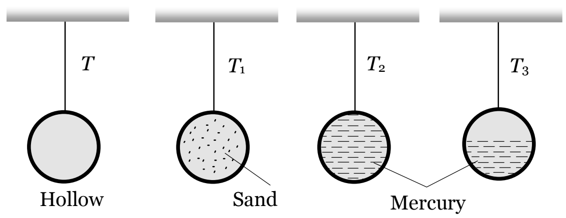
# Simple Harmonic Motion

## SET Self Evaluation Test -16

**1.** The period of a simple pendulum, whose bob is a hollow metallic sphere, is $T$. The period is $T_1$ when the bob is filled with sand, $T_2$ when it is filled with mercury and $T_3$ when it is half filled with mercury. Which of the following is true




(a) $T = T_1 = T_2 > T_3$ (b) $T_1 = T_1 = T_3 > T$

(c) $T > T_3 > T_1 = T_2$ (d) $T = T_1 = T_2 < T_3$

**2.** A pendulum clock that keeps correct time on the earth is taken to the moon it will run (it is given that $g_{Moon} = g_{Earth}/6$ )

(a) At correct rate (b) 6 time faster

(c) $\sqrt{6}$ times faster (d) $\sqrt{6}$ times slowly

**3.** A pendulum has time period $T$ in air. When it is made to oscillate in water, it acquired a time period $T' = \sqrt{2}T$ . The density of the pendulum bob is equal to (density of water = 1)

(a) $\sqrt{2}$ (b) 2

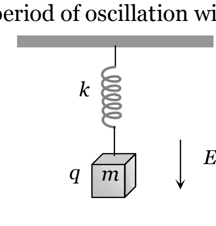
(c) $2\sqrt{2}$ (d) None of these

**4.** An object of mass 0.2 *kg* executes simple harmonic along $X$-axis with frequency of $\frac{25}{\pi} Hz$ . At the position $x = 0.04 m$ , the object has kinetic energy of 0.5 $J$ and potential energy of 0.4 $J$ amplitude of oscillation in meter is equal to

(a) 0.05 (b) 0.06

(c) 0.01 (d) None of these

**5.** Time period of a block suspended from the upper plate of a parallel plate capacitor by a spring of stiffness $k$ is $T$. When block is uncharged. If a charge $q$ is given to the block them, the new time period of oscillation will be



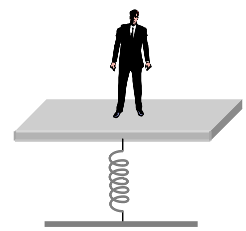

(a) $T$

(b) $> T$

(c) $< T$

(d) $\geq T$

**6.** A man weighing 60 *kg* stands on the horizontal platform of a spring balance. The platform starts executing simple harmonic motion of amplitude 0.1 *m* and frequency $\frac{2}{\pi} Hz$ . Which of the following statement is correct



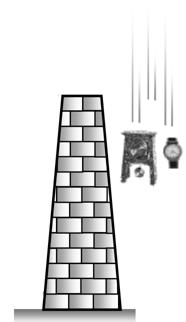
(a) The spring balance reads the weight of man as 60 *kg*

(b) The spring balance reading fluctuates between 60 *kg*. and 70 *kg*

(c) The spring balance reading fluctuates between 50 *kg* and 60 *kg*

(d) The spring balance reading fluctuates between 50 *kg* and 70 *kg*

**7.** A man having a wrist watch and a pendulum clock rises on a *TV* tower. The wrist watch and pendulum clock per chance fall from the top of the tower. Then



(a) Both will keep correct time during the fall.

(b) Both will keep incorrect time during the fall.

(c) Wrist watch will keep correct time and clock will become fast.

(d) Clock will stop but wrist watch will function normally.

**8.** A force of 6.4 $N$ stretches a vertical spring by 0.1 *m*. The mass that must be suspended from the spring so that it oscillates with a period of $\left(\frac{\pi}{4}\right)$ *sec*. is **[Roorkee 1990]**

(a) $\left(\frac{\pi}{4}\right) kg$ (b) $1 kg$

(c) $\left(\frac{1}{\pi}\right) kg$ (d) $10 kg$

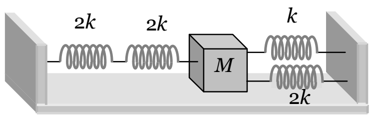
**9.** A spring with 10 coils has spring constant $k$. It is exactly cut into two halves, then each of these new springs will have a spring constant **[Kerala PMT 2004]**

(a) $k/2$ (b) $3k/2$

(c) $2k$ (d) $3k$

(e) $4k$

**10.** Four massless springs whose force constants are $2k$, $2k$, $k$ and $2k$ respectively are attached to a mass $M$ kept on a frictionless plane (as shown in figure). If the mass $M$ is displaced in the horizontal direction, then the frequency of oscillation of the system is




(a) $\frac{1}{2\pi}\sqrt{\frac{k}{4M}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{4k}{M}}$

(c) $\frac{1}{2\pi}\sqrt{\frac{k}{7M}}$ (d) $\frac{1}{2\pi}\sqrt{\frac{7k}{M}}$

**11.** Values of the acceleration $A$ of a particle moving in simple harmonic motion as a function of its displacement $x$ are given in the table below.

| | | | | | |
|---|---|---|---|---|---|
| $A$ ($mm\ s^{-2}$) | 16 | 8 | 0 | – 8 | – 16 |
| $x$ ($mm$) | – 4 | – 2 | 0 | 2 | 4 |

The period of the motion is

(a) $\frac{1}{\pi}s$ (b) $\frac{2}{\pi}s$

(c) $\frac{\pi}{2}s$ (d) $\pi\,s$

**12.** Two pendulums have time periods $T$ and $\frac{5T}{4}$. They start S.H.M. at the same time from the mean position. What will be the phase difference between them after the bigger pendulum has complete one oscillation

(a) 45° (b) 90°

(c) 60° (d) 30°

**13.** The periodic time of a particle doing simple harmonic motion is 4 *second*. The time taken by it to go from its mean position to half the maximum displacement (amplitude) is

(a) 2*s* (b) 1*s*

(c) $\frac{2}{3}s$ (d) $\frac{1}{3}s$

**14.** The displacement of a particle from its mean position (in metre) is given by $y = 0.2\sin(10\pi t + 1.5\pi)\cos(10\pi t + 1.5\pi)$. The motion of particle is **[CPMT 1998]**

(a) Periodic but not S.H.M.

(b) Non-periodic

(c) Simple harmonic motion with period 0.1 *s*

(d) Simple harmonic motion with period 0.2 *s*

**15.** The kinetic energy and the potential energy of a particle executing S.H.M. are equal. The ratio of its displacement and amplitude will be **[RPMT 2003; CPMT 2001]**

(a) $\frac{1}{\sqrt{2}}$ (b) $\frac{\sqrt{3}}{2}$

(c) $\frac{1}{2}$ (d) $\sqrt{2}$

**16.** Two simple pendulums of lengths 1.44 *m* and 1 *m* start swinging together. After how many vibrations will they again start swinging together

(a) 5 oscillations of smaller pendulum

(b) 6 oscillations of smaller pendulum

(c) 4 oscillations of bigger pendulum

(d) 6 oscillations of bigger pendulum

**17.** Equations $y_1 = A\sin\omega t$ and $y_2 = \frac{A}{2}\sin\omega t + \frac{A}{2}\cos\omega t$ represent S.H.M. The ratio of the amplitudes of the two motions is

(a) 1 (b) 2

(c) 0.5 (d) $\sqrt{2}$

**18.** A particle doing simple harmonic motion, amplitude = 4 *cm*, time period = 12 *sec*. The ratio between time taken by it in going from its mean position to 2 *cm* and from 2 *cm* to extreme position is **[CPMT 2002]**

(a) 1 (b) 1/3

(c) 1/4 (d) 1/2

**19.** On a planet a freely falling body takes 2 *sec* when it is dropped from a height of 8 *m*, the time period of simple pendulum of length 1 *m* on that planet is **[Pb. PMT 2004]**

(a) 3.14 *sec* (b) 16.28 *sec*

(c) 1.57 *sec* (d) None of these

**20.** If a simple pendulum is taken to place where $g$ decreases by 2%, then the time period **[Pb. PET 2002]**

(a) Decreases by 1% (b) Increases by 2%

(c) Increases by 2% (d) Increases by 1%

**21.** Two simple pendulum first of bob mass $M_1$ and length $L_1$ second of bob mass $M_2$ and length $L_2$. $M_1 = M_2$ and $L_1 = 2L_2$. If these vibrational energy of both is same. Then which is correct **[RPMT 2002]**

(a) Amplitude of $B$ greater than $A$

(b) Amplitude of $B$ smaller than $A$

(c) Amplitudes will be same

(d) None of these

# Answers and Solutions

**(SET -16)**

**1.** (d) Time period of pendulum doesn't depends upon mass but it depends upon length (distance between point of suspension and centre of mass).

In first three cases length are same so $T = T_1 = T_2$ but in last case centre of mass lowers which in turn increases the length. So in this case time period will be more than the other cases.

**2.** (d) $T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow \frac{T_e}{T_m} = \sqrt{\frac{g_m}{g_e}} = \sqrt{\frac{g_e/6}{g_e}} = \frac{1}{\sqrt{6}}$

$\Rightarrow T_m = \sqrt{6}T_e$ *i.e.* clock becomes slower.

**3.** (b) The effective acceleration of a bob in water

$= g' = g\left(1 - \frac{\sigma}{\rho}\right)$ where $\sigma$ and $\rho$ are the density of water and the bob respectively. Since the period of oscillation of the bob in air and water are given as

$T = 2\pi\sqrt{\frac{l}{g}}$ and $T' = 2\pi\sqrt{\frac{l}{g'}}$

$\therefore \frac{T}{T'} = \sqrt{\frac{g'}{g}} = \sqrt{\frac{g(1-\sigma/\rho)}{g}} = \sqrt{1 - \frac{\sigma}{\rho}} = \sqrt{1 - \frac{1}{\rho}}$

Putting $\frac{T}{T'} = \frac{1}{\sqrt{2}}$. We obtain, $\frac{1}{2} = 1 - \frac{1}{\rho} \Rightarrow \rho = 2$

**4.** (b) $E = \frac{1}{2}m\omega^2 A^2 \Rightarrow E = \frac{1}{2}m(2\pi f)^2 A^2 \Rightarrow A = \frac{1}{2\pi f}\sqrt{\frac{2E}{m}}$

Putting $E = K + U$ we obtain,

$A = \frac{1}{2\pi\left(\frac{25}{\pi}\right)}\sqrt{\frac{2 \times (0.5 + 0.4)}{0.2}} \Rightarrow A = 0.06\, m$

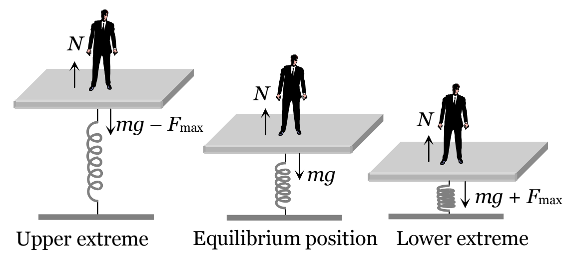
**5.** (a) The forces that act on the block are $qE$ and $mg$. Since $qE$ and $mg$ are constant forces, the only variable elastic force changes by $kx$. Where $x$ is the elongation in the spring $\Rightarrow$ unbalanced (restoring) force $= F = -kx$

$\Rightarrow -m\omega^2 X = -KX \Rightarrow \omega = \sqrt{\frac{k}{M}} = T$.

**6.** (d) The maximum force acting on the body executing simple harmonic motion is

$m\omega^2 a = m \times (2\pi f)^2 a = 60 \times \left(2\pi \times \frac{2}{\pi}\right)^2 \times 0.1\, N$

$= 60 \times 16 \times 0.1 = 96\, N = \frac{96}{9.8} \approx 10 kgf$ and this force is towards mean position.




The reaction of the force on the platform away from the mean position. It reduces the weight of man on upper extreme *i.e.* net weight = (60 – 10) *kgf*.

This force adds to the weight at lower extreme position *i.e.* net weight becomes = (60 + 10) *kgf*.

Therefore, the reading the weight recorded by spring balance fluctuates between 50 *kgf* and 70 *kgf*.

**7.** (d) Function of wrist watch depends upon spring action so it is not effected by gravity but pendulum clock has time period, $T = 2\pi\sqrt{\frac{l}{g}}$. During free fall effective acceleration becomes zero, so time period comes out to be infinity i.e. the clock stops.

**8.** (b) Force constant of a spring is given by $F = kx$

$6.4 = k(0.1)$ or $k = 64\, N/m$

$\because T = 2\pi\sqrt{\frac{m}{k}} \Rightarrow \frac{\pi}{4} = 2\pi\sqrt{\frac{m}{64}}$ ; $\frac{m}{64} = \left(\frac{1}{8}\right)^2$ ; $m = 1kg$

**9.** (b) $K \propto \frac{1}{l} \Rightarrow Kl = K' \times \frac{l}{2} \Rightarrow K' = 2K$

**10.** (b) The two springs on left side having spring constant of $2k$ each are in series, equivalent constant is $\frac{1}{\left(\frac{1}{2k} + \frac{1}{2k}\right)} = k$. The two springs on right hand side of mass $M$ are in parallel. Their effective spring constant is $(k + 2k) = 3k$.

Equivalent spring constants of value $k$ and $3k$ are in parallel and their net value of spring constant of all the four springs is $k + 3k = 4k$

$\therefore$ Frequency of mass is $n = \frac{1}{2\pi}\sqrt{\frac{4k}{M}}$

**11.** (d) $|A| = \omega^2 x \Rightarrow \frac{|A|}{x} = \omega^2$

From the given value $\frac{|A|}{x} = \omega^2 = 4 \Rightarrow \omega = 2.$

Also $\omega = \frac{2\pi}{T} \Rightarrow 2 = \frac{2\pi}{T} \Rightarrow T = \pi\ sec$

**12.** (b) $\frac{5T}{4} = T + \frac{T}{4}$


By the time, the bigger pendulum makes one full oscillation, the smaller pendulum will make $\left(1 + \frac{1}{4}\right)$ oscillation. The bigger pendulum will be in the mean position and the smaller one will be in the positive extreme position. Thus, phase difference = 90°

**13.** (d) $y = A \sin\left(\frac{2\pi}{T}\right) \cdot t$

$\Rightarrow \frac{A}{2} = A \sin\left(\frac{2\pi}{4}\right) t \Rightarrow \frac{\pi t}{2} = \frac{\pi}{6} \Rightarrow t = \frac{1}{3}\ sec$

**14.** (c) $y = 0.2 \sin(10\pi t + 1.5\pi) \cos(10\pi t + 1.5\pi)$

$= 0.1 \sin 2(10\pi t + 1.5\pi) \quad [\because \sin 2A = 2 \sin A \cos A]$

$= 0.1 \sin(20\pi t + 3.0\pi)$

$\therefore$ Time period, $T = \frac{2\pi}{\omega} = \frac{2\pi}{20\pi} = \frac{1}{10} = 0.1\ sec$

**15.** (a) Given $K.E. = P.E. \Rightarrow \frac{1}{2}mv^2 = \frac{1}{2}kx^2$

$\Rightarrow \frac{1}{2}m\omega^2(a^2 - x^2) = \frac{1}{2}m\omega^2 x^2$

$\Rightarrow a^2 - x^2 = x^2 \Rightarrow x^2 = \frac{a^2}{2} \Rightarrow \frac{x}{a} = \frac{1}{\sqrt{2}}.$

**16.** (b) $n \propto \frac{1}{\sqrt{l}} \Rightarrow \frac{n_2}{n_1} = \sqrt{\frac{1.44}{1}} = \frac{1.2}{1} \Rightarrow n_2 = 1.2 n_1$

For $n_2$ be integer minimum value of $n_1$ should be 5 and then $n_2$ = 6 *i.e.,* after 6 oscillations of smaller pendulum both will be in phase.

**17.** (d) $y_2 = \frac{A}{2} \sin\omega t + \frac{A}{2} \cos\omega t$

$y_2 = \frac{A}{2}(\sin\omega t + \cos\omega t) = \frac{A}{2} \times \sqrt{2}\ [\sin(\omega t + 45^o)]$

$y_2 = \frac{A}{\sqrt{2}} \sin(\omega t + 45^o) \Rightarrow \frac{A_1}{A_2} = \frac{A}{A/\sqrt{2}} = \sqrt{2}$

**18.** (d) $\omega = \frac{2\pi}{T} = \frac{2\pi}{12} = \frac{\pi}{6} \frac{rad}{sec}$ (For $y = 2\ cm$) $2 = 4\left(\sin\frac{\pi}{6} t_1\right)$

By solving $t_1 = 1\ sec$ (For $y = 4\ cm$) $t_2 = 3\ sec$

So time taken by particle in going from 2 *cm* to extreme position is $t_2 - t_1 = 2\ sec$. Hence required ratio will be $\frac{1}{2}$.

**19.** (a) On a planet, if a body dropped initial velocity ($u$ = 0) from a height $h$ and takes time $t$ to reach the ground then $h = \frac{1}{2} g_P t^2 \Rightarrow g_P = \frac{2h}{t^2} = \frac{2 \times 8}{4} = 4\ m/s^2$

Using $T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow T = 2\pi\sqrt{\frac{1}{4}} = \pi = 3.14\ sec.$

**20.** (d) $T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow T \propto \frac{l}{\sqrt{g}}$

$\Rightarrow \frac{\Delta T}{T} \times 100 = -\frac{1}{2}\left(\frac{\Delta g}{g}\right) \times 100 = -\frac{1}{2}(-2\%) = 1\%.$

**21.** (b) $n = \frac{1}{2\pi}\sqrt{\frac{g}{l}} \Rightarrow n \propto \frac{1}{\sqrt{l}} \Rightarrow \frac{n_1}{n_2} = \sqrt{\frac{l_2}{l_1}} = \sqrt{\frac{L_2}{2L_2}}$

$\Rightarrow \frac{n_1}{n_2} = \frac{1}{\sqrt{2}} \Rightarrow n_2 = \sqrt{2}\, n_1 \Rightarrow n_2 > n_1$

Energy $E = \frac{1}{2} m\omega^2 a^2 = 2\pi^2 mn^2 a^2$

$\Rightarrow \frac{a_1^2}{a_2^2} = \frac{m_2 n_2^2}{m_1 n_1^2} \quad (\because E \text{ is same})$

Given $n_2 > n_1$ and $m_1 = m_2 \Rightarrow a_1 > a_2$

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