From the diagram,

$\mathrm{mg} - \mathrm{N} = \mathrm{ma}$

For the object to just lose the Contact with the surface,

$\mathrm{N} = 0$

$$\therefore \quad mg = ma$$
$$\therefore \quad g = a$$
$$\therefore \quad g = A\omega^2$$
$$\therefore \quad \omega = \sqrt{\frac{g}{A}} = \sqrt{\frac{10}{0.4}} = \sqrt{\frac{100}{4}} = \frac{10}{2} = 5$$
$$\therefore \quad \frac{2\pi}{T} = 5$$
$$\therefore \quad T = \frac{2\pi}{5} = 0.4\pi$$

Question48

Starting from mean position, a body oscillates simple harmonically with a period ' T '. After what time will its kinetic energy be 75% of the total energy? $(\sin 30^{\circ} = 0.5)$

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Options:

A. $\frac{\mathrm{T}}{8}$

B. $\frac{\mathrm{T}}{12}$

C. $\frac{\mathrm{T}}{16}$

D. $\frac{\mathrm{T}}{24}$

Answer: B

Solution:

$$\mathrm{KE} = 75\% \text{ of TE}$$

$\therefore \quad \frac{1}{2}\mathrm{ma}^2\omega^2\cos^2\omega t = \frac{75}{100} \times \frac{1}{2}\mathrm{ma}^2\omega^2$

$\therefore \quad \cos^2\omega t = \frac{3}{4}$

$\therefore \quad \cos\omega t = \frac{\sqrt{3}}{2}$

$\therefore \quad \omega t = \frac{\pi}{6}$

$\therefore \quad \frac{2\pi}{T}t = \frac{\pi}{6} \quad \therefore \quad t = \frac{T}{12}$

Question49

The maximum velocity of a particle, executing S.H.M. with an amplitude 7 mm is $4.4\ \mathrm{ms}^{-1}$The period of oscillation is $\left[\pi = \frac{22}{7}\right]$

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Options:

A. 100 s

B. 10 s

C. 0.1 s

D. 0.01 s

Answer: D

Solution:

$$\mathrm{V}_{\max} = \mathrm{A}\omega$$

$\therefore \quad 4.4 = 7 \times 10^{-3}\left(\frac{2\pi}{T}\right)$

$\therefore \quad T = \frac{7 \times 10^{-3} \times 2 \times 22}{4.4 \times 7} = 0.01\ \mathrm{s}$

Question50

A particle is performing S.H.M. about its mean position with an amplitude ' a ' and periodic time ' T '. The speed of the particle when its displacement from mean position is $\frac{a}{3}$ will be

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Options:

A. $\frac{2\pi \mathrm{a}}{\mathrm{T}}$

B. $\frac{4\sqrt{2}\pi \mathrm{a}}{3\ \mathrm{T}}$

C. $\frac{4\pi^2 a}{3\ \mathrm{T}}$

D. $\frac{\sqrt{3}\pi^2 a}{2\ \mathrm{T}}$

Answer: B

Solution:

In simple harmonic motion (S.H.M.), the displacement of a particle from the mean position is given by:

$x = a\cos(\omega t)$

where:

a is the amplitude,

ω is the angular frequency,

t is the time.

The angular frequency ω is related to the periodic time T by:

$\omega = \frac{2\pi}{T}$

The speed v of a particle performing S.H.M. is given by:

$v = \omega\sqrt{a^2 - x^2}$

Substituting the displacement $x=\frac{a}{3}$ into the equation, we get:

$v=\omega \sqrt{a^2-\left(\frac{a}{3}\right)^2}$

Calculate $a^2-\left(\frac{a}{3}\right)^2$:

$a^2-\left(\frac{a}{3}\right)^2=a^2-\frac{a^2}{9}=\frac{9 a^2}{9}-\frac{a^2}{9}=\frac{8 a^2}{9}$

Therefore, the speed v is:

$v=\omega \sqrt{\frac{8 a^2}{9}}=\omega \cdot a \cdot \frac{2 \sqrt{2}}{3}$

Substitute $\omega=\frac{2 \pi}{T}$:

$v=\frac{2 \pi}{T} \cdot a \cdot \frac{2 \sqrt{2}}{3}$

Simplifying this expression gives:

$v=\frac{4 \sqrt{2} \pi a}{3 T}$

Thus, the correct answer is Option B:

$\frac{4 \sqrt{2} \pi a}{3 T}$

Question51

A piece of wood has length, breadth and height, ' a ', ' b ' and ' c ' respectively. Its relative density, is ' d '. It is floating in water such that the side ' a ' is vertical. It is pushed down a little and released. The time period of S.H.M. executed by it is ($\mathrm{g}=$ acceleration due to gravity)

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Options:

A. $2 \pi \sqrt{\frac{a b c}{g}}$

B. $2 \pi \sqrt{\frac{\mathrm{bc}}{\mathrm{dg}}}$

C. $2\pi\sqrt{\frac{g}{da}}$

D. $2\pi\sqrt{\frac{\mathrm{ad}}{\mathrm{g}}}$

Answer: D

Solution:

Time period of SHM of small vertical oscillations in liquid is given by

$\mathrm{T}=2\pi\sqrt{\frac{l}{\mathrm{g}}}$ where l is the length of piece of wood

Weight of wood $=$ weight of water displaced

$\therefore \quad$ Mass of wood $\times\mathrm{g}=$ Mass of water displaced $\times\mathrm{g}$

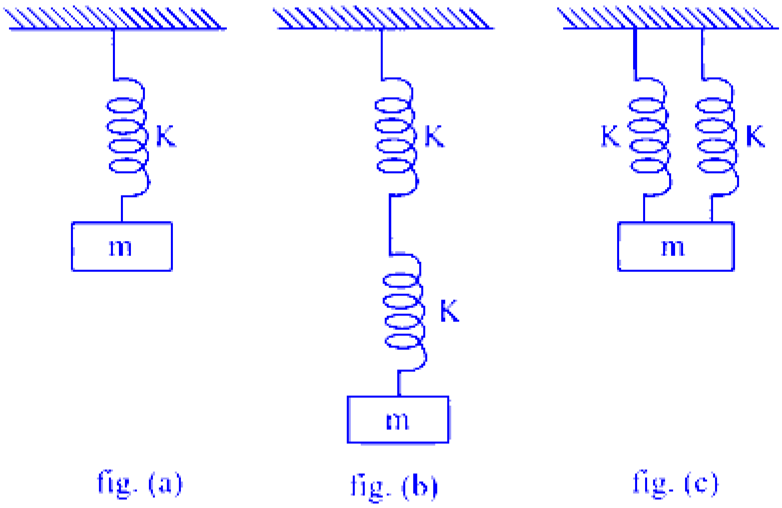
$\therefore \quad \mathrm{abc}\times\mathrm{d}\times\mathrm{g}=\mathrm{bc}l\times 1\times\mathrm{g}\ldots$ (mass $=$ volume $\times$ density)

$l=\mathrm{da}$

$$\therefore \quad \mathrm{T}=2\pi\sqrt{\frac{\mathrm{ad}}{\mathrm{g}}}$$

Question52

All the springs in fig. (a), (b) and (c) are identical, each having force constant K . Mass attached to each system is ' m '. If T_a, T_b and T_c are the time periods of oscillations of the three systems respectively, then



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Options:

A. $\mathrm{T_a} = \sqrt{2}\,\mathrm{T_b}$

B. $\mathrm{T_a} = \frac{\mathrm{T_c}}{\sqrt{2}}$

C. $T_b = 2T_a$

D. $T_b = 2T_c$

Answer: D

Solution:

$$\mathrm{T_a} = 2\pi\sqrt{\frac{\mathrm{m}}{\mathrm{K}}}$$

$$\mathrm{T_b} = 2\pi\sqrt{\frac{\mathrm{m}}{\frac{\mathrm{K}}{2}}}$$

$$\therefore \quad \mathrm{T_b} = 2\pi\sqrt{\frac{2\,\mathrm{m}}{\mathrm{K}}} = \sqrt{2}\,\mathrm{T_a} \Rightarrow \mathrm{T_a} = \frac{\mathrm{T_b}}{\sqrt{2}} \quad \text{.... (i)}$$

$$\mathrm{T_c} = 2\pi\sqrt{\frac{\mathrm{m}}{2\,\mathrm{K}}} = \frac{\mathrm{T_a}}{\sqrt{2}} \Rightarrow \mathrm{T_a} = \sqrt{2}\,\mathrm{T_c} \quad \text{.... (ii)}$$

From (i) and (ii),

$$\frac{T_b}{\sqrt{2}} = \sqrt{2}T_c \Rightarrow T_b = 2T_c$$

Question53

A simple pendulum of length ' L ' has mass ' M ' and it oscillates freely with amplitude ' A '. At extreme position, its potential energy is

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Options:

A. $\frac{\mathrm{MgA}^2}{\mathrm{L}}$

B. $\frac{2\mathrm{MgA}^2}{\mathrm{L}}$

C. $\frac{\mathrm{MgA}}{2\ \mathrm{L}}$

D. $\frac{\mathrm{MgA}^2}{2\ \mathrm{L}}$

Answer: D

Solution:

Potential energy of particle at extreme position is

$$\text{P.E.} = \frac{1}{2} M\omega^2 A^2$$

$$= \frac{1}{2} M \times \frac{g}{L} \times A^2 \quad \ldots\ldots \left(\because \omega = \sqrt{\frac{g}{l}}\right)$$

Question54

A particle performing S.H.M. starts from equilibrium position and its time period is 12 second. After 2 seconds its velocity is $\pi \mathrm{m/s}$. Amplitude of the oscillation is

$$\left[\sin 30^\circ = \cos 60^\circ = 0 \cdot 5, \sin 60^\circ = \cos 30^\circ = \sqrt{3}/2\right]$$

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Options:

A. 6 m

B. 12 m

C. $12\sqrt{3}$ m

D. $6\sqrt{3}$ m

Answer: B

Solution:

Displacement of the particle, $x = A \sin \omega t$

Velocity of the particle,

$v = \frac{dx}{dt} = A\omega \cos \omega t \quad .... \text{(i)}$

Given that,

$$\begin{aligned} & v = \pi \mathrm{m/s},\ \mathrm{T} = 12 \mathrm{~s}, \\ \therefore \quad & \omega = \frac{2\pi}{\mathrm{T}} = \frac{\pi}{6} \mathrm{rad/s} \end{aligned}$$

Substituting in equation (i), we get,

$$\begin{aligned} & \pi = \mathrm{A} \times \frac{\pi}{6} \times \cos\left(\frac{\pi}{6} \times 2\right) \\ \therefore \quad & 1 = \frac{A}{6} \cos\left(\frac{\pi}{3}\right) = \frac{A}{6} \times \frac{1}{2} \\ \therefore \quad & A = 12 \mathrm{~m} \end{aligned}$$

Question55

A particle performs linear S.H.M. at a particular instant, velocity of the particle is ' u ' and acceleration is ' a_1 ' while at another instant velocity is ' V ' and acceleration is a_2 $(0 < a_1 < a_2)$. Find the relation between u,v,a_1,a_2 and angular frequency ω."

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Options:

A. $\frac{v^2-u^2}{a_1-a_2}$

B. $\frac{v^2+u^2}{a_1+a_2}$

C. $\frac{u^2+v^2}{a_1-a_2}$

D. $\frac{u^2-V^2}{a_1+a_2}$

Answer: D

Solution:

When velocity is u and acceleration is a_1, let the position of particle be x_1.

When velocity is v and acceleration is a_2, let the position of particle be x_2.

If ω is the angular frequency then, $a_1=\omega^2 x_1$

and $a_2=\omega^2 x_2$

$\therefore \quad \mathrm{a}_1+\mathrm{a}_2=\omega^2\left(\mathrm{x}_1+\mathrm{x}_2\right) \quad \ldots$ (i)

Also, velocity of particle at particular instant can be given as,

$$u^2=\omega^2 A^2-\omega^2 x_1^2$$
$$\text{and } v^2=\omega^2 A^2-\omega^2 x_2^2$$
$$\text{i.e., } v^2-u^2=\omega^2\left(x_1^2-x_2^2\right)$$
$$v^2-u^2=\omega^2\left(x_1-x_2\right)\left(x_1+x_2\right) \quad \text{.... (ii)}$$

from equation (i) we get

$$\therefore \quad x_1-u_2=\frac{v^2-u^2}{a_1+a_2}$$
$$\text{or } x_2-x_1=\frac{u^2-v^2}{a_1+a_2}$$

Question56

A particle starts oscillating simple harmonically from its equilibrium position with time period ' T '. What is the ratio of potential energy to kinetic energy of the particle at time $t=\frac{T}{12}$? $\left(\sin\left(\frac{\pi}{6}\right)=\frac{1}{2}\right)$

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Options:

A. 1 : 2

B. 2 : 1

C. 1 : 3

D. 3 : 1

Answer: C

Solution:

For SHM,

$$\text{P.E.} = \frac{1}{2} m \omega^2 x^2 \quad \text{.... (i)}$$
$$\text{and K.E.} = \frac{1}{2} m \omega^2 \left(A^2 - x^2\right) \quad \text{.... (ii)}$$

Given $t = \frac{T}{12}$

$$\therefore \quad x = A \sin \omega t = A \sin \frac{2\pi}{T} \cdot t$$
$$\therefore \quad x = A \sin \frac{2\pi}{T} \times \frac{T}{12}$$
$$= A \sin \left(\frac{\pi}{6}\right)$$
$$= \frac{A}{2} \quad \text{.... (iii)}$$

Substituting equation (iii) in equation (i),

$$\text{P.E.} = \frac{1}{2} m \omega^2 \left(\frac{A^2}{4}\right)$$

$$= \frac{m \omega^2 A^2}{8}$$

Substituting equation (iii) in equation (ii),

$$\begin{aligned} \text{K.E.} &= \frac{1}{2} \mathrm{m}\omega^2 \left(\mathrm{A}^2 - \frac{\mathrm{A}^2}{4} \right) \\ &= \frac{1}{2} \mathrm{m}\omega^2 \left(\frac{3\ \mathrm{A}^2}{4} \right) \end{aligned}$$

$$\therefore \quad \frac{\text{P.E.}}{\text{K.E.}} = \frac{\frac{1}{2} m\omega^2 A^2 \times \frac{1}{4}}{\frac{1}{2} m\omega^2 A^2 \times \frac{3}{4}} = \frac{1}{3}$$

Question57

A particle performs linear S.H.M. When the displacement of the particle from mean position is 3 cm and 4 cm , corresponding velocities are $8 \mathrm{~cm} / \mathrm{s}$ and $6 \mathrm{~cm} / \mathrm{s}$ respectively. Its periodic time is

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Options:

A. 2π s

B. πs

C. 3π s

D. 4π s

Answer: B

Solution:

We have $v=\omega \sqrt{A^2-x^2}$

Substituting the given values in the above equation we get,

$8=\omega \sqrt{\mathrm{A}^2-9} \ldots \text{(i)} \left(\because x=3 \mathrm{~cm}, \mathrm{v}=8 \mathrm{cms}^{-1}\right)$

$6=\omega \sqrt{A^2-16} \ldots \text{(ii)} \left(\because x=4 \mathrm{~cm}, \mathrm{v}=6 \mathrm{~cms}^{-1}\right)$

Diving equation (i) and (ii),

$$\frac{8}{6}=\frac{\sqrt{A^2-9}}{\sqrt{A^2-16}}$$

$$\frac{4}{3}=\frac{\sqrt{A^2-9}}{\sqrt{A^2-16}}$$

$$\therefore \quad \frac{16}{9}=\frac{A^2-9}{A^2-16}$$

$$\therefore \quad 16 A^2-256=9 A^2-81$$

$$7 A^2=175$$

$$\therefore \quad A^2=\frac{175}{7}$$

Substituting this value of A^2 in equation (ii) and solving we get

$$6=\omega \sqrt{\frac{175}{7}-16}$$

$$6=\omega \sqrt{\frac{175-112}{7}}=\omega \sqrt{9}$$

$$6=3 \omega$$

$$\omega=2$$

$$\therefore \quad \omega=\frac{2 \pi}{T}=2$$

$$\therefore \quad T=\pi \text{ seconds}$$

Question58

A simple pendulum of length ' l ' has a brass bob attached at its lower end. It's period is ' T '. A steel bob of the same size, having density ' x ' times that of brass, replaces the brass bob. Its length is then so changed that the period becomes ' 2 T '. What is the new length?

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Options:

A. $4 l x$

B. $\frac{4 l}{x}$

C. $4l$

D. $2l$

Answer: C

Solution:

The period of a simple pendulum is given by the formula:

$$T=2\pi\sqrt{\frac{l}{g}}$$

where T is the period, l is the length of the pendulum, and g is the acceleration due to gravity.

For the pendulum with the initial brass bob, the period is:

$$T=2\pi\sqrt{\frac{l}{g}}$$

When the brass bob is replaced with a steel bob of the same size but x times the density, the material change does not directly affect the period because the period of a simple pendulum depends only on its length and gravity, not the mass or density of the bob.

However, you are then modifying the length such that the new period becomes $2T$:

$$2T=2\pi\sqrt{\frac{l_{\text{new}}}{g}}$$

Setting this equal to the original equation for T scaled by 2:

$$2\left(2\pi\sqrt{\frac{l}{g}}\right)=2\pi\sqrt{\frac{l_{\text{new}}}{g}}$$

Solving for l_{new} :

Simplify both sides:

$$\sqrt{\frac{l_{\text{new}}}{g}}=2\sqrt{\frac{l}{g}}$$

Square both sides to eliminate the square roots:

$$\frac{l_{\text{new}}}{g}=4\cdot\frac{l}{g}$$

Multiply through by g:

$$l_{\text{new}}=4l$$

The new length of the pendulum that makes the period $2T$ is $l_{\text{new}}=4l$.

Therefore, the correct option is:

Option C: $4l$

Question59

A particle performing S.H.M. with maximum velocity ' V '. If the amplitude double and periodic time is made, $\left(\frac{1}{3}\right)^{\text{rd}}$ then the maximum velocity is

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Options:

A. 6V

B. $\frac{\mathrm{V}}{3}$

C. $\frac{3V}{2}$

D. $\frac{2\mathrm{~V}}{3}$

Answer: A

Solution:

In simple harmonic motion (S.H.M.), the maximum velocity ($v_{\max}$) of a particle can be given by the formula:

$v_{\max} = A\omega$

where A is the amplitude and ω is the angular frequency. The angular frequency ω can be related to the period T by:

$\omega = \frac{2\pi}{T}$

Initially, the particle has an amplitude A and period T, so the initial maximum velocity is:

$V = A \cdot \frac{2\pi}{T}$

Now, the amplitude is doubled to $2A$ and the period becomes $\left(\frac{1}{3}\right)T$. The new angular frequency ω' is:

$\omega' = \frac{2\pi}{(1/3)T} = \frac{6\pi}{T}$

Thus, the new maximum velocity $v'_{\max}$ is:

$v'_{\max} = (2A) \cdot \frac{6\pi}{T} = 12A \cdot \frac{\pi}{T}$

Since the original maximum velocity V was:

$V = A \cdot \frac{2\pi}{T}$

Relating the new maximum velocity to the original, we get:

$v'_{\max} = 6 \cdot (A \cdot \frac{2\pi}{T}) = 6V$

Therefore, the maximum velocity, when the amplitude is doubled and the period is reduced to one-third, is:

Option A: 6V

Question60

Let ' l_1 ' be the length of simple pendulum. Its length changes to ' l_2 ' to increase the periodic time by 20%. The ratio $\frac{l_2}{l_1} =$

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Options:

A. 1.22

B. 1.33

C. 1.44

D. 1.55

Answer: C

Solution:

$\mathrm{T} = 2\pi\sqrt{\frac{l}{g}}$

As the periodic time increases by 20%,

$$T_2 = T_1 + \frac{20}{100} = \frac{120}{100} T_1$$

$$\frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}}$$

$$\left(\frac{T_2}{T_1}\right)^2 = \frac{l_2}{l_1}$$

$$\left(\frac{120 T_1}{100 \times T_1}\right)^2 = \frac{l_2}{l_1}$$

$$\frac{36}{25} = \frac{l_2}{l_1}$$

$$\frac{l_2}{l_1} = 1.44$$

Question61

A particle is executing a linear simple harmonic motion. Let ' V_1 ' and ' V_2 ' are its speed at distance ' x_1 ' and ' x_2 ' from the equilibrium position. The amplitude of oscillation is

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Options:

A. $\sqrt{\frac{V_1^2 x_2^2 - V_2^2 x_2^2}{V_1^2 - V_2^2}}$

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

C. $\sqrt{\frac{V_1^2 x_2^2 - V_2^2 x_1^2}{V_1^2 - V_2^2}}$

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

Answer: A

Solution:

For S.H.M, velocity is given by,

$$V=\omega\sqrt{A^2-x^2} \Rightarrow V^2=\omega^2\left(A^2-x^2\right) \quad \text{... (i)}$$

$$\therefore \quad V_1^2=\omega^2\left(A^2-x_1^2\right)$$

$$\text{and } V_2^2=\omega^2\left(A^2-x_2^2\right) \quad \text{... [From (i)]}$$

$$\frac{V_1^2}{V_2^2}=\frac{\omega^2\left(A^2-x_1^2\right)}{\omega^2\left(A^2-x_2^2\right)}$$

$$V_1^2\left(A^2-x_2^2\right)=V_2^2\left(A^2-x_1^2\right)$$

$$A=\sqrt{\frac{V_1^2 x_2^2-V_2^2 x_1^2}{V_1^2-V_2^2}}$$

Question62

In S.H.M. the displacement of a particle at an instant is $Y=A\cos 30^{\circ}$, where $A=40$ cm and kinetic energy is 200 J . If force constant is $1\times 10^{\times}\mathrm{N/m}$, then x will be $\left(\cos 30^{\circ}=\sqrt{3}/2\right)$

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Options:

A. 4

B. 3

C. 2

D. 1

Answer: A

Solution:

$$Y=A\cos 30^{\circ}=40\times\frac{\sqrt{3}}{2}=20\sqrt{3}\text{ cm}$$
$$\text{K.E. }=\frac{1}{2}k\left(A^{2}-Y^{2}\right)$$
$$200=\frac{1}{2}k\left(\frac{1600}{10^{4}}-\frac{1200}{10^{4}}\right)$$
$$200=\frac{1}{2}k\left(\frac{400}{10^{4}}\right)$$
$$k=10000=1\times10^{4}$$
$$\therefore\quad x=4$$

Question63

A particle is performing S.H.M. with an amplitude 4 cm . At the mean position the velocity of the particle is $12\ \mathrm{cm/s}$. When the speed of the particle becomes $6\ \mathrm{cm/s}$, the distance of the particle from mean position is

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Options:

A. $\sqrt{3}$ cm

B. $\sqrt{6}$ cm

C. $2\sqrt{3}$ cm

D. $2\sqrt{6}$ cm

Answer: C

Solution:

At mean position, $\mathrm{v_{max}}=\mathrm{A}\omega$

$\therefore\quad \omega=\frac{\mathrm{v_{max}}}{\mathrm{A}}=\frac{12}{4}=3\mathrm{rad/s}$

Now, $\mathrm{v}=\omega\sqrt{\mathrm{A}^{2}-\mathrm{x}^{2}}$

$\therefore \quad v^2 = \omega^2 \left(A^2 - x^2\right)$

$\therefore \quad x^2 = A^2 - \frac{v^2}{\omega^2}$

$\therefore \quad x = \sqrt{16 - \frac{36}{9}} = \sqrt{12} = 2\sqrt{3}\ \mathrm{cm}$

Question64

The maximum velocity and maximum acceleration of a particle performing a linear S.H.M. is ' α ' and ' β ' respectively. Then the path length of the particle is

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Options:

A. $\frac{\alpha^2}{\beta}$

B. $\frac{\beta\alpha^2}{2\alpha^2}$

C. $\frac{2\alpha^2}{\beta}$

D. $\frac{2\beta}{\alpha^2}$

Answer: C

Solution:

For S.H.M.,

Maximum velocity, $\alpha = A\omega$

$\omega = \frac{\alpha}{A}$ .... (i)

Maximum acceleration, $\beta = A\omega^2$

$$\beta = A\left(\frac{\alpha}{A}\right)^2 = \frac{\alpha^2}{A}$$

$$\Rightarrow A = \frac{\alpha^2}{\beta}$$

$\therefore \quad$ Path length $= 2A = \frac{2\alpha^2}{\beta}$

Question65

A mass ' m ' attached to a spring oscillates with a period of 3 second. If the mass is increased by 0.6 kg , the period increases by 3 second. The initial mass ' m ' is equal to

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Options:

A. 0.1 kg

B. 0.2 kg

C. 0.3 kg

D. 0.4 kg

Answer: B

Solution:

Time period,

$\mathrm{T} = 2\pi\sqrt{\frac{\mathrm{m}}{\mathrm{k}}}$ .... (i)

$\therefore \quad \mathrm{T}_1 = 2\pi\sqrt{\frac{\mathrm{m}}{\mathrm{k}}}$ .... [From (i)]

$\therefore \quad 3 = 2\pi\sqrt{\frac{\mathrm{m}}{\mathrm{k}}}$ .....(given, $\mathrm{T}_1 = 3$ s)

$\frac{9}{4\pi^2} = \frac{\mathrm{m}}{\mathrm{k}}$

$\therefore \quad \mathrm{k} = \frac{4\pi^2 \mathrm{~m}}{9}$ .... (ii)

When mass is increased by 0.6 kg

$T_2 = 2\pi\sqrt{\frac{m+0.6}{k}}$ ... [From (i)]

$6 = \sqrt{\frac{m+0.6}{k}}$ $\ldots$ [given $T_2 = 3+3 = 6$ s$\left.\left.\right)\right]$

$\frac{36}{4\pi^2} = \frac{m+0.6}{k}$

$\frac{36}{4\pi^2} = (m+0.6)\frac{9}{4\pi^2 m}$

$4m = m + 0.6$

$m = 0.2kg$

Question66

The velocity of particle executing S.H.M. varies with displacement (x) as 4 $V^2 = 50 - x^2$. The time period of oscillation is $\frac{x}{7}$ second. The value of ' x ' is (Take $\pi = \frac{22}{7}$)

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Options:

A. 22

B. 44

C. 66

D. 88

Answer: D

Solution:

For the given particle velocity is given by,

$4V^2 = 50 - x^2$

$\therefore \quad V^2 = \frac{1}{4}(50 - x^2)$

$\therefore \quad V = \frac{1}{2}\sqrt{(50 - x^2)}$

We know that, $V=\omega\left(A^2-x_1^2\right)^{1/2}$

$\therefore \quad \omega=\frac{1}{2} \quad \Rightarrow T=\frac{2\pi}{\omega}=4\pi$

$\therefore \quad T=4\pi=4\times\frac{22}{7}=\frac{88}{7}$

$\therefore \quad x=88$

Question67

A simple pendulum of length l_1 has time period T_1. Another simple pendulum of length $l_2\ (l_1>l_2)$ has time period T_2. Then the time period of the pendulum of length (l_1-l_2) will be

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Options:

A. T_1-T_2

B. $\sqrt{\frac{T_1}{T_2}}$

C. $\sqrt{\mathrm{T}_1^2-\mathrm{T}_2^2}$

D. $\sqrt{\frac{T_2}{T_1}}$

Answer: C

Solution:

For a simple pendulum,

$\mathrm{T}_1=2\pi\sqrt{\frac{l_1}{\mathrm{g}}}$ and $\mathrm{T}_2=2\pi\sqrt{\frac{l_2}{\mathrm{g}}}$

Now, $\mathrm{T}_1^2=4\pi\times\frac{l_1}{\mathrm{g}}$ and $\mathrm{T}_2^2=4\pi\times\frac{l_2}{\mathrm{g}}$

$\therefore \quad l_1 = \frac{T_1^2 g}{4\pi}$ and $l_2 = \frac{T_2^2 g}{4\pi}$

$\therefore \quad l_1 - l_2 = \left(T_1^2 - T_2^2\right) \times \frac{g}{4\pi}$ .... (i)

Time period of pendulum of length $(l_1 - l_2)$ is,

$$T = 2\pi\sqrt{\frac{(l_1 - l_2)}{g}} = 2\pi\sqrt{\frac{\left(T_1^2 - T_2^2\right) \times \frac{g}{4\pi}}{g}}$$

$\therefore \quad T = \sqrt{T_1^2 - T_2^2}$

Question68

Two bodies A and B of equal mass are suspended from two separate massless springs of spring constants K_1 and K_2 respectively. The two bodies oscillate vertically such that their maximum velocities are equal. The ratio of the amplitude of B to that of A is

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Options:

A. $\frac{K_1}{K_2}$

B. $\frac{K_2}{K_1}$

C. $\sqrt{\frac{K_1}{K_2}}$

D. $\sqrt{\frac{K_2}{K_1}}$

Answer: C

Solution:

If the maximum velocities of the bodies are equal, then their total energy would also be the same. If $A_1,\ A_2$ are the amplitudes of A and B respectively, then

$$\frac{1}{2} K_1 A_1^2 = \frac{1}{2} K_2 A_2^2$$

$$\therefore \quad \frac{A_2}{A_1} = \sqrt{\frac{K_1}{K_2}}$$

Question69

The period of a simple pendulum gets doubled when

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Options:

A. its length is doubled.

B. its length is made four times.

C. its length is made half.

D. the mass of the bob is doubled.

Answer: B

Solution:

The period of a simple pendulum is given by the formula:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

where:

T is the period of the pendulum,

L is the length of the pendulum,

g is the acceleration due to gravity.

To determine when the period T gets doubled, consider the scenario where $T' = 2T$. Using the period formula, we have:

$$T' = 2\pi\sqrt{\frac{L'}{g}} = 2 \cdot 2\pi\sqrt{\frac{L}{g}}$$

This simplifies to:

$\sqrt{\frac{L'}{g}} = 2\sqrt{\frac{L}{g}}$

Squaring both sides gives:

$\frac{L'}{g} = 4 \cdot \frac{L}{g}$

which implies:

$L' = 4L$

Therefore, the period of a simple pendulum gets doubled when its length is made four times. The correct option is **Option B: its length is made four times**.

Question70

Frequency of a particle performing S.H.M. is 10 Hz . The particle is suspended from a vertical spring. At the highest point of its oscillation the spring is unstretched. Maximum speed of the particle is $\left(\mathrm{g}=10 \mathrm{~m} / \mathrm{s}^2\right)$

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Options:

A. $\frac{1}{\pi} \mathrm{~m} / \mathrm{s}$

B. $\frac{1}{2 \pi} \mathrm{~m} / \mathrm{s}$

C. $\frac{1}{4 \pi} \mathrm{~m} / \mathrm{s}$

D. $2 \pi \mathrm{~m} / \mathrm{s}$

Answer: B

Solution:

To find the maximum speed of the particle in simple harmonic motion (SHM) with frequency $10 \mathrm{~Hz}$, we will use the relationship between angular frequency, frequency, and maximum speed.

Determine Angular Frequency (ω):

The angular frequency ω is related to the frequency f by the formula:

$\omega = 2\pi f$

Given $f = 10\,\text{Hz}$, we have:

$\omega = 2\pi \times 10 = 20\pi\,\text{rad/s}$

Maximum Speed Formula in SHM:

The maximum speed v_{max} of a particle in SHM is given by:

$v_{\text{max}} = A\omega$

where A is the amplitude of the oscillation.

Determine Amplitude (A):

At the highest point, the spring is unstretched, meaning the elongation due to the particle's weight is equal to the amplitude of oscillation.

Use the equilibrium condition $mg = kA$, and since $\omega = \sqrt{\frac{k}{m}}$, $k = m\omega^2$.

Therefore, at maximum elongation, the net force provides the centripetal force for the circular motion:

$mg = m\omega^2 A$

Consequently, $A = \frac{g}{\omega^2}$.

Substitute Values to Find v_{max} :

Substituting for amplitude:

$A = \frac{10}{(20\pi)^2} = \frac{10}{400\pi^2} = \frac{1}{40\pi^2}$

Now, substitute A and ω into $v_{\text{max}} = A\omega$:

$v_{\text{max}} = \left(\frac{1}{40\pi^2}\right) \times 20\pi = \frac{20\pi}{40\pi^2}$

$v_{\text{max}} = \frac{1}{2\pi}\text{ m/s}$

Thus, the maximum speed of the particle is $\frac{1}{2\pi}$ m/s.

Answer:

Option B: $\frac{1}{2\pi}$ m/s

Question71

When a particle in linear S.H.M. completes two oscillations, its phase increases by

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Options:

A. π rad.

B. 2π rad.

C. 3π rad.

D. 4π rad.

Answer: D

Solution:

In linear simple harmonic motion (S.H.M.), the phase of a particle increases by 2π rad for each complete oscillation. Therefore, when the particle completes two oscillations, the phase increase will be:

$2 \times 2\pi = 4\pi$ rad

So, the correct option is:

Option D 4π rad.

Question72

A small sphere oscillates simple harmonically in a watch glass whose radius of curvature is 1.6 m . The period of oscillation of the sphere in second is (acceleration due to gravity, $\mathrm{g}=10 \mathrm{~m} / \mathrm{s}^2$)

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Options:

A. 0.8π

B. 0.6π

C. 0.4π

D. $0 \cdot 2\pi$

Answer: A

Solution:

$$\begin{aligned} \mathrm{T} &= 2\pi\sqrt{\frac{l}{\mathrm{g}}} \\ &= 2\pi\sqrt{\frac{1.6}{10}} \quad \ldots(\because \mathrm{R}=l) \\ &= 0.8\pi \end{aligned}$$

Question73

A tube of uniform bore of cross-sectional area ' A ' has been set up vertically with open end facing up. Now ' M ' gram of a liquid of density ' d ' is poured into it. The column of liquid in this tube will oscillate with a period ' T ', which is equal to [$g=$ acceleration due to gravity]

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Options:

A. $2\pi\sqrt{\frac{\mathrm{MA}}{\mathrm{gd}}}$

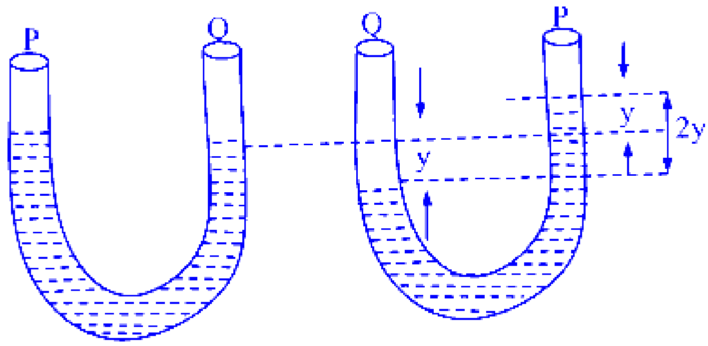
B. $2\pi\sqrt{\frac{\mathrm{M}}{2\mathrm{Adg}}}$

C. $2\pi\sqrt{\frac{M}{g}}$

D. $2\pi\sqrt{\frac{M}{gdA}}$

Answer: B

Solution:



For a depression of y cm on one side, the level of liquid will be 2 y cm higher on the other side.

$\therefore$ Weight of extra liquid on the P -side = 2 Aydg The above weight acts as the restoring force acting on mass M .

$\therefore$ Restoring acceleration $= -\frac{2\text{Aydg}}{\text{M}} \ldots$ (−ve sign indicates the acceleration and force are opposite to each other) ... (i)

We know for simple harmonic motion, $a = -\left(\frac{k}{m}\right)x$ .... (ii)

Comparing (i) and (ii), we see the motion is simple harmonic.

$$\therefore \quad \text{T} = 2\pi\sqrt{\frac{\text{Displacement}}{\text{Acceleration}}} = 2\pi\sqrt{\frac{\text{y}}{\frac{2\text{Aydg}}{\text{M}}}}$$

$$= 2\pi\sqrt{\frac{\text{M}}{2\text{Adg}}}$$

Question74

A spring has a certain mass suspended from it and its period of vertical oscillations is T_1. The spring is now cut into two equal halves and the same mass is suspended from one of the halves. The period of vertical oscillations is now T_2. The ratio of T_2/T_1 is

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Options:

A. 1 : 2

B. $1 : \sqrt{2}$

C. $\sqrt{2} : 1$

D. 2 : 1

Answer: B

Solution:

$$T = 2\pi\sqrt{\frac{m}{K}} \Rightarrow T \propto \frac{1}{\sqrt{K}}$$

$$\therefore \quad \frac{T_2}{T_1} = \sqrt{\frac{K_1}{K_2}} \quad .... \text{(i)}$$

Let K be the spring constant of the spring cut in half.

For series combination,

$K_1 = \frac{K \times K}{K+K} = \frac{K}{2}$

For second case, the mass is hung to only one half of the spring,

$K_2 = K$

Substituting in K_1 and K_2 in (i),

$\frac{T_2}{T_1} = \sqrt{\frac{K/2}{K}} = \frac{1}{\sqrt{2}}$

Question75

For a body performing simple harmonic motion, its potential energy is E_x at displacement x and E_y at displacement y from mean position. The potential energy E_0 at displacement $(x+y)$ is

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Options:

A. $\sqrt{E_x^2 + E_y^2}$

B. $\sqrt{E_x - E_y}$

C. $E_x + E_y$

D. $E_x + E_y + 2\sqrt{E_x E_y}$

Answer: D

Solution:

Potential energy at $\mathrm{x} = \mathrm{E_x} = \frac{1}{2}\mathrm{kx}^2$

$\therefore \quad \mathrm{x} = \sqrt{\frac{2\mathrm{E_x}}{\mathrm{k}}} \quad .... \text{(i)}$

Similarly,

Potential energy at $\mathrm{y} = \mathrm{E_y} = \frac{1}{2}\mathrm{ky}^2$

$\therefore \quad \mathrm{y} = \sqrt{\frac{2\mathrm{E_y}}{\mathrm{k}}} \quad .... \text{(ii)}$

P.E. at displacement $(x+y) = E = \frac{1}{2}k(x+y)^2$

$\therefore \quad E = \frac{1}{2}k\left(x^2 + y^2 + 2xy\right)$

$\therefore \quad E = \frac{k}{2}\left[\frac{2E_1}{k} + \frac{2E_2}{k} + \frac{2\times 2\sqrt{E_1 E_2}}{k}\right]$

$\therefore \quad E = E_x + E_y + 2\sqrt{E_x E_y}$

Question76

The displacement of a particle performing S.H.M. is given by $Y = A\cos[\pi(t+\phi)]$. If at $\mathrm{t} = 0$, the displacement is $\mathrm{y} = 2$ cm and velocity is 2π cm/s, the value of amplitude A in cm is

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Options:

A. 2

B. $\sqrt{2}$

C. $2\sqrt{2}$

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

Answer: C

Solution:

$y = A\cos(\pi t + \pi\phi)$
$v = A\pi\sin(\pi t + \pi\phi)$
At $t = 0$, $\frac{y_0}{A} = \cos\pi\phi$ .... (i)
$-\frac{v_0}{A} = \sin\pi\phi$ .... (ii)
Squaring and adding (i) and (ii)
$y_0^2 + \frac{v_0^2}{\pi^2} = A^2$

Putting $y_0 = 2$ cm and $v_0 = 2\pi$ cm/s
$2^2 + \frac{(2\pi)^2}{\pi^2} = A^2 \quad \Rightarrow A = 2\sqrt{2}$

Question77

A particle is performing simple harmonic motion and if the oscillations are Camped oscillations then the angular frequency is given by

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Options:

A. $\sqrt{\frac{k}{m} + \left(\frac{b}{2m}\right)^2}$

B. $\frac{k}{m} + \left(\frac{b}{2m}\right)^2$

C. $\sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}$

D. $\frac{k}{m} - \left(\frac{b}{2m}\right)^2$

Answer: C

Solution:

$\omega^2=\frac{\mathrm{k}}{\mathrm{m}}, \mathrm{r}=\frac{\mathrm{b}}{2 \mathrm{~m}}$

Angular frequency,

$\omega'=\sqrt{(\omega^2-r^2)}$

$=\sqrt{\frac{k}{m}-\left(\frac{b}{2m}\right)^2}$

Question78

Choose the correct answer.When a point of suspension of pendulum is moved vertically upward with acceleration ' a ', its period of oscillation

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Options:

A. decreases

B. increases

C. remains same

D. some times increases and some times decreases

Answer: A

Solution:

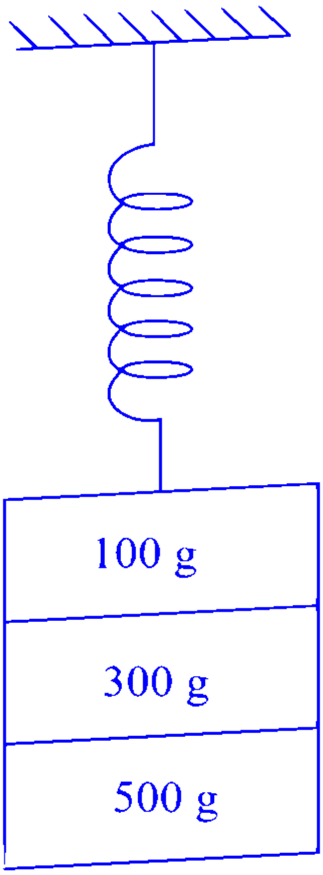
For a simple pendulum,

$\mathrm{T}=2\pi\sqrt{\frac{l}{\mathrm{g}}} \Rightarrow \mathrm{T} \propto \frac{1}{\mathrm{g}}$

When the point of suspension is moved vertically upwards with acceleration a, g becomes $g+a$. Hence, T decreases.

Question79

Three masses 500 g, 300 g **and 100 g are suspended at the end of spring as shown in figure and are in equilibrium. When the 500 g mass is removed, the system oscillates with a period of 3 second. When the 300 g mass is also removed it will oscillate with a period of**



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Options:

A. 1 s

B. 1.5 s

C. 2 s

D. 2.5 s

Answer: B

Solution:

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

When 500 g is removed, $m = (100 + 300)g$

$= 0.4$ kg

$$\therefore \quad T = 2\pi\sqrt{\frac{0.4}{k}} = 3 \text{ s}$$

$$\frac{2\pi}{\sqrt{k}} = \frac{3}{\sqrt{0.4}} \quad \text{... (i)}$$

Similarly when 300 g is removed,

$m' = 100 \text{ g} = 0.1 \text{ kg}$

$T' = 2\pi\sqrt{\frac{0.1}{k}} = x$

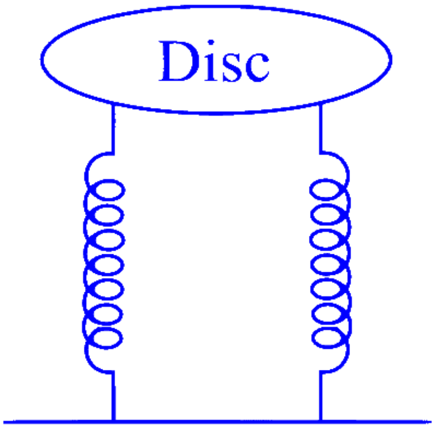
$$\therefore \quad \frac{2\pi}{\sqrt{k}} = \frac{x}{\sqrt{0.1}}$$

$$\frac{3}{\sqrt{0.4}} = \frac{x}{\sqrt{0.1}} \quad \text{.... (from (i))}$$

$$\therefore \quad x = T' = \frac{3}{2} = 1.5 \text{ s}$$

Question80

A uniform circular disc of mass 12 kg is held by two identical springs. When the disc is slightly pressed down and released, it executes S.H.M. of period 2 second. The force constant of each spring is (nearly) (Take $\pi^2 = 10$)



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Options:

A. 230 Nm^{-1}

B. 120 Nm^{-1}

C. 60 Nm^{-1}

D. 30 Nm^{-1}

Answer: C

Solution:

The two springs are connected in parallel. So, the effective spring constant is, $\mathrm{k}_{\text{eff}} = 2\mathrm{k}$

Time period of the spring system is,

$$\mathrm{T} = 2\pi\sqrt{\frac{\mathrm{m}}{2\mathrm{k}}}$$
$$\therefore \quad \mathrm{T}^2 = 4\pi^2 \times \frac{\mathrm{m}}{2\mathrm{k}}$$
$$\therefore \quad \mathrm{k} = 4\pi^2 \times \frac{\mathrm{m}}{2\,\mathrm{T}^2} = 4 \times 10 \times \frac{12}{2 \times 4} = 60\ \mathrm{N/m}$$

Question81

A light spring is suspended with mass m_1 at its lower end and its upper end fixed to a rigid support. The mass is pulled down a short distance and then released. The period of oscillation is T second. When a mass m_2 is added to m_1 and the system is made to oscillate, the period is found to be $\frac{3}{2}T$. The ratio $m_1 : m_2$ is

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Options:

A. 2 : 3

B. 3 : 4

C. 4 : 5

D. 5 : 6

Answer: C

Solution:

The time period is $T \propto \sqrt{\mathrm{m}}$

$$\begin{aligned} \therefore \quad & \frac{T}{\frac{3}{2}T} = \frac{\sqrt{m_1}}{\sqrt{m_1 + m_2}} \\ \therefore \quad & \frac{2}{3} = \frac{\sqrt{m_1}}{\sqrt{m_1 + m_2}} \\ \therefore \quad & \frac{4}{9} = \frac{m_1}{m_1 + m_2} \\ \therefore \quad & 4m_1 + 4m_2 = 9m_1 \\ \therefore \quad & 5m_1 = 4m_2 \\ \therefore \quad & \frac{m_1}{m_2} = \frac{4}{5} \end{aligned}$$

Question82

A block of mass 'M' rests on a piston executing S.H.M. of period one second. The amplitude of oscillations, so that the mass is separated from the piston, is (acceleration due to gravity, $\mathrm{g} = 10 \mathrm{~ms}^{-2}, \pi^2 = 10$)

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Options:

A. 0.25 m

B. 0.5 m

C. 1 m

D. ∞

Answer: A

Solution:

Given that, $T=2\pi\sqrt{\frac{\mathrm{m}}{\mathrm{k}}}=1\ \mathrm{s}$

$\therefore\quad \frac{\mathrm{m}}{\mathrm{k}}=\frac{1}{4\pi^2}$

The block will separate, when the restoring force exceeds the force due to gravity.

i.e., $\mathrm{kx}\geq \mathrm{Mg}$

$\therefore\quad x\geq\frac{Mg}{k}=\frac{g}{4\pi^2}=\frac{10}{4\times10}=0.25\ \mathrm{m}$

Question83

A simple pendulum of length 'l' and a bob of mass 'm' is executing S.H.M. of small amplitude 'A'. The maximum tension in the string will be (g = acceleration due to gravity)

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Options:

A. 2 mg

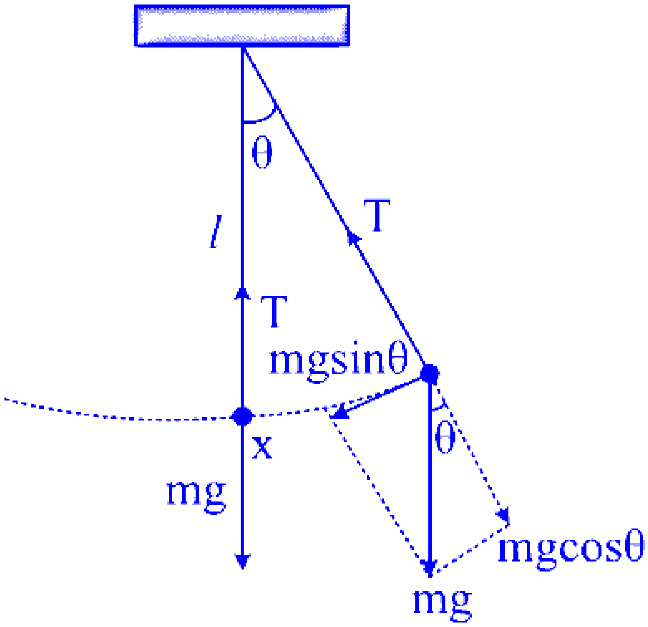
B. $\mathrm{mg}\left[1+\left(\frac{\mathrm{A}}{\ell}\right)^2\right]$

C. $mg\left[1+\left(\frac{A}{\ell}\right)\right]^2$

D. $mg\left[1+\left(\frac{A}{\ell}\right)\right]$

Answer: B

Solution:



Tension in the string is given as,

$$T' = mg\cos\theta + \frac{mv^2}{l}$$

$$T'_{max} = mg + \frac{mv^2}{l}$$

Now, time period $T = 2\pi\sqrt{\frac{l}{g}}$

$\omega = \frac{2\pi}{T} = \sqrt{\frac{g}{l}}$

Maximum Velocity is given as $v_{max} = A\omega$

Substituting the values

$$T'_{max} = mg + \frac{m(A\omega)^2}{l}$$

$$= mg + \frac{\frac{mA^2 g}{l}}{l}$$

$$= mg + \frac{mA^2 g}{l^2}$$

$$= \mathrm{mg}\left(1+\left(\frac{\mathrm{A}}{l}\right)^2\right)$$

Question84

The displacement of a particle executing S.H.M. is $x=\mathrm{a}\sin(\omega t-\phi)$. Velocity of the particle at time $\mathrm{t}=\frac{\phi}{\omega}$ is $(\cos 0^{\circ}=1)$

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Options:

A. $\omega\cos\phi$

B. $\mathrm{a}\omega$

C. $\omega\cos 2\phi$

D. $-\mathrm{a}\omega\cos 2\phi$

Answer: B

Solution:

To calculate the velocity of a particle in simple harmonic motion (S.H.M.), we use the derivative of the displacement function with respect to time. The displacement function given is:

$x=a\sin(\omega t-\phi)$

The velocity v is the first derivative of displacement x with time t:

$v=\frac{dx}{dt}$

Let's compute the derivative:

$v=\frac{d}{dt}[a\sin(\omega t-\phi)]v=a\cos(\omega t-\phi)\cdot\frac{d}{dt}(\omega t-\phi)v=a\cos(\omega t-\phi)\cdot\omega v=a\omega\cos(\omega t-\phi)$

We need to calculate this velocity at time $t = \frac{\phi}{\omega}$:

$$v = a\omega \cos\left(\omega \cdot \frac{\phi}{\omega} - \phi\right) v = a\omega \cos(\phi - \phi) v = a\omega \cos(0^\circ) v = a\omega \cdot 1 v = a\omega$$

Therefore, the correct answer is Option B:

$a\omega$

Question85

The bob of simple pendulum of length 'L' is released from a position of small angular displacement θ. Its linear displacement at time 't' is (g $=$ acceleration due to gravity)

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Options:

A. $L\theta \cos\left[\sqrt{\frac{g}{L}} \cdot t\right]$

B. $L\theta \sin\left[2\pi\sqrt{\frac{g}{L}} \cdot t\right]$

C. $L\theta \cos\left[2\pi\sqrt{\frac{g}{L}} \cdot t\right]$

D. $L\theta \sin\left[\sqrt{\frac{g}{L}} \cdot t\right]$

Answer: A

Solution:

Equation for displacement for a particle performing S.H.M. is,

$y=A \cos \omega t=L \cos \left(\frac{2 \pi}{T} \times t\right)$

But time period of a simple pendulum,

$$T=2 \pi \sqrt{\frac{L}{g}}$$

$$\therefore \quad y=L \cos \left(\frac{2 \pi}{2 \pi \sqrt{\frac{L}{g}}} \times t\right)=L \cos \left(\sqrt{\frac{g}{L}} \times t\right)$$

$\therefore$ The linear displacement is,

$$s=y \theta=L \theta \cos \left[\sqrt{\frac{g}{L}} \times t\right]$$

Question86

Under the influence of force F_1 the body oscillates with a period T_1 and due to another force F_2 body oscillates with period T_2. If both forces acts simultaneously, then the resultant period is(consider displacement is same in all three cases)

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Options:

A. $T=\sqrt{\frac{T_1^2+T_2^2}{T_1^2 T_2^2}}$

B. $T=\sqrt{\frac{T_1^2 T_2^2}{T_1^2+T_2^2}}$

C. $T=\sqrt{\frac{T_1^2}{T_2^2}}$

D. $T=\sqrt{T_1^2+T_2^2}$

Answer: B

Solution:

Time period for the force $F_1 = T_1$

Time period for the force $F_2 = T_2$

If both forces acts simultaneously then the resultant force is F,

$F = F_1 + F_2$

Let, time period for the force F be T

Now, $F = F_1 + F_2$

$$m\omega^2 y = m\omega_1^2 y + m\omega_2^2 y \quad (\because F = m\omega^2 y)$$
$$\omega^2 = \omega_1^2 + \omega_2^2$$

$$\Rightarrow \quad \left(\frac{2\pi}{T}\right)^2 = \left(\frac{2\pi}{T_1}\right)^2 + \left(\frac{2\pi}{T_2}\right)^2$$
$$\Rightarrow \quad \frac{1}{T^2} = \frac{1}{T_1^2} + \frac{1}{T_2^2}$$
$$\Rightarrow \quad \frac{1}{T^2} = \frac{T_2^2 + T_1^2}{T_1^2 T_2^2}$$
$$\Rightarrow \quad T^2 = \frac{T_1^2 T_2^2}{T_1^2 + T_2^2} \Rightarrow T = \sqrt{\frac{T_1^2 T_2^2}{T_1^2 + T_2^2}}$$

Question87

A mass M is suspended from a light spring. An additional mass M_1 added extends the spring further by a distance x. Now, the combined mass will oscillate on the spring with period $T =$

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Options:

A. $2\pi\left[\left(\frac{M_1 g}{x(M+M_1)}\right)\right]^{\frac{1}{2}}$

B. $2\pi\left[\frac{(M+M_1)x}{M_1 g}\right]^{\frac{1}{2}}$

C. $\left(\frac{\pi}{2}\right)\left[\left(\frac{M_1 g}{x(M+M_1)}\right)\right]^{\frac{1}{2}}$

D. $2\pi\left[\left(\frac{M+M_1}{M_1 g x}\right)\right]^{\frac{1}{2}}$

Answer: B

Solution:

Time period of oscillation when mass M hangs by spring of spring constant k is given by,

$T = 2\pi\sqrt{M/k}$

From Hooke's law, $kx = mg$

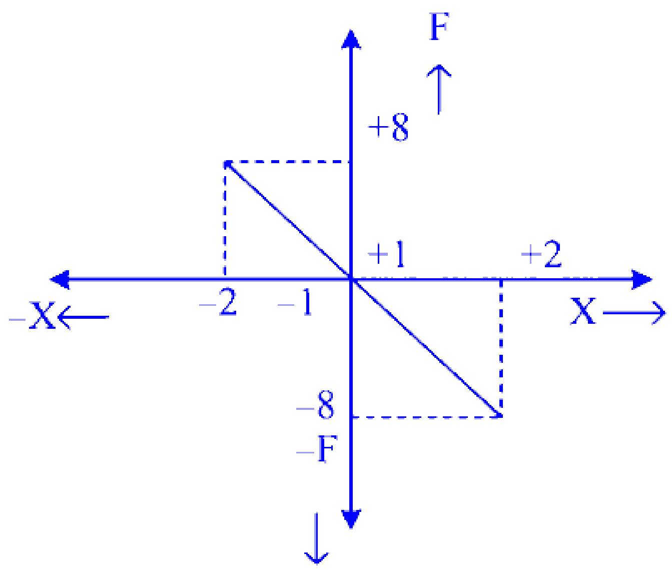
$\Rightarrow \quad \frac{1}{k} = \frac{x}{mg}$

When mass M_1 is added to the system

$T' = 2\pi\sqrt{\frac{(M_1+M)}{k}} = 2\pi\sqrt{\frac{x(M_1+M)}{mg}}$

Question88

A body of mass 0.04 kg executes simple harmonic motion (SHM) about x = 0 under the influence of force F as shown in graph. The period of



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Options:

A. $2\pi s$

B. $0.2\pi s$

C. πd

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

Answer: B

Solution:

$k = 400 \mathrm{~N/m}$

$m = 0.04$

From the graph,

$K = \frac{F}{x} = \frac{8}{2} = 4$

From $T = 2\pi\sqrt{\frac{M}{K}}$,

we get

$T = 2\pi\sqrt{\frac{0.04}{4}} = 0.2\pi s$

Question89

A simple pendulum has a time period 'T' in air. Its time period when it is completely immersed in a liquid of density one eighth the density of the material of bob is

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Options:

A. $\left(\sqrt{\frac{7}{8}}\right)\mathrm{T}$

B. $\left(\sqrt{\frac{5}{8}}\right)\mathrm{T}$

C. $\left(\sqrt{\frac{3}{8}}\right)\mathrm{T}$

D. $\left(\sqrt{\frac{8}{7}}\right)\mathrm{T}$

Answer: D

Solution:

Time period of simple pendulum $\mathrm{T} = 2\pi\sqrt{\frac{l}{\mathrm{g}}}$

$\Rightarrow \mathrm{T} \propto \frac{1}{\sqrt{\mathrm{g}}}$

Net downward force acting on the bob inside the liquid $=$ Weight of bob $-$ Upthrust

$\Rightarrow \mathrm{Vpg} - \mathrm{V}\frac{\rho}{\rho}\mathrm{g} = \frac{7}{8}\,\mathrm{V}\rho\mathrm{g}$

The value of g inside the liquid will be $\frac{g}{8}$

$\therefore$ Time period in liquid $\mathrm{T}_1 = \frac{1}{2\pi}\sqrt{\frac{l}{\frac{7}{8}}} = \sqrt{\frac{8}{7}}\,\mathrm{T}$

Question90

In a stationary lift, time period of a simple pendulum is 'T'. The lift starts accelerating downwards with acceleration $\left(\frac{\mathrm{g}}{4}\right)$, then the time period of the pendulum will be

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Options:

A. $\frac{\sqrt{3}}{2}$ T

B. $\frac{2}{\sqrt{3}}$ T

C. $\frac{3}{4}$ T

D. $\frac{4}{3}$ T

Answer: B

Solution:

Time period of pendulum: $T = 2\pi\sqrt{\frac{L}{g}}$

When lift is accelerated downward with acceleration $\frac{g}{4}$,

$$g = g - \frac{g}{4}$$
$$g = \frac{3g}{4}$$

$\therefore$ New Time period will be

$$T_1 = 2\pi\sqrt{\frac{4L}{3g}}$$
$$T_1 = 2\pi\frac{2}{\sqrt{3}}\sqrt{\frac{L}{g}}$$
$$T_1 = \frac{2}{\sqrt{3}}T$$

Question91

A particle starts from mean position and performs S.H.M. with period 4 second. At what time its kinetic energy is 50% of total energy?

$\left(\cos 45^{\circ}=\frac{1}{\sqrt{2}}\right)$

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Options:

A. 0.1 s

B. 0.2 s

C. 0.4 s

D. 0.5 s

Answer: D

Solution:

The total energy is given by $T \cdot E=\frac{1}{2} \mathrm{kA}^2$

Kinetic energy is given by $\mathrm{K} \cdot \mathrm{E}=\frac{1}{2} \mathrm{k}\left(\mathrm{A}^2-\mathrm{x}^2\right)$

$$
\begin{aligned}
& \text{K.E} = \frac{1}{2} P.E \quad \text{...(given)} \\
\therefore \quad & \frac{1}{2} k\left(A^2-x^2\right)=\frac{1}{2}\left(\frac{1}{2} k A^2\right) \\
\therefore \quad & \left(A^2-x^2\right)=\frac{1}{2} A^2 \\
\therefore \quad & \left(A^2-x^2\right)=\frac{1}{2} A^2 \\
\therefore \quad & x=\frac{A}{\sqrt{2}}
\end{aligned}
$$

The equation of displacement in SHM is

$$
\begin{aligned}
& \mathrm{x}=\mathrm{A} \sin \frac{2 \pi \mathrm{t}}{\mathrm{T}} \\
\therefore \quad & \frac{\mathrm{A}}{\sqrt{2}}=\mathrm{A} \sin \frac{2 \pi \mathrm{t}}{4} \quad \ldots .(\because \mathrm{T}=4 \mathrm{sec}) \\
\therefore \quad & \frac{1}{\sqrt{2}}=\sin \frac{\pi \mathrm{t}}{2}
\end{aligned}
$$

$$\therefore \quad \frac{\pi t}{2} = \sin^{-1}\frac{1}{\sqrt{2}}$$

$$\frac{\pi t}{2} = \frac{\pi}{4}$$

$$\therefore \quad t = 0.5 \text{ s}$$

Question92

A simple pendulum performs simple harmonic motion about $x = 0$ with an amplitude 'a' and time period 'T'. The speed of the pendulum at $x = \frac{a}{2}$ is

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Options:

A. $\frac{\pi a}{T}$

B. $\frac{3\pi^2 a}{T}$

C. $\frac{\pi a\sqrt{3}}{T}$

D. $\frac{\pi a\sqrt{3}}{2}$

Answer: C

Solution:

$$v = \omega\sqrt{a^2 - x^2}$$

$$\text{At } x = \frac{a}{2},$$

$$\therefore \quad v = \omega\sqrt{a^2 - \frac{a^2}{4}}$$

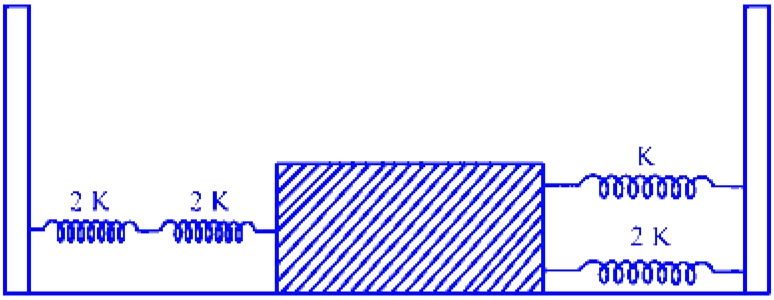
$$= \omega \frac{\sqrt{3}a}{2}$$

$$= \frac{2\pi}{T} \times \frac{\sqrt{3}a}{2} \quad \ldots\ldots \left(\because \omega = \frac{2\pi}{T}\right)$$

$$\therefore \quad v = \frac{\pi a \sqrt{3}}{T}$$

Question93

Four massless springs whose force constants are $2\ K, 2\ K,\ K$ and $2\ K$ respectively are attached to a mass M kept on a frictionless plane as shown in figure, If mass M is displaced in horizontal direction then frequency of oscillating system is



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Options:

A. $\frac{1}{2\pi}\sqrt{\frac{K}{4M}}$

B. $\frac{1}{2\pi}\sqrt{\frac{4\ K}{M}}$

C. $\frac{1}{2\pi}\sqrt{\frac{K}{7M}}$

D. $\frac{1}{2\pi}\sqrt{\frac{7\ K}{M}}$

Answer: B

Solution:

On the right hand side of the block, springs are connected in parallel

$\therefore$ Their effective spring constant is given by

$$
\begin{aligned}
& K_1=K+2 K \\
& K_1=3 K
\end{aligned}
$$

On the left hand side of the block, springs are connected in series.

$\therefore$ Their effective spring constant is given by,

$$
\begin{aligned}
& \frac{1}{K_2}=\frac{1}{2 K}+\frac{1}{2 K} \\
\therefore \quad & K_2=K
\end{aligned}
$$

$\therefore \quad$ Effective spring constant of the system is given by,

$$
\begin{aligned}
& K_E=3 K+K=4 K \\
\therefore \quad & \omega=\sqrt{\frac{K_E}{M}}=\sqrt{\frac{4 K}{M}} \\
\therefore \quad & f=\frac{\omega}{2 \pi}=\frac{1}{2 \pi} \sqrt{\frac{4 K}{M}}
\end{aligned}
$$

Question94

The upper end of the spring is fixed and a mass 'm' is attached to its lower end. When mass is slightly pulled down and released, it oscillates with time period 3 second. If mass 'm' is increased by $1 \mathrm{~kg}$, the time period becomes 5 second. The value of 'm' is (mass of spring is negligible)

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Options:

A. $\frac{3}{8} \mathrm{~kg}$

B. $\frac{5}{9} \mathrm{~kg}$

C. $\frac{8}{13} \mathrm{~kg}$

D. $\frac{9}{16}$ kg

Answer: D

Solution:

The formula for the time period of a spring mass system is $T=2\pi\sqrt{\frac{m}{k}}$

For mass $\mathrm{m}+1,\ \mathrm{T}'=2\pi\sqrt{\frac{\mathrm{m}+1}{\mathrm{k}}}$

Taking the ratio,

$$\begin{aligned}
\frac{\mathrm{T}}{\mathrm{T}'} &= \frac{2\pi\sqrt{\frac{\mathrm{m}}{\mathrm{k}}}}{2\pi\sqrt{\frac{\mathrm{m}+1}{\mathrm{k}}}} \\
\frac{\mathrm{T}}{\mathrm{T}'} &= \sqrt{\frac{\mathrm{m}}{\mathrm{m}+1}} \\
\frac{3}{5} &= \sqrt{\frac{\mathrm{m}}{\mathrm{m}+1}} \\
\frac{9}{25} &= \frac{\mathrm{m}}{\mathrm{m}+1} \\
\therefore\quad & 9\mathrm{~m}+9=25\mathrm{~m} \\
\therefore\quad & 16\mathrm{~m}=9 \\
\therefore\quad & \mathrm{m}=\frac{9}{16}\mathrm{~kg}
\end{aligned}$$

Question95

For a particle executing S.H.M., its potential energy is 8 times its kinetic energy at certain displacement 'x' from the mean position. If 'A' is the amplitude of S.H.M the value of 'x' is

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Options:

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

B. $A\sqrt{3}$

C. $\frac{2\sqrt{2}\ A}{3}$

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

Answer: C

Solution:

Potential energy: $U=\frac{1}{2} m \omega^2 x^2$ and

Kinetic energy: $K=\frac{1}{2} m \omega^2\left(A^2-x^2\right)$

Given: Potential energy $=8 \times$ Kinetic energy

$$
\begin{aligned}
& \therefore \quad \mathrm{U}=8 \mathrm{~K} \\
& \frac{1}{2} m \omega^2 x^2=8 \times \frac{1}{2} m \omega^2\left(A^2-x^2\right) \\
& x^2=8 A^2-8 x^2 \\
& 9 x^2=8 A^2 \\
& x^2=\frac{8 A^2}{9} \\
& x=\frac{2 \sqrt{2} A}{3}
\end{aligned}
$$

Question96

The time period of a simple pendulum inside a stationary lift is 'T'. When the lift starts accelerating upwards with an acceleration $\left(\frac{\mathrm{g}}{3}\right)$, the time period of the pendulum will be

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Options:

A. $\frac{\sqrt{5}}{2} \mathrm{~T}$

B. $\frac{\sqrt{3}}{2} \mathrm{~T}$

C. $\frac{2 \mathrm{~T}}{\sqrt{3}}$

D. $\frac{2 \mathrm{~T}}{\sqrt{5}}$

Answer: B

Solution:

Time period of a simple pendulum is $\mathrm{T}=2\pi\sqrt{\left(\frac{l}{\mathrm{a}}\right)}$

In stationary lift, the value of acceleration is $\mathrm{a}=\mathrm{g}$

$$\mathrm{T}=2\pi\sqrt{\left(\frac{l}{\mathrm{g}}\right)}$$

When the lift is accelerating in an upward direction, there is a pseudo force acting in a downward direction.

$$\therefore \quad \mathrm{ma}=\mathrm{mg}+\frac{\mathrm{mg}}{3}$$

$$\therefore \quad \mathrm{a}=\mathrm{g}+\frac{\mathrm{g}}{3}$$

$$\therefore \quad \mathrm{a}=\frac{4\,\mathrm{g}}{3}$$

$\therefore$ Period for a pendulum in accelerating lift is

$$\mathrm{T}'=2\pi\sqrt{\frac{l}{\mathrm{a}}}=2\pi\sqrt{\frac{3l}{4\,\mathrm{g}}}$$

$$\therefore \quad \mathrm{T}'=\frac{\sqrt{3}}{2}\left(2\pi\sqrt{\frac{l}{\mathrm{g}}}\right)$$

$$\therefore \quad \mathrm{T}'=\frac{\sqrt{3}}{2}\,\mathrm{T}$$

Question97

A body is executing a linear S.H.M. Its potential energies at the displacement 'x' and 'y' are 'E_1' and 'E_2' respectively. Its potential energy at displacement $(\mathrm{x}+\mathrm{y})$ will be

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Options:

A. $\mathrm{E}_1+\mathrm{E}_2$

B. $\left(\sqrt{\mathrm{E}_1}+\sqrt{\mathrm{E}_2}\right)^2$

C. $\mathrm{E}_1-\mathrm{E}_2$

D. $\left(\sqrt{E_2}-\sqrt{E_1}\right)^2$

Answer: B

Solution:

We know,

Potential Energy $E_P=\frac{1}{2}Kx^2$

$\therefore \quad E_1=\frac{1}{2}Kx^2 \Rightarrow x=\sqrt{\frac{2E_1}{K}}$ .... (i)

and

$E_2=\frac{1}{2}Ky^2 \Rightarrow y=\sqrt{\frac{2E_2}{K}}$ ..... (ii)

Given, total displacement $=(x+y)$

$\therefore \quad$ Potential energy at displacement $(x+y)$,

E is $\frac{1}{2}K(x+y)^2$

$$=\frac{1}{2}K\left(\sqrt{\frac{2E_1}{K}}+\sqrt{\frac{2E_2}{K}}\right)^2$$
$$=\frac{1}{2}K\left[\frac{2E_1}{K}+\frac{2E_2}{K}+2\left(\sqrt{\frac{E_1}{K}}\right)\left(\sqrt{\frac{2E_2}{K}}\right)\right]$$
$$=\left(\sqrt{E_1}+\sqrt{E_2}\right)^2=\left(E_1+E_2+2\sqrt{E_1E_2}\right)$$

Question98

A simple harmonic progressive wave is represented by $y=A\sin(100\pi t+3x)$. The distance between two points on the wave at a phase difference of $\frac{\pi}{3}$ radian is

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Options:

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

B. $\frac{\pi}{9}$ m

C. $\frac{\pi}{6}$ m

D. $\frac{\pi}{3}$ m

Answer: B

Solution:

Equation of the given harmonic progressive wave $y = A \sin(100\pi t + 3)$ ...... (i)

General equation of a harmonic wave

$\mathrm{y} = \mathrm{A} \sin(\mathrm{wt} + \mathrm{kx})$ ..... (ii)

From equations (i) and (ii), $\omega = 100\pi, k = 3$

But, $\mathrm{k} = \frac{2\pi}{\lambda} \Rightarrow 3 = \frac{2\pi}{\lambda}$

$\therefore \quad \lambda = \frac{2\pi}{3}$

We also know,

Path difference $\Delta x = \frac{\lambda}{2\pi} \times$ Phase difference $\Delta \phi$

$$\begin{aligned} \therefore \quad \Delta x &= \frac{2\pi}{3 \times 2\pi} \times \frac{\pi}{3} \quad \ldots \left(\text{Given } \Delta \phi = \frac{\pi}{3}\right) \\ &= \frac{\pi}{9} \text{ m} \end{aligned}$$

Question99

The amplitude of a particle executing S.H.M. is 3 cm. The displacement at which its kinetic energy will be 25% more than the potential energy is

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Options:

A. 1 cm

B. 2 cm

C. 3 cm

D. 4 cm

Answer: B

Solution:

$$\text{Given } : K \cdot E = P \cdot E + \frac{25}{100} \cdot P \cdot E$$

$$K \cdot E = P \cdot E + \frac{1}{4} P \cdot E$$

$$\text{We know K.E } = \frac{1}{2} m\omega^2 \left(A^2 - x^2 \right) \text{ and P.E } = \frac{1}{2} m\omega^2 x^2$$

$$\therefore \quad K \cdot E = \frac{5}{4} P \cdot E$$

$$\frac{1}{2} m\omega^2 \left(A^2 - x^2 \right) = \frac{5}{4} \left(\frac{1}{2} m\omega^2 x^2 \right)$$

$$A^2 - x^2 = \frac{5}{4} x^2$$

$$A^2 = \frac{9}{4} x^2$$

$$\therefore \quad A = \frac{3}{2} x$$

$$\therefore \quad x = A \times \frac{2}{3} = 2 \text{ cm}$$

Question100

Two S.H.Ms. are represented by equations $y_1 = 0.1 \sin \left(100\pi t + \frac{\pi}{3}\right)$ and $y_2 = 0.1 \cos(100\pi t)$ The phase difference between the speeds of the two particles is

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Options:

A. $\frac{\pi}{3}$

B. $-\frac{\pi}{6}$

C. $+\frac{\pi}{6}$

D. $-\frac{\pi}{3}$

Answer: B

Solution:

Given: $y_1 = 0.1 \sin\left(100\pi t + \frac{\pi}{3}\right)$ and

$y_2 = 0.1 \cos(100\pi t)$

$$\begin{aligned} \therefore \quad v_1 &= \frac{dy_1}{dt} = 0.1 \times 100\pi \cos\left(100\pi t + \frac{\pi}{3}\right) \\ v_2 &= \frac{dy_2}{dt} = -0.1 \times 100\pi \sin(100\pi t) \\ &= (0.1 \times 100\pi) \cos\left(100\pi t + \frac{\pi}{2}\right) \end{aligned}$$

Phase difference of velocity of first particle with respect to the velocity of second particle at $t = 0$ is

$\therefore \quad \Delta\phi = \phi_1 - \phi_2 = \frac{\pi}{3} - \frac{\pi}{2} = \frac{-\pi}{6}$

Question101

A spring has a certain mass suspended from it and its period for vertical oscillations is 'T_1'. The spring is now cut in to two equal halves and the same mass is suspended from one of the halves. The period of vertical oscillations is now 'T_2'. The ratio T_1/T_2 is

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Options:

A. 2

B. $\sqrt{2}$

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

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

Answer: B

Solution:

$T_1 = 2\pi\sqrt{\frac{m}{k}}$.

Also, spring constant (k) $\propto \frac{1}{\text{Length} \quad (l)}$

When the spring is half in length, then k becomes twice.

$\therefore \quad T_2 = 2\pi\sqrt{\frac{m}{2k}}$

$\therefore \quad \frac{T_1}{T_2} = \frac{1}{\frac{1}{\sqrt{2}}} = \sqrt{2}$

Question102

A particle is vibrating in S.H.M. with an amplitude of 4 cm. At what displacement from the equilibrium position is its energy half potential and half kinetic?

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Options:

A. 1 cm

B. $\sqrt{2}$ cm

C. 2 cm

D. $2\sqrt{2}$ cm

Answer: D

Solution:

$$\begin{aligned} \text{K.E} &= \frac{1}{2} m\omega^2 \left(A^2 - x^2\right) \text{ and} \\ \text{P.E} &= \frac{1}{2} m\omega^2 x^2 \\ \therefore \quad \text{T.E} &= \text{K.E} + \text{P.E} \\ &= \frac{1}{2} m\omega^2 \left(A^2 - x^2\right) + \frac{1}{2} m\omega^2 x^2 \\ &= \frac{1}{2} m\omega^2 A^2 \end{aligned}$$

$$\text{Given: K.E} = \text{P.E}$$
$$\therefore \quad A^2 - x^2 = x^2$$
$$\therefore \quad A^2 = 2x^2$$
$$\therefore \quad x = \sqrt{\frac{A^2}{2}} = \frac{A}{\sqrt{2}}$$
$$\therefore \quad x = \frac{4}{\sqrt{2}} = 2\sqrt{2}\text{ cm}$$

Question103

A rubber ball filled with water, having a small hole is used as the bob of a simple pendulum. The time period of such a pendulum

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Options:

A. is a constant.

B. decreases with time.

C. increases with time.

D. first increases and then decreases, finally having same value as at the beginning.

Answer: D

Solution:

From $T = 2\pi\sqrt{\frac{L}{g}}$

The effective length increases due to this flow of water. Therefore, T increases. As the water flows out, the length decreases and becomes equal to the original length. Hence, the time period becomes equal to the value at the beginning.

Question104

The maximum velocity of a particle performing S.H.M. is 'V'. If the periodic time is made $\left(\frac{1}{3}\right)^{d}$ and the amplitude is doubled, then the new maximum velocity of the particle will be

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Options:

A. $\frac{\mathrm{V}}{6}$

B. $\frac{3\ \mathrm{V}}{2}$

C. 3 V

D. 6 V

Answer: D

Solution:

Given $\mathrm{T}' = \frac{1}{3}\ \mathrm{T}$ and $\mathrm{A}' = 2\ \mathrm{A}$

$\therefore \quad \omega' = \frac{2\pi}{T'} = \frac{2\pi}{\left(\frac{1}{3}T\right)} = \frac{6\pi}{T} = 3\omega$

$\therefore$ The new maximum velocity

$$\begin{aligned} \mathrm{V}' &= \mathrm{A}'\omega' \\ &= (2\ \mathrm{A}) \times (3\omega) \\ &= 6\ \mathrm{A}\omega \\ &= 6\ \mathrm{V} \end{aligned}$$

Question105

The time taken by a particle executing simple harmonic motion of period 'T', to move from the mean position to half the maximum displacement is

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Options:

A. $\frac{T}{12}$ s

B. $\frac{T}{2}$ s

C. $\frac{T}{4}$ s

D. $\frac{T}{6}$ s

Answer: A

Solution:

$$x = A\sin\omega t = A\sin\left(\frac{2\pi t}{T}\right) \text{ where } x = A/2$$
$$\therefore \frac{A}{2} = A\sin\left(\frac{2\pi t}{T}\right)$$
$$\therefore \frac{1}{2} = \sin\frac{\pi}{6} = \sin\left(\frac{2\pi t}{T}\right)$$
$$\therefore \frac{2\pi t}{T} = \frac{\pi}{6}$$
$$\therefore t = \frac{T}{12} \text{ s}$$

Question106

In a medium, the phase difference between two particles separated by a distance 'x' is $\left(\frac{\pi}{5}\right)^c$. If the frequency of the oscillation of particles is $25\ \mathrm{Hz}$ and the velocity of propagation of the waves is $75\ \mathrm{m/s}$, then the value of x is

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Options:

A. 0.4 m

B. 0.1 m

C. 0.2 m

D. 0.3 m

Answer: D

Solution:

$$\lambda=\frac{\mathrm{v}}{\mathrm{n}}=\frac{75}{25}=3 \mathrm{~m}$$
$$\text{and phase difference } =\frac{2 \pi}{\lambda}(\text{path difference})$$
$$\therefore \frac{\pi}{5}=\frac{2 \pi}{3} \mathrm{x}$$
$$\therefore 10 \mathrm{x}=3$$
$$\therefore \mathrm{x}=\frac{3}{10}=0.3 \mathrm{~m}$$

Question107

A particle starts oscillating simple harmonically from its mean position with time period 'T'. At time $t=\frac{T}{12}$, the ratio of the potential energy to kinetic energy of the particle is

$$\left(\sin 30^{\circ}=\cos 60^{\circ}=0.5, \cos 30^{\circ}=\sin 60^{\circ}=\sqrt{3}/2\right)$$

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Options:

A. 1 : 2

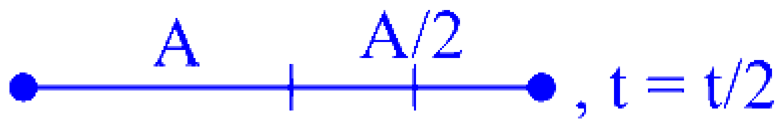
B. 3 : 1

C. 2 : 1

D. 1 : 3

Answer: D

Solution:



The particle starts from the mean position.

$$\begin{aligned} x = A\sin\omega t &= A\sin\left(\frac{2\pi}{T}\right)\times t \\ &= A\sin\left(\frac{2\pi}{T}\times\frac{T}{12}\right) \\ &= A\sin\left(\frac{\pi}{6}\right) \end{aligned}$$

$\therefore x = A\sin 30^\circ = \frac{A}{2} \quad \therefore x^2 = \frac{A^2}{4}$

$\therefore$ The particle is at a distance $A/2$ from the mean position.

At this point its P.E. $= \frac{1}{2}Kx^2 = \frac{1}{2}m\omega^2x^2$ ...... (1)

and its K.E. $= \frac{1}{2}mv^2$

$\therefore K = \frac{1}{2}m\omega^2\left(A^2 - x^2\right)$ ..... (2)

$$\therefore \frac{\text{P.E. (U)}}{\text{K.E. (K)}} = \frac{x^2}{A^2 - x^2} = \frac{\frac{A^2}{4}}{A^2 - \frac{A^2}{4}} = \frac{\frac{A^2}{4}}{\frac{3A^2}{4}}$$

$$\therefore \frac{U}{K} = \frac{1}{3}$$

Question108

The displacement of a particle performing S.H.M. is given by $x = 5\sin(3t + 3)$, where x is in cm and t is in second. The maximum acceleration of the particle will be

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Options:

A. $15\ \text{cm s}^{-2}$

B. $30\ \text{cm s}^{-2}$

C. $45 \mathrm{~cm} \mathrm{~s}^{-2}$

D. $90 \mathrm{~cm} \mathrm{~s}^{-2}$

Answer: C

Solution:

To determine the maximum acceleration of a particle performing Simple Harmonic Motion (S.H.M.), we start with the given displacement function:

$x=5 \sin (3 t+3)$

Here, x is in centimeters and t is in seconds. In S.H.M., the acceleration a is directly proportional to the displacement x and is given by:

$a=-\omega^2 x$

where ω is the angular frequency. From the given displacement equation, we can see that the angular frequency ω is 3. Thus, the maximum displacement $x_{\max }$ is 5 cm because the sine function's amplitude is 5.

The maximum acceleration $a_{\max }$ occurs when the sine function equals 1 (i.e., at maximum displacement). Hence, we can calculate the maximum acceleration as follows:

$a_{\max }=\omega^2 \cdot x_{\max }$

Substituting the values:

$a_{\max }=3^2 \cdot 5$

$a_{\max }=9 \cdot 5$

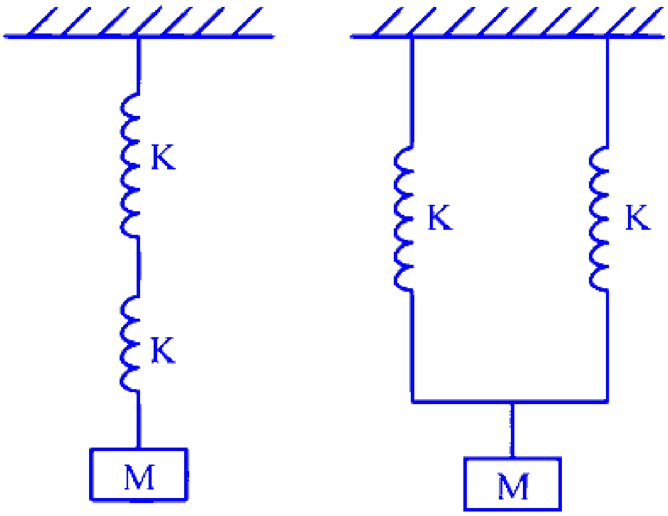
$a_{\max }=45 \mathrm{~cm} \mathrm{~s}^{-2}$

Thus, the maximum acceleration of the particle is:

Option C: $45 \mathrm{~cm} \mathrm{~s}^{-2}$

Question109

Two identical springs of constant 'K' are connected in series and parallel in shown in figure. A mass 'M' is suspended from them. The ratio of their frequencies is series to parallel combination will be



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Options:

A. 1 : 2

B. 1 : 4

C. 4 : 1

D. $1 : \sqrt{2}$

Answer: A

Solution:

In series combination, the effective spring constant

$k_1 = \frac{k}{2}$

In the parallel combination, the effective spring constant is

$$k_2 = 2k$$
$$f_1 = \frac{1}{2\pi}\sqrt{\frac{k_1}{m}} = \frac{1}{2\pi}\sqrt{\frac{k}{2m}}$$
$$f_2 = \frac{1}{2\pi}\sqrt{\frac{k_2}{m}} = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$$
$$\therefore \frac{f_1}{f_2} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

Question110

A particle performing linear S.H.M. of amplitude $0.1 \mathrm{~m}$ has displacement $0.02 \mathrm{~m}$ and acceleration $0.5 \mathrm{~m} / \mathrm{s}^2$. The maximum velocity of the particle in m / s is

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Options:

A. 0.05

B. 0.50

C. 0.01

D. 0.25

Answer: B

Solution:

$$\begin{aligned} & \text{Acceleration } \mathrm{a}=\omega^2 \mathrm{x} \\ & \therefore \quad \omega^2=\frac{\mathrm{a}}{\mathrm{x}}=\frac{0.5}{0.02}=25 \\ & \therefore \quad \omega=5 \mathrm{rad} / \mathrm{s} \\ & \quad \mathrm{V}_{\max }=\mathrm{A} \omega^2=0.1 \times 5=0.5 \mathrm{~m} / \mathrm{s} \end{aligned}$$

Question111

A body is executing S.H.M. under the action of force having maximum magntude $50 \mathrm{~N}$. When its energy is half kinetic and half potential; the magnitude of the force acting on the particle is

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Options:

A. $\frac{25}{\sqrt{2}}$ N

B. 50 N

C. 25 N

D. $25\sqrt{2}$ N

Answer: D

Solution:

Potential energy is a half of the total energy

$$\therefore \frac{1}{2} \mathrm{m}\omega^2 x^2 = \frac{1}{2}\left[\frac{1}{2} m\omega^2 A^2\right]$$
$$\therefore x^2 = \frac{A^2}{2} \text{ or } x = \frac{A}{\sqrt{2}}$$

Maximum force $F_m = \omega^2$ A

Force at a distance x is $\mathrm{F}' = \omega^2 \mathrm{x}$

$$\therefore \frac{F'}{F_m} = \frac{x}{A} = \frac{1}{\sqrt{2}}$$
$$\therefore F' = \frac{F_m}{\sqrt{2}} = \frac{50}{\sqrt{2}} = 25\sqrt{2}$$

Question112

A bob of simple pendulum of mass 'm' perform SHM with amplitude 'A' and period 'T'. Kinetic energy of pendulum of displacement $x = \frac{A}{2}$ will be

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Options:

A. $\frac{2\ \mathrm{m}\pi^2 A}{3\ \mathrm{T}^2}$

B. $\frac{3\mathrm{m}\pi^2\mathrm{A}}{2\mathrm{T}}$

C. $\frac{2 \mathrm{~m} \pi \mathrm{A}^2}{3 \mathrm{~T}}$

D. $\frac{2 \mathrm{~m} \pi^2 \mathrm{~A}^2}{2 \mathrm{~T}^2}$

Answer: D

Solution:

$$\text{Kinetic energy } = \frac{1}{2} m \omega^2 \left(A^2 - x^2\right)$$

$$\text{At } x = \frac{A}{2}, \text{ K.E. } = \frac{1}{2} m \omega^2 \left(\frac{3}{4} A^2\right) = \frac{3}{8} m \omega^2 A^2$$

$$= \frac{3}{8} \mathrm{~m}\left(\frac{2 \pi}{\mathrm{T}}\right)^2 \cdot \mathrm{A}^2$$

$$= \frac{3}{8} \mathrm{~m} \cdot \frac{4 \pi^2}{\mathrm{~T}^2} \cdot \mathrm{A}^2$$

$$= \frac{3}{2} \cdot \frac{m \pi^2 A^2}{T^2}$$

Question113

An object executes SHM along x-axis with amplitude $0.06 \mathrm{~m}$. At certain distance 'x' metre from mean position, it has kinetic energy $10 \mathrm{~J}$ and potential energy $8 \mathrm{~J}$. the distance 'x' will be

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Options:

A. 0.08 m

B. 0.02 m

C. 0.04 m

D. 0.06 m

Answer: C

Solution:

In Simple Harmonic Motion (SHM), the total energy (E) of the system remains constant and is the sum of its kinetic energy (K.E) and potential energy (P.E). Therefore, we have:

$E = \text{K.E} + \text{P.E}$

Given that the kinetic energy is 10 J and the potential energy is 8 J, the total energy can be calculated as:

$E = 10\text{ J} + 8\text{ J} = 18\text{ J}$

The total energy in SHM can also be expressed in terms of amplitude (A) and the maximum potential energy which occurs at the extreme position. Hence, the total energy is given by:

$E = \frac{1}{2}kA^2$

where k is the force constant. Since the amplitude (A) is 0.06 m, we can substitute the values to get:

$18\text{ J} = \frac{1}{2}k(0.06)^2$

Solving for k, we get:

$k = \frac{2\times18}{(0.06)^2}$

$k = \frac{36}{0.0036}$

$k = 10000\text{ N/m}$

Now, using the given kinetic and potential energy values at a distance x from the mean position, we know that:

$\text{K.E} = \frac{1}{2}k(A^2 - x^2)$

$\text{P.E} = \frac{1}{2}kx^2$

Given that:

$10\text{ J} = \frac{1}{2}k(A^2 - x^2)$

$8\text{ J} = \frac{1}{2}kx^2$

First, let's solve for x from the potential energy equation:

$8 = \frac{1}{2}kx^2$

$x^2 = \frac{16}{k}$

Substituting $k = 10000\text{ N/m}$:

$x^2 = \frac{16}{10000}$

$x^2 = 0.0016\text{ m}^2$

$x = 0.04\text{ m}$

Therefore, the distance 'x' from the mean position where the kinetic energy is 10 J and the potential energy is 8 J is:

Option C: 0.04 m

Question114

A body executes SHM under the action of force 'F_1' with time period 'T_1'. If the force is changed to 'F_2', it executes SHM with period 'T_2'. If both the forces 'F_1' and 'F_2' act simultaneously in the same direction on the body, its time period is

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Options:

A. $\frac{\sqrt{T_1^2-T_2^2}}{T_1\ T_2}$

B. $\frac{T_1 T_2}{\sqrt{T_1^2-T_2^2}}$

C. $\frac{\sqrt{T_1^2+T_2^2}}{T_1\ T_2}$

D. $\frac{T_1\ T_2}{\sqrt{T_1^2+T_2^2}}$

Answer: D

Solution:

$$\therefore \quad T_1 = K_1 x = 2\pi\sqrt{\frac{m}{K}} \quad F_2 = K_2 x = 2\pi\sqrt{\frac{m}{K}} \quad F = (K_1 + K_2)x$$

$$\therefore \quad T_1^2 = 4\pi^2\frac{m}{K_1} \quad T_2^2 = 4\pi^2\frac{m}{K_2}$$

$$T^2 = 4\pi^2\frac{m}{K_1 + K_2}$$

$$\therefore \quad \frac{1}{T^2} = \frac{K_1 + K_2}{4\pi^2\ m} = \frac{K_1}{4\pi^2\ m} + \frac{K_2}{4\pi^2\ m}$$

$$= \frac{1}{T_1^2} + \frac{1}{T_2^2}$$

$$= \frac{T_1^2 + T_2^2}{T_1^2 T_2^2}$$

$$\therefore \quad T^2 = \frac{T_1^2 T_2^2}{T_1^2 + T_2^2}$$

$$\therefore T = \frac{T_1 T_2}{\sqrt{T_1^2 + T_2^2}}$$

Question115

A particle performing S.H.M. when displacement is 'x', the potential energy and restoring force acting on it are denoted by 'E' and 'F' respectively. The relation between x, E and F is

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Options:

A. $\frac{2E}{F} - x^2 = 0$

B. $\frac{2E}{F} + x^2 = 0$

C. $\frac{2E}{F} + x = 0$

D. $\frac{2E}{F} - x = 0$

Answer: C

Solution:

$$E = \frac{1}{2}kx^2; \quad F = -kx$$

$$\therefore \quad 2E = kx^2$$

$$\therefore \quad \frac{2E}{F} = -x$$

$$\therefore \quad \frac{2E}{F} + x = 0$$

Question116

A body is performing S.H.M. of amplitude 'A'. The displacement of the body from a point where kinetic energy is maximum to a point where potential energy is maximum, is

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Options:

A. zero

B. $\pm$A

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

D. $\pm\frac{A}{4}$

Answer: B

Solution:

The correct answer is **Option B:** $\pm A$.

Here's why:

In Simple Harmonic Motion (SHM), the total mechanical energy (the sum of kinetic and potential energy) remains constant. This means that when kinetic energy is at its maximum, potential energy is at its minimum, and vice-versa.

Let's break down the key points:

- **Kinetic Energy Maximum:** This occurs when the body is passing through its equilibrium position. At this point, the velocity is maximum, and therefore kinetic energy is maximum.
- **Potential Energy Maximum:** This occurs at the extreme ends of the motion, where the body momentarily comes to rest. At these points, the displacement from equilibrium is maximum, and hence potential energy is maximum.
- **Displacement:** The displacement from the point of maximum kinetic energy (equilibrium) to the point of maximum potential energy (extreme position) is exactly equal to the amplitude 'A'.

Therefore, the displacement is $\pm A$ (positive or negative depending on the direction of the motion).

Question117

A particle excuting S.H.M starts from the mean position. Its amplitude is 'A' and time period 'T' At what displacement its speed is one-fourth of the maximum speed?

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Options:

A. $\frac{\mathrm{A}}{\sqrt{15}}$

B. $\frac{\mathrm{A}}{4}$

C. $\frac{4\ \mathrm{A}}{15}$

D. $\frac{\mathrm{A}\sqrt{15}}{40}$

Answer: D

Solution:

To determine the displacement at which the speed of the particle is one-fourth of its maximum speed, we need to understand the relationship between displacement, amplitude, and velocity in Simple Harmonic Motion (SHM).

In SHM, the velocity v of a particle at a displacement x from the mean position is given by:

$v=\omega\sqrt{A^2-x^2}$

where:

- ω is the angular frequency, and
- A is the amplitude.

The angular frequency ω is related to the time period T by:

$\omega=\frac{2\pi}{T}$

The maximum speed v_{max} occurs when the particle is at the mean position (i.e., $x = 0$), and it is given by:

$v_{max} = \omega A$

We are given that the speed is one-fourth of the maximum speed. Therefore, we can write:

$\frac{v_{max}}{4} = \frac{\omega A}{4}$

We need to find the displacement x at which this condition holds:

$\frac{\omega A}{4} = \omega\sqrt{A^2 - x^2}$

We can divide both sides by ω:

$\frac{A}{4} = \sqrt{A^2 - x^2}$

Next, we square both sides to eliminate the square root:

$\left(\frac{A}{4}\right)^2 = A^2 - x^2$

This simplifies to:

$\frac{A^2}{16} = A^2 - x^2$

Next, we rearrange the equation to solve for x:

$x^2 = A^2 - \frac{A^2}{16}$

$x^2 = \frac{16A^2 - A^2}{16}$

$x^2 = \frac{15A^2}{16}$

$x = \frac{A\sqrt{15}}{4}$

Therefore, the displacement at which the speed is one-fourth of the maximum speed is:

Option D: $\frac{\mathrm{A}\sqrt{15}}{40}$

Question118

A particle connected to the end of a spring executes S.H.M. with period 'T_1'. While the corresponding period for another spring is 'T_2'. If the period of oscillation with two springs in series is 'T', then

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Options:

A. $\mathrm{T}=\sqrt{\mathrm{T}_1^2+\mathrm{T}_2^2}$

B. $\mathrm{T}=\sqrt{\mathrm{T}_2^2-\mathrm{T}_1^2}$

C. $\mathrm{T}=\mathrm{T}_1+\mathrm{T}_2$

D. $\mathrm{T}=\mathrm{T}_1-\mathrm{T}_2$

Answer: A

Solution:

$T_1=2\pi\sqrt{\frac{m}{k_1}} \quad T_2=2\pi\sqrt{\frac{m}{k_2}}$

When the two springs are connected in series, the effective spring constant is given by

$\frac{1}{\mathrm{k}}=\frac{1}{\mathrm{k}_1}+\frac{1}{\mathrm{k}_2}$

When connected in series

$$\begin{aligned}
&\mathrm{T}=2\pi\sqrt{\frac{\mathrm{m}}{\mathrm{k}}}\\
\therefore\ &\mathrm{T}^2=4\pi^2\frac{\mathrm{m}}{\mathrm{k}}=4\pi^2\,\mathrm{m}\left[\frac{1}{\mathrm{k}_1}+\frac{1}{\mathrm{k}_2}\right]=4\pi^2\frac{\mathrm{m}}{\mathrm{k}_1}+4\pi^2\frac{\mathrm{m}}{\mathrm{k}_2}\\
&=\mathrm{T}_1^2+\mathrm{T}_2^2\\
\therefore\ &\mathrm{T}=\sqrt{\mathrm{T}_1^2+\mathrm{T}_2^2}
\end{aligned}$$

Question119

'n' waves are produced on a string in 1 second. When the radius of the string is doubled, keeping tension same, the number of waves produced in 1 second for the same harmonic will be

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Options:

A. 2n

B. $\frac{n}{2}$

C. $\frac{n}{\sqrt{2}}$

D. $\sqrt{2}n$

Answer: B

Solution:

The frequency of a wave on a string depends on the tension in the string and the linear mass density (mass per unit length) of the string. The formula for the frequency, when we consider the tension T and the linear mass density μ, is given by:

$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$

where:

- f is the frequency of the wave,
- L is the length of the vibrating segment of the string,
- T is the tension in the string,
- μ is the linear mass density of the string ($\mu = \frac{m}{L}$, with m being the mass and L the length).

When the radius of the string is doubled, its cross-sectional area becomes four times larger (since the area of a circle is $A = \pi r^2$, doubling r increases A by a factor of 4). This implies that the mass of a given length of the string also becomes four times larger, and therefore, the linear mass density (μ) increases by a factor of 4, because the length of the string we are examining hasn't changed.

Now, taking this into account, the new linear mass density is 4μ, and substituting this into the frequency formula gives us:

$f_{new} = \frac{1}{2L}\sqrt{\frac{T}{4\mu}} = \frac{1}{2L} \cdot \frac{1}{2}\sqrt{\frac{T}{\mu}} = \frac{1}{2}f$

This shows that the frequency of the wave, and therefore the number of waves produced per second (since frequency and the number of waves per second are equivalent), will be halved if the radius of the string is doubled while keeping the tension the same. The correct answer is thus:

Option B $\frac{n}{2}$

Question120

A body of mass 'm' performs linear S.H.M. given by equation $x = P\sin\omega t + Q\sin\left(\omega t + \frac{\pi}{2}\right)$. The total energy of the particle at any instant is

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Options:

A. $\frac{1}{2}$ mω^2PQ

B. $\frac{1}{2}\frac{\mathrm{m}\omega^2}{\mathrm{P}^2\mathrm{Q}^2}$

C. $\frac{1}{2}m\omega^2\left(P^2+Q^2\right)$

D. $\frac{1}{2}m\omega^2p^2Q^2$

Answer: C

Solution:

To find the total energy of a particle performing Simple Harmonic Motion (S.H.M.), we start with the given equation of motion:

$x=P\sin\omega t+Q\sin\left(\omega t+\frac{\pi}{2}\right)$

First, we simplify the given equation using trigonometric identities. The identity for sin $\left(\omega t+\frac{\pi}{2}\right)$ can be rewritten as $\cos\omega t$ because $\sin\left(\theta+\frac{\pi}{2}\right)=\cos\theta$. Hence, the motion equation becomes:

$x=P\sin\omega t+Q\cos\omega t$

To find the total energy, we need to consider both kinetic and potential energies of the system. The total energy in S.H.M. is given by the sum of potential and kinetic energies, which remains constant and can be represented as:

$E=\frac{1}{2}m\omega^2A^2$

where A is the amplitude of the motion. In this case, the total amplitude of the motion given by the resultant of $P\sin\omega t$ and $Q\cos\omega t$ is actually the resultant vector magnitude of P and Q, since they can be seen as perpendicular components (similar to a Pythagorean theorem scenario), and hence the resultant or effective amplitude A is:

$A=\sqrt{P^2+Q^2}$

Thus, substituting $A=\sqrt{P^2+Q^2}$ into the equation for total energy, we get:

$E=\frac{1}{2}m\omega^2(\sqrt{P^2+Q^2})^2$

$E=\frac{1}{2}m\omega^2(P^2+Q^2)$

Therefore, the correct option is:

Option C: $\frac{1}{2}m\omega^2\left(P^2+Q^2\right)$

Question121

A mass 0.4 kg performs S.H.M. with a frequency $\frac{16}{\pi}$ Hz. At a certain displacement it has kinetic energy 2 J and potential energy 1.2 J. The amplitude of oscillation is

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Options:

A. 0.15 m

B. 0.125 m

C. 0.075 m

D. 0.1 m

Answer: B

Solution:

To determine the amplitude of the oscillation for the given simple harmonic motion (SHM), we first use some basic principles and formulas related to SHM.

Given:

- Mass, $m = 0.4$ kg
- Frequency, $f = \frac{16}{\pi}$ Hz
- Kinetic energy, $KE = 2$ J at a certain displacement
- Potential energy, $PE = 1.2$ J at the same displacement

First, the total energy in the SHM system is the sum of kinetic energy and potential energy:

$$E_{\text{total}} = KE + PE = 2\text{ J} + 1.2\text{ J} = 3.2\text{ J}$$

In SHM, the total energy is also given by the formula:

$$E_{\text{total}} = \frac{1}{2} m\omega^2 A^2$$

where:

- m is the mass.
- ω is the angular frequency.
- A is the amplitude of oscillation.

First, we need to find the angular frequency ω from the given frequency f:

$\omega = 2\pi f$

Substituting the given frequency, we get:

$\omega = 2\pi\left(\frac{16}{\pi}\right) = 32 \text{ rad/s}$

Now, we use the total energy formula to find the amplitude A:

$3.2 = \frac{1}{2} \times 0.4 \times 32^2 \times A^2$

Simplifying, we get:

$3.2 = 0.2 \times 1024 \times A^2$

$3.2 = 204.8A^2$

$A^2 = \frac{3.2}{204.8} = 0.015625$

$A = \sqrt{0.015625} = 0.125 \text{ m}$

Hence, the amplitude of oscillation is 0.125 m.

Therefore, the correct option is:

Option B

0.125 m

Question122

If the amplitude of linear S.H.M. is decreased then

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Options:

A. its period and total energy will increase.

B. its period will increase and total energy will decrease

C. its period and total energy will decrease.

D. its period will not change but total energy will decrease

Answer: D

Solution:

To answer this question, it's essential to understand the characteristics of Simple Harmonic Motion (S.H.M.) and the effects of amplitude on its various aspects.

Period of S.H.M.: The period of a simple harmonic oscillator is the time it takes for one complete cycle of motion. For a mass-spring system, the period T is given by:

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

where m is the mass of the object and k is the spring constant. Notice that the period T depends only on the mass and the spring constant, and not on the amplitude A of the oscillation. Thus, decreasing the amplitude does not affect the period of the motion.

Total Energy of S.H.M.: The total energy E in simple harmonic motion is proportional to the square of its amplitude A. For a mass-spring system, the total energy is given by:

$E = \frac{1}{2}kA^2$

Given this relationship, if the amplitude is decreased, the total energy will also decrease.

Therefore, based on this analysis:

- **Option A**: Incorrect. The period does not increase with a decrease in amplitude, and the total energy decreases rather than increases.
- **Option B**: Incorrect. The period does not increase with a decrease in amplitude, though the total energy does decrease.
- **Option C**: Incorrect. The period does not decrease with a decrease in amplitude, though the total energy does decrease.
- **Option D**: Correct. The period remains unchanged, but the total energy decreases with a decrease in amplitude.

Hence, the correct answer is:

Option D: *its period will not change but total energy will decrease*.

Question123

A child is sitting on a swing which performs S.H.M. It has minimum and maximum heights from ground 0.75 cm and 2 m respectively. Its maximum speed will be $\left[\mathrm{g} = 10 \frac{\mathrm{m}}{\mathrm{s}^2}\right]$

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Options:

A. $\sqrt{1.25} \text{ m/s}$

B. $\sqrt{12.5}\ \mathrm{m/s}$

C. $5\ \mathrm{m/s}$

D. $25\ \mathrm{m/s}$

Answer: C

Solution:

Maximum potential energy is attained at the highest point which gets converted into kinetic energy at the lowest point.

$$\begin{aligned} & \mathrm{h}=2-0.75=1.25\ \mathrm{m} \\ & \frac{1}{2}\mathrm{mv}^2=\mathrm{mgh} \\ \therefore \quad & v^2=2\mathrm{gh}=2\times 10\times 1.25=25 \\ \therefore \quad & \mathrm{v}=5\ \mathrm{m/s} \end{aligned}$$

Question124

A pendulum clock is running fast. To correct its time, we should

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Options:

A. reduce the mass of the bob.

B. reduce the amplitude of oscillation.

C. increase the length of the pendulum.

D. reduce the length of the pendulum.

Answer: C

Solution:

The periodic time of a pendulum is given by

$\mathrm{T}=2\pi\sqrt{\frac{\mathrm{l}}{\mathrm{g}}}$

$\therefore T \propto \sqrt{l}$

Hence, to increase the periodic time, length has to be increased. The periodic time is independent of mass and amplitude.

Question125

A particle is performing S.H.M. with maximum velocity 'v'. If the amplitude is tripled and periodic time is doubled then maximum velocity will be

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Options:

A. 1.5 v

B. 3 v

C. 2 v

D. v

Answer: A

Solution:

To solve this problem, we first need to recall the formula that relates the maximum velocity (v_{max}) of a particle performing simple harmonic motion (S.H.M.) to its amplitude (A) and its angular frequency (ω). The formula for maximum velocity in S.H.M. is given by:

$v_{max} = \omega A$

Now the angular frequency (ω) is related to the period (T) of the S.H.M. by the relationship:

$\omega = \frac{2\pi}{T}$

Thus, we can rewrite the expression for maximum velocity as:

$v_{max} = A \cdot \frac{2\pi}{T}$

In the initial situation, let's denote the amplitude as A and the periodic time as T. The maximum velocity given is v, so we can write:

$v = A \cdot \frac{2\pi}{T}$

According to the question, the amplitude is tripled (making it $3A$), and the periodic time is doubled (making it $2T$). We need to find the new maximum velocity, let's call it v':

$v' = (3A) \cdot \frac{2\pi}{(2T)}$

Simplifying gives us:

$v' = 3A \cdot \frac{\pi}{T}$

Now, if we recall the original maximum velocity $v = A \cdot \frac{2\pi}{T}$, we can express $\frac{\pi}{T}$ in terms of v and A:

$\frac{\pi}{T} = \frac{v}{2A}$

Substituting this into the expression for v', we get:

$v' = 3A \times \frac{v}{2A} = \frac{3}{2}v = 1.5v$

Therefore, the new maximum velocity when the amplitude is tripled and the periodic time is doubled is $1.5v$. The correct answer is:

Option A 1.5 v

Question126

A particle executes S.H.M. of period $\frac{2\pi}{\sqrt{3}}$ second along a straight line 4 cm long. The displacement of the particle at which the velocity is numerically equal to the acceleration is

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Options:

A. 2 cm

B. 1 cm

C. 4 cm

D. 3 cm

Answer: B

Solution:

$\mathrm{T}=\frac{2 \pi}{\sqrt{3}} \mathrm{~s}, \mathrm{ZA}=4 \mathrm{~cm}$

$\therefore \mathrm{A}=2 \mathrm{~cm}=2 \times 10^{-2} \mathrm{~m}$

Acceleration, $a=\omega^2 \mathrm{x}$

Velocity, $v=\omega \sqrt{A^2-x^2}$

$\therefore \quad \omega^2 \mathrm{x}=\omega \sqrt{A^2-\mathrm{x}^2}$

$\omega x=\sqrt{A^2-x^2}$

$\omega^2 x^2=A^2-x^2$

$\therefore \quad 3 \mathrm{x}^2=\mathrm{A}^2-\mathrm{x}^2 \quad\left(\therefore \omega=\frac{2 \pi}{\mathrm{T}}=\sqrt{3}\right)$

$\therefore \quad 4 \mathrm{x}^2=\mathrm{A}^2$

$\mathrm{c}=\frac{\mathrm{A}}{2}=\frac{2}{2}=1 \mathrm{~cm}$

Question127

A particle is suspended from a vertical spring which is executing S.H.M. of frequency $5 \mathrm{~Hz}$. The spring is unstretched at the highest point of oscillation. Maximum speed of the particle is $\left(\mathrm{g}=10 \mathrm{~m} / \mathrm{s}^2\right)$

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Options:

A. $\frac{1}{\pi} \mathrm{m} / \mathrm{s}$

B. $\frac{1}{4 \pi} \mathrm{m} / \mathrm{s}$

C. $\frac{1}{2 \pi} \mathrm{m} / \mathrm{s}$

D. $\pi \mathrm{~m} / \mathrm{s}$

Answer: A

Solution:

At the highest point the particle will come to rest momentarily, hence it is at extreme position and has maximum force and acceleration. Since the spring is unstretched, the restoring forceto provided by the weight of the particle

$\therefore \mathrm{mA}\omega^2 = \mathrm{mg}$

or $A\omega^2 = \mathrm{g}$

$$\therefore A = \frac{g}{\omega^2}$$
$$\omega = 2\pi f = 2\pi \times 5 = 10\pi$$
$$\therefore A = \frac{10}{100\pi^2} = \frac{1}{10\pi^2}$$
$$V_{\max} = A\omega = \frac{1}{10\pi^2} \times 10\pi = \frac{1}{\pi}$$

Question128

A body performs S.H.M. under the action of force 'F_1' with period 'T_1' second. If the force is changed to 'F_2' it performs S.H.M. with period 'T_2' second. If both forces 'F_1' and 'F_2' act simultaneously in the same direction on the body, the period in second will be

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Options:

A. $\frac{T_1+T_2}{T_1T_2}$

B. $\frac{T_1^2+T_2^2}{T_1T_2}$

C. $\frac{\mathrm{T}_1\ \mathrm{T}_2}{\sqrt{\mathrm{T}_1^2+\mathrm{T}_2^2}}$

D. $\frac{T_1T_2}{T_1+T_2}$

Answer: C

Solution:

$\mathrm{F}_1 = \mathrm{K}_1\mathrm{x} \quad \mathrm{F}_2 = \mathrm{K}_2\mathrm{x} \quad \mathrm{F} = (\mathrm{K}_1 + \mathrm{K}_2)\mathrm{x}$

$$\therefore T_1 = 2\pi\sqrt{\frac{m}{K}} \quad T_2 = 2\pi\sqrt{\frac{\mathrm{m}}{\mathrm{K}}}$$

$$\therefore \mathrm{T}_1^2 = 4\pi^2 \frac{\mathrm{m}}{\mathrm{K}_1} \quad \mathrm{T}_2^2 = 4\pi^2 \frac{\mathrm{m}}{\mathrm{K}_2}$$

$$T^2 = 4\pi^2 \frac{m}{K_1 + K_2}$$

$$\therefore \frac{1}{\mathrm{T}^2} = \frac{\mathrm{K}_1 + \mathrm{K}_2}{4\pi^2 \mathrm{~m}} \quad = \frac{\mathrm{K}_1}{4\pi^2 \mathrm{~m}} + \frac{\mathrm{K}_2}{4\pi^2 \mathrm{~m}}$$

$$= \frac{1}{\mathrm{T}_1^2} + \frac{1}{\mathrm{T}_2^2} = \frac{\mathrm{T}_1^2 + \mathrm{T}_2^2}{\mathrm{T}_1^2 \mathrm{T}_2^2}$$

$$\therefore \mathrm{T}^2 = \frac{\mathrm{T}_1^2 \mathrm{T}_2^2}{\mathrm{T}_1^2 + \mathrm{T}_2^2}$$

$$\therefore \mathrm{T} = \frac{\mathrm{T}_1 \mathrm{T}_2}{\sqrt{\mathrm{T}_1^2 + \mathrm{T}_2^2}}$$

Question129

A mass 'm_1' is suspended from a spring of negligible mass. A spring is pulled slightly in downward direction and released, mass performs S.H.M. of period 'T_1'. If the mass is increased by 'm_2', the time period becomes 'T_2'. The ratio $\frac{\mathrm{m}_2}{\mathrm{m}_1}$ is

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Options:

A. $\frac{\mathrm{T}_1^2+\mathrm{T}_2^2}{\mathrm{T}_1^2}$

B. $\frac{\mathrm{T}_1-\mathrm{T}_2}{\mathrm{T}_1}$

C. $\frac{\mathrm{T}_2^2-\mathrm{T}_1^2}{\mathrm{T}_1^2}$

D. $\frac{T_1^2-T_2^2}{T_1^2}$

Answer: C

Solution:

$$T_1 = 2\pi\sqrt{\frac{m_1}{k}}, T_2 = 2\pi\sqrt{\frac{m_1+m_2}{k}}$$
$$\therefore \frac{T_2}{T_1} = \sqrt{\frac{m_1+m_2}{m_1}}$$
$$\therefore \frac{T_2^2}{T_1^2} = \frac{m_1+m_2}{m_1}$$
$$\therefore \frac{T_2^2 - T_1^2}{T_1^2} = \frac{m_2}{m_1}$$

Question130

Two particles P and Q performs S.H.M. of same amplitude and frequency along the same straight line. At a particular instant, maximum distance between two particles is $\sqrt{2}$ a. The initial phase difference between them is

$$\left[\sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = \cos^{-1}\left(\frac{1}{\sqrt{2}}\right) = \frac{\pi}{4}\right]$$

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Options:

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

B. $\frac{\pi}{2}$

C. zero

D. $\frac{\pi}{3}$

Answer: B

Solution:

$x = x_1 + x_2 = A\sin(\omega t + \alpha)$

Maximum value of $x_1 + x_2 = A = \sqrt{2}a$

$A^2 = a^2 + a^2 + 2a^2 \cos\alpha = 2a^2(1 + \cos\alpha)$
$\therefore 2a^2 = 2a^2(1 + \cos\alpha) \quad \therefore 1 = 1 + \cos\alpha$
$\therefore \quad \cos\alpha = 0 \quad \therefore \alpha = \frac{\pi}{2}$

Question131

A particle of mass 5kg is executing S.H.M. with an amplitude 0.3 m and time period $\frac{\pi}{5}$ s. The maximum value of the force acting on the particle is

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Options:

A. 0.15 N

B. 4 N

C. 5 N

D. 0.3 N

Answer: A

Solution:

$\mathrm{m} = 5\ \mathrm{g} = 5 \times 10^{-3}$ kg, A = 0.3 m, $\mathrm{T} = \frac{\pi}{5}$ s

$\omega = \frac{2\pi}{\mathrm{T}} = 10$ rad/s

Maximum force

$\mathrm{F} = \mathrm{m}\omega^2\mathrm{A} = 5 \times 10^{-3} \times (10)^2 \times 0.3 = 0.15$ N

Question132

Two bodies A and B of equal mass are suspended from two separate massles springs of force constant k_1 and k_2, respectively. The bodies oscillate vertically such that their maximum velocities are equal. The ratio of the amplitudes of body A to that of body B is

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Options:

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

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

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

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

Answer: A

Solution:

The maximum velocity of body in SHM,

$v = A\omega$

where, A is amplitude of body and ω is the angulat frequency.

It is given that, the maximum velocities of bodies are equal.

$$\begin{aligned} v_A &= v_B \\ A_A\omega_A &= A_B\omega_B \\ A_A\sqrt{\frac{k_1}{m}} &= A_B\sqrt{\frac{k_2}{m}} \quad \left(\because \omega = \sqrt{\frac{k}{m}}\right) \\ \frac{A_A}{A_B} &= \sqrt{\frac{k_2}{k_1}} \end{aligned}$$

Question133

A bob of a simple pendulum has mass m and is oscillating with an amplitude a. If the length of the pendulum is L, then the maximum

tension in the string is $[\cos 0^\circ = 1, g =$ acceleration due to gravity$]$

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Options:

A. $mg\left[1+\left(\frac{a}{L}\right)^2\right]$

B. $mg\left[1-\left(\frac{L}{a}\right)^2\right]$

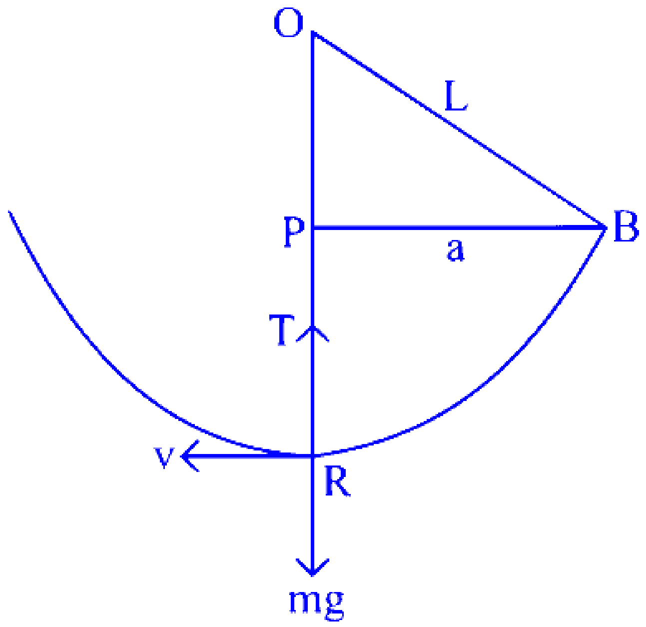
C. $mg\left[1+\left(\frac{L}{a}\right)^2\right]$

D. $mg\left[1-\left(\frac{a}{L}\right)^2\right]$

Answer: A

Solution:

Consider the figure shown below



The string posses maximum tension when bob is at mean position of oscillation i.e., at position R.

From geometry, $OP = \sqrt{L^2 - a^2}$

Also, $RP = OR - OP = L - \sqrt{L^2 - a^2}$

The whole kinetic energy of bob at position R is converted into its potential energy at position B.

$$\therefore \quad \frac{1}{2}mv^2 = mg\left(L - \sqrt{L^2 - a^2}\right)$$
$$v^2 = 2g\left(L - \sqrt{L^2 - a^2}\right)$$

Balancing forces at R,

$$T - mg = \frac{mv^2}{I} = \frac{2mg\left(L - \sqrt{L^2 - a^2}\right)}{L}$$
$$\therefore \quad T = mg + 2mg\left(1 - \sqrt{1 - \frac{a^2}{L^2}}\right)$$

Using approximation, $\sqrt{1 - x^2} = 1 - \frac{x^2}{2}$ for $x << 1$, we get

$$T = mg + 2mg\left[1 - \left(1 - \frac{a^2}{2^2}\right)\right]$$
$$= mg + mg\left(\frac{a}{L}\right)^2 = mg\left[1 + \left(\frac{a}{L}\right)^2\right]$$

Question134

A body of mass 64 g is made to oscillate turn by turn on two different springs A and B. Spring A and B has force constant $4\frac{\mathrm{N}}{\mathrm{m}}$ and $16\frac{\mathrm{N}}{\mathrm{m}}$ respectively. If T_1 and T_2 are period of oscillations of springs A and B respectively, then $\frac{T_1+T_2}{T_1-T_2}$ will be

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Options:

A. 1 : 2

B. 1 : 3

C. 3 : 1

D. 2 : 1

Answer: C

Solution:

Given, $m = 64 \text{ g} = 64 \times 10^{-3}$ kg,

$k_A = 4 \text{ N/m}$ and $k_B = 16 \text{ N/m}$

The time period of oscillation of a spring,

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

$$\Rightarrow \quad T_A = T_1 = 2\pi\sqrt{\frac{m}{k_A}} = 2\pi\sqrt{\frac{64 \times 10^{-3}}{4}}$$

$$= 2\pi\sqrt{16 \times 10^{-3}} \quad \text{... (i)}$$

$$\text{and} \quad T_B = T_2 = 2\pi\sqrt{\frac{m}{k_B}} = 2\pi\sqrt{\frac{64 \times 10^{-3}}{16}}$$

$$= 2\pi\sqrt{4 \times 10^{-3}} \quad \text{... (ii)}$$

Dividing Eq. (i) by Eq. (ii), we get

$$\frac{T_1}{T_2} = \sqrt{\frac{16 \times 10^{-3}}{4 \times 10^{-3}}} = 2$$

$$\Rightarrow \quad T_1 = 2T_2$$

$$\therefore \quad \frac{T_1 + T_2}{T_1 - T_2} = \frac{2T_2 + T_2}{2T_2 - T_2} = \frac{3T_2}{T_2} = \frac{3}{1} \text{ or } 3:1$$

Question135

The damping force of an oscillator is directly proportional to the velocity. The unit of constant of proportionality is

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Options:

A. kg ms^{-1}

B. kg s^{-1}

C. kg ms^{-2}

D. kg-s

Answer: B

Solution:

Given, damping force $\propto$ velocity

$F \propto v$
$F = kv$

where, k is the proportionality constant.

$$\Rightarrow \quad k = \frac{F}{v} = \frac{\text{kg} - \text{m/s}^2}{\text{m/s}} = \frac{\text{kg}}{\text{s}} = \text{kg s}^{-1}$$

Question136

A particle performs simple harmonic motion with period of 3 s . The time taken by it to cover a distance equal to half the amplitude from mean position is [$\sin 30^\circ = 0.5$]

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Options:

A. $\frac{1}{4}$ s

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

C. $\frac{3}{4}$ s

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

Answer: A

Solution:

The displacement of particle in SHM at any instant,

$$x = A \sin \omega t$$
$$\frac{A}{2} = A \sin \omega t \quad \left(\text{given, } x = \frac{A}{2}\right)$$
$$\sin \omega t = \frac{1}{2} = \sin \frac{\pi}{6} \Rightarrow \omega t = \frac{\pi}{6}$$

$\Rightarrow \quad \frac{2\pi}{T} \cdot t = \frac{\pi}{6} \quad \left(\because \omega = \frac{2\pi}{T}\right)$

$\Rightarrow \quad \frac{2\pi}{3} t = \frac{\pi}{6} \quad (\because T = 3 \text{ s})$

$\Rightarrow \quad t = \frac{1}{4} \text{ s}$

Question137

A simple pendulum of length I has a bob of mass m. It executes SHM of small amplitude A. The maximum tension in the string is ($g =$ acceleration due to gravity)

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Options:

A. mg

B. $mg\left(\frac{A^2}{I^2}+1\right)$

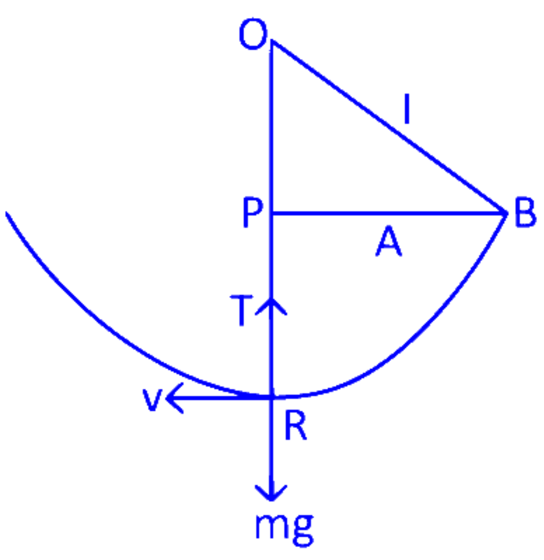
C. 2 mg

D. $mg\left(\frac{A}{I}+1\right)$

Answer: B

Solution:

Consider the figure shown below



The string possess maximum tension when bolls at mean position of oscillation i.e., at position R.

From geometry, $OP = \sqrt{1^2 - A^2}$

Also, $RP = OR - OP = I - \sqrt{1^2 - A^2}$

The whole kinetic energy of bob at position R is converted into its potential energy at position B.

$$\therefore \quad \frac{1}{2} m v^2 = mg\left(I - \sqrt{I^2 - A^2}\right)$$
$$v^2 = 2g\left(I - \sqrt{I^2 - A^2}\right)$$

Balancing forces at R,

$$T - mg = \frac{mv^2}{I} = \frac{2mg\left(I - \sqrt{l^2 - A^2}\right)}{I}$$
$$\therefore \quad T = mg + 2mg\left(1 - \sqrt{1 - \frac{A^2}{l^2}}\right)$$

Using approximation, $\sqrt{1 - x^2} = 1 - \frac{x^2}{2}$ for $x << 1$, we

$$T = mg + 2mg\left[1 - \left(1 - \frac{A^2}{2^2}\right)\right]$$
$$= mg + mg\left(\frac{A}{I}\right)^2$$
$$= mg\left[1 + \left(\frac{A}{I}\right)^2\right]$$

Question138

A block of mass m attached to one end of the vertical spring produces extension x. If the block is pulled and released, the periodic time of oscillation is

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Options:

A. $2\pi\sqrt{\frac{x}{4g}}$

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

C. $2\pi\sqrt{\frac{x}{2g}}$

D. $2\pi\sqrt{\frac{x}{g}}$

Answer: D

Solution:

For vertical spring, the periodic time of oscillation is

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

As, restoring force, $|F| = kx$

$\Rightarrow \quad k = \frac{F}{x} = \frac{mg}{x}$

$\therefore \quad T = 2\pi\sqrt{\frac{m}{\frac{mg}{x}}} = 2\pi\sqrt{\frac{x}{g}}$

Question139

A simple pendulum of length L has mass m and it oscillates freely with amplitude A. At extreme position, its potential energy is ($g =$ acceleration due to gravity)

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Options:

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

B. $\frac{mgA}{2l}$

C. $\frac{mgA^2}{L}$

D. $\frac{mgA^2}{2L}$

Answer: D

Solution:

At extreme position, the potential energy of simple pendulum,

$PE = \frac{1}{2} m A^2 \omega^2$ .... (i)

where, $\omega =$ angular frequency $= \frac{2\pi}{T}$

For simple pendulum, $T = 2\pi\sqrt{\frac{L}{g}}$

$\therefore \quad \omega = \frac{2\pi}{2\pi}\sqrt{\frac{g}{L}} = \sqrt{\frac{g}{L}} \quad \left[\because T = \frac{2\pi}{\omega}\right]$

On putting value of ω in Eq. (i), we get

$\mathrm{PE} = \frac{1}{2} m A^2 \left(\sqrt{\frac{g}{L}}\right)^2 = \frac{m g A^2}{2L}$

Question140

For a particle performing SHM when displacement is x, the potential energy and restoring force acting on it is denoted by E and F, respectively. The relation between x, E and F is

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Options:

A. $\frac{E}{F} + x = 0$

B. $\frac{2E}{F} - x = 0$

C. $\frac{2E}{F} + x = 0$

D. $\frac{E}{F} - x = 0$

Answer: B

Solution:

For a particle performing Simple Harmonic Motion (SHM), the potential energy (PE) at a displacement x from the equilibrium position is given by

$E = \frac{1}{2}kx^2$

where k is the spring constant.

The restoring force F acting on the particle is given by Hooke's law, which states that $F = -kx$. The negative sign indicates that the force is directed towards the equilibrium position, opposing the displacement.

To find the relation between x, E, and F, we can express k from the equation of force:

$F = -kx \Rightarrow k = -\frac{F}{x}$

Substituting k into the equation for potential energy:

$E = \frac{1}{2}\left(-\frac{F}{x}\right)x^2 = \frac{1}{2} \cdot \frac{F}{x} \cdot x^2$

We simplify this to get:

$E = \frac{1}{2}Fx$

To find a relational formula involving E, F, and x, we can solve the equation $E = \frac{1}{2}Fx$ for one variable in terms of the others. However, let's examine the given options instead. Rearranging the equation for E to isolate terms similar to the options given, we obtain:

$2E = Fx$

Dividing both sides of this equation by F gives us:

$\frac{2E}{F} = x$

Rearranging the terms to match the given options, we get:

$\frac{2E}{F} - x = 0$

Therefore, the correct relation between x, E, and F is given by Option B:

$\frac{2E}{F} - x = 0$

Question141

A person measures a time period of a simple pendulum inside a stationary lift and finds it to be T. If the lift starts accelerating upwards with an acceleration $\left(\frac{g}{3}\right)$, the time period of the pendulum will be

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Options:

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

B. $\sqrt{3} \frac{T}{2}$

C. $\sqrt{3} T$

D. $\frac{T}{3}$

Answer: B

Solution:

Time period of simple pendulum inside a stationary lift,

$T = 2\pi\sqrt{\frac{l}{g}}$ .... (i)

where, $I =$ length of string

and $g =$ gravitational acceleration

Acceleration of lift in upward direction,

$a = \frac{g}{3}$

$\therefore$ Time period of pendulum, d of pendulum,

$$\begin{aligned} T' &= 2\pi\sqrt{\frac{l}{g+a}} = 2\pi\sqrt{\frac{l}{g+\frac{g}{3}}} \\ &= 2\pi\sqrt{\frac{3l}{4g}} = 2\pi \cdot \frac{\sqrt{3}}{2} \cdot \sqrt{\frac{l}{g}} \\ &= \frac{\sqrt{3}}{2} \cdot 2\pi\sqrt{\frac{l}{g}} = \frac{\sqrt{3}}{2} T \text{ [from Eq. (i)]} \end{aligned}$$

Question142

In damped SHM, the SI unit of damping constant is

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Options:

A. $\frac{\mathrm{N}}{\mathrm{s}}$

B. $\frac{\mathrm{kg}}{\mathrm{s}}$

C. $\frac{\mathrm{kg}}{\mathrm{m}}$

D. $\frac{N}{m}$

Answer: B

Solution:

In damped SHM, damping force is proportional to the velocity of the oscillator.

i.e., $F_d \propto v \Rightarrow F_d = bv$

where, b is a damping constant.

$\therefore$ Damping constant, $b = \frac{F_d}{v}$

SI unit of damping constant

$$b = \frac{\text{SI unit of force}}{\text{SI unit of velocity}} = \frac{\mathrm{kg} \cdot \mathrm{m} \cdot \mathrm{s}^{-2}}{\mathrm{m} \cdot \mathrm{s}^{-1}}$$

$$= \mathrm{kg} \cdot \mathrm{s}^{-1} = \frac{\mathrm{kg}}{\mathrm{s}}$$

Hence, the SI unit of damping constant is kg/s.

Question143

The total energy of a simple harmonic oscillaior is proportional to

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Options:

A. square of this amplitude

B. square root of displacement

C. amplitude

D. frequency

Answer: A

Solution:

Total energy of simple harmonic oscillator is given by

$E=\frac{1}{2} m \omega^2 A^2$

where, $m=$ mass of body performing SHM, $\omega=$ angular velocityand $A=$ amplitude.

$\therefore \quad E \propto A^2$

Question144

A particle is performing a linear simple harmonic motion of amplitude ' A '. When it is midway between its mean and extreme position, the magnitudes of its velocity and acceleration are equal. What is the periodic time of the motion?

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Options:

A. $\frac{2 \pi}{\sqrt{3}}$ s

B. $\frac{\sqrt{3}}{2 \pi} s$

C. $2\pi\sqrt{3}$ s

D. $\frac{1}{2\pi\sqrt{3}}$ s

Answer: A

Solution:

In linear simple harmonic motion, the velocity of particle is given by

$v=\omega\sqrt{A^2-x^2}$ .... (i)

where, $\omega=$ angular frequency

$A=$ maximum displacement of amplitude

and $x=$ displacement from mean position.

The acceleration of a particle in simple harmonic motion, (SHM) is given by

$a=\omega^2 x$ .... (ii)

Here, $x=\frac{A}{2}$

Also, $v=a$ (given)

$\omega\sqrt{(A^2-x^2)}=\omega^2 x$ [from Eqs. (i) and (ii), we get]

$$\Rightarrow \sqrt{\left(A^2-\frac{A^2}{4}\right)}=\omega\times\frac{A}{2} \Rightarrow \frac{\sqrt{3}A}{2}=\omega\times\frac{A}{2}$$

$$\Rightarrow \frac{2\pi}{T}=\sqrt{3} \quad \left[\because \omega=\frac{2\pi}{T}\right]$$

$$\Rightarrow T=\frac{2\pi}{\sqrt{3}} \text{ s}$$

Question145

Two pendulums begin to swing simultaneously. The first pendulum makes nine full oscillations when the other makes seven. The ratio of the lengths of the two pendulums is

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Options:

A. $\frac{49}{81}$

B. $\frac{64}{81}$

C. $\frac{8}{9}$

D. $\frac{7}{9}$

Answer: A

Solution:

As two pendulums begin to swing simultaneously, then

$n_1 T_1 = n_2 T_2 \quad \text{.... (i)}$

where, n_1 and n_2 are the number of oscillations of first and second pendulum respectively and T_1 and T_2 be their respective time periods.

The time period of simple pendulum is given by

$T = 2\pi\sqrt{\frac{l}{g}}$

where, $I =$ length of pendulum

and $g =$ acceleration due to gravity

$\Rightarrow \quad T^2 \propto l \quad \text{.... (ii)}$

So, from Eqs. (i) and (ii), we get

$\frac{l_1}{l_2} = \frac{T_1^2}{T_2^2} = \frac{n_2^2}{n_1^2}$

Here, $n_1 = 9, n_2 = 7$

$\Rightarrow \quad \frac{l_1}{l_2} = \frac{(7)^2}{(9)^2} = \frac{49}{81}$

Hence, the ratio of pendulum lengths $I_1 : I_2 = 49 : 81$.

Question146

If ' x ', v ' and ' a ' denote the displacement, velocity and acceleration of a particle respectively executing SHM of periodic time h then which one of the following does not change with time?

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Options:

A. $\frac{aT}{x}$

B. $at + 2\pi v$

C. $\frac{aT}{v}$

D. $aT + 4\pi^2 v^2$

Answer: C

Solution:

The dimensions of given variables of SHM are as

Displacement, $[x] = \left[M^0 L T^0\right]$

Velocity, $[\mathrm{v}] = \left[\mathrm{M^0 L T^{-1}}\right]$

Acceleration, $[a] = \left[M^0 L T^{-2}\right]$

and time period, $[T] = \left[M^0 L^0 T\right]$

Now, checking each option for these values

For option (a)

$$\frac{[a][T]}{[x]} = \frac{\left[M^0 L T^{-2}\right]\left[M^0 L^0 T\right]}{\left[M^0 L T^0\right]} = \left[M^0 L^0 T^{-1}\right]$$

As it depends on time, so change with it.

For option (b),

$$\begin{aligned}[a][T] + 2\pi[v] &= \left[M^0 L T^{-2}\right]\left[M^0 L^0 T\right] + \left[M^0 L^0 T^{-1}\right] \\ &= \left[M^0 L T^{-1}\right]\end{aligned}$$

It is also dependent on time and hence changes with it.

For option (c),

$$\frac{[a][T]}{[v]} = \frac{[M^0LT^{-2}][M^0L^0T]}{[M^0LT^{-1}]} = [M^0L^0T^0]$$

As it is a constant having no dimension, so it does not change with time.

For option (d),

$$\begin{aligned}[\text{a}]\ [t] + 4\pi^2[d]^2 &= [M^\rho LT^{-2}]\ [M^0L^0T] + [M^0LT^{-1}]^2 \\ &= [LT^{-1}] + [L^2T^{-2}]\end{aligned}$$

As, the term is dependent on time, so changes with it.

Also, it is dimensionally incorrect.

Hence, option (c) is correct.

Question147

The quantity which does not vary periodically for a particle performing SHM is

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Options:

A. acceleration

B. total energy

C. displacement

D. velocity

Answer: B

Solution:

For a particle executing simple harmonic motion (SHM),

Total energy = kinetic energy + potential energy

$$= E_K + E_P = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

$= \frac{1}{m}\left(A^2 - x^2\right) + \frac{1}{2} m\omega^2 A^2$

($\because v = \sqrt{A^2 - x^2}$ where, A is the amplitude of the particle)

$= \frac{1}{2} K A^2$

It is independent of t, x is remains constant i.e., it does not vary periodically.

However, the displacement of a particle executing SHM along x-axis is given by

$x = A \sin(\omega t + \phi)$

(where, $A =$ amplitude, $\omega =$ angular velocity $t =$ time, $\phi =$ initial phase of the particle)

i.e., displacement varies periodically with time t. velocity of particles executing SHM,

$v = \frac{dx}{dt} = \omega\sqrt{A^2 - x^2}$

which varies with x.

Acceleration of the particle,

$a = \frac{dv}{dt} = -\omega^2 x$

Which also varies with x.

Question148

A particle executes the simple harmonic motion with an amplitude 'A'. The distance travelled by it in one periodic time is

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Options:

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

B. A

C. $2A$

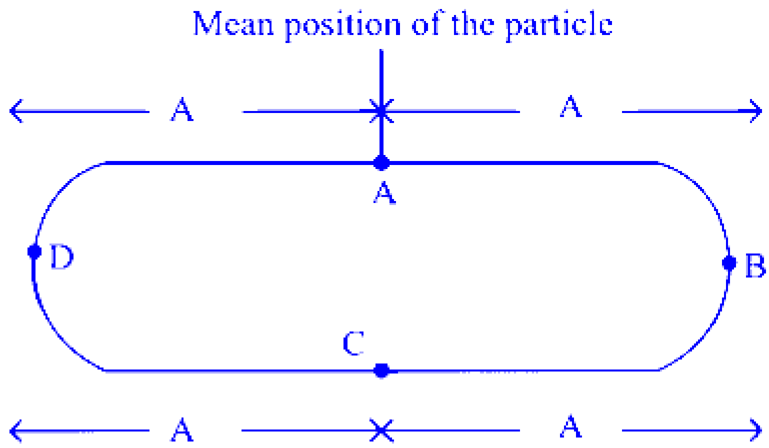
D. $4A$

Answer: D

Solution:

Key Idea One time period means the total time in which the particle returns to the same point and in the same direction from where it was released.

Now, in simple harmonic motion (SHM) total distance travelled is 4A.



This is because the particle covers A in $\frac{T}{4}$ time period i.e., when it moves from A to B, So in complete T time it covers 4 times the amplitude distance i.e., $4A$.
