Important Questions for Class 11 Physics Chapter 13: Chapter 13 of Class 11 Physics, titled "Oscillations," introduces the concept of periodic motion, focusing on simple harmonic motion (SHM). Key topics include the conditions for SHM, displacement, velocity, and acceleration equations in SHM, along with concepts like amplitude, frequency, period, and phase. The chapter also explores the energy in oscillations, including potential and kinetic energy, and the concept of simple pendulums and springs in oscillatory motion.

Important formulas such as the angular frequency and the time period of a simple pendulum and mass-spring system are essential. Understanding damping and resonance is also covered, providing a comprehensive overview of oscillatory systems.

Important Questions for Class 11 Physics Chapter 13 Overview

Chapter 13 of Class 11 Physics, "Oscillations," is crucial for understanding the behavior of systems in periodic motion, a foundational concept in mechanics. Key questions typically cover simple harmonic motion (SHM), the mathematical formulation of SHM, and applications like pendulums and springs.

Understanding energy conservation in oscillations, the relationship between displacement, velocity, and acceleration, and concepts like resonance and damping are important for both theoretical and practical purposes. These questions help develop a strong grasp of oscillatory motion, which is essential for higher-level physics concepts, engineering applications, and various real-world systems involving vibrations and waves.

Important Questions for Class 11 Physics Chapter 13 Oscillations

Below is the Important Questions for Class 11 Physics Chapter 13 Oscillations -

1. The girl sitting on a swing stands up. What will be the effect on periodic time of swing?

Ans: The time period T is directly proportional to the square root of effective length of pendulum (l). If the girl stands up, the effective length of swing (i.e., pendulum) decreases, thus the time period (T) also decreases.

2. At what distance from the mean position, is the kinetic energy in a simple harmonic oscillator equal to potential energy?

Ans: Consider the displacement of particle executing S.H.M to be Y,

Amplitude of particle executing S.H.M to be a,

Mass of particle to be m,

Angular velocity to be ω.

The kinetic energy will be $\frac{1}{2}m\omega^2\left(a^2-y^2\right)$.

$Potential\ energy = \frac{1}{2}m\omega^2 y^2$.

Now, $Kinetic\ energy = Potential\ energy$

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

$\Rightarrow a^2 - y^2 = y^2$

$\Rightarrow a^2 = 2y^2$

$\Rightarrow a = \sqrt{2}y$

$\Rightarrow y = \frac{a}{\sqrt{2}}$, which is the required distance from mean position.

3. The soldiers marching on a suspended bridge are advised to go out of steps. Why?

Ans: When the soldiers are marching on a suspended bridge, they are advised to go out of steps. This is because in this case the frequency of marching steps matches with the natural frequency of the suspended bridge. This results in resonance. Thus, amplitude of oscillation increases extensively which may lead to the collapsing of bridges.

4. Is the motion of a simple pendulum strictly simple harmonic?

Ans: The motion of a simple pendulum isn't strictly harmonic because we make the assumption that $sin\theta = \theta$, which is nearly valid only if θ is very small.

5. Can a simple pendulum experiment be done inside a satellite?

Ans: Time period of a simple pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$.

Inside a satellite, the effective value of 'g' is 0. When $g = 0$,

$T \to \infty$. Thus, the pendulum does not oscillate at all inside the satellite. Hence, the experiment cannot be performed inside a satellite.

6. Give some practical examples of S. H. M?

Ans: Some practical examples of S. H. M. are as follows:

1. Motion of piston in a gas – filled cylinder.
2. Atoms vibrating in a crystal lattice.
3. Motion of helical spring.

7. What is the relation between uniform circular motion and S.H.M?

Ans: Uniform circular motion can be treated as two simple harmonic motions operating at right angles to each other.

8. What is the minimum condition for a system to execute S.H.M?

Ans: The minimum condition for a body to execute S.H.M to have elasticity and inertia.

9. The piston in the cylinder head of a locomotive has a stroke (twice the amplitude) of 1.0 m. If the piston moves with simple harmonic motion with an angular frequency of 200 rad/min, what is its maximum speed?

Ans: In the above question it is given that:

Angular frequency of the piston is $\omega = 200\, rad/\, min$.

Stroke is 1.0 m.

Amplitude is $A = \frac{1.0}{2} = 0.5$

The maximum speed $(v_{\max})$ of the piston is given by the relation:

$v_{\max} = A\omega$

$= 200 \times 0.5 = 100 m/\min$.

2 Marks Questions

1. A simple harmonic oscillator is represented by the equation: $Y = 0.40\, sin\, (440t + 0.61)$. Y is in metres t is in seconds. Find the values of 1) Amplitude 2) Angular frequency 3) Frequency of oscillation 4) Time period of oscillation, 5) Initial phase.

Ans: A simple harmonic oscillator is represented by the equation:

$Y = 0.40\, Sin\, (440t + 0.61)$

On comparing with equation of S.H.M: $Y = asin\,(\omega t + \phi_0)$ we get:

1) $Amplitude = 0.40m$.

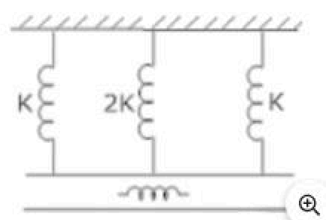
2) $Angular\ frequency = \omega = 440Hz$.

3) Frequency of oscillation, $v = \frac{\omega}{2\pi} = \frac{440}{2\pi} = 70Hz$.

4) Time period of oscillation, $T = \frac{1}{v} = \frac{1}{70} = 0.0143s$.

5) $Initial\ phase\, (\phi) = 0.61rad$.

2. The springs of spring factor k, 2k, k respectively are connected in parallel to a mass m. If the mass = 0.08kg m and k = 2N/m, then find the new time period?



Ans: Consider the figure given in the question.

Therefore, total spring constant is given by:

$$K' = K_1 + K_2 + K_3$$
$$= K + 2K + K$$
$$= 4K$$
$$= 4 \times 2 \ (k = 2 \ N/m)$$
$$= 8N/m$$

Time period is given by:

$$T = 2\pi\sqrt{\frac{m}{K'}}$$
$$\Rightarrow T = 2\pi\sqrt{\frac{m}{4K}}$$
$$\Rightarrow T = 2\pi\sqrt{\frac{0.08}{4 \times 2}} = 0.628s$$

3. The bob of a vibrating simple pendulum is made of ice. How will the period of swing will change when the ice starts melting?

Ans: The period of swing of simple pendulum will remain unchanged till the location of centre of gravity of the bob left after melting of the ice remains at the fixed position from the point of suspension. When centre of gravity of ice bob after melting is shifted upwards, the effective length of pendulum decreases and thus the time period of swing decreases. Similarly, if centre of gravity shifts downward, time period increases.

4. An 8 kg body performs S.H.M. of amplitude 30 cm. The restoring force is 60N, when the displacement is 30cm. Find: - a) Time period b) the acceleration c) potential and kinetic energy when the displacement is 12cm?

Ans: In the above question it is given that:

$\mathrm{m} = 8\ \mathrm{kg}$

$\mathrm{a} = 30\mathrm{cm} = 0.30\mathrm{m}$

a) $f = 60\ N,$

$Y = displacement = 0.30m$

$K = spring\ constant$

Since,

$F = Ky$

$K = \frac{F}{y} = \frac{60}{0.30} = 200N/m$

As, Angular velocity $\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{200}{8}} = 5rad/s$

Time period, $T = \frac{2\pi}{\omega} = \frac{2\times22}{7\times5} = 1.256s.$

b) $Y = displacement = 0.12m$

Acceleration, $A = \omega^2 y$

$A = (5)^2(0.12) = 3m/s^2.$

$P.E. = Potential\ energy = \frac{1}{2}ky^2 = \frac{1}{2}(200)(0.12)^2$

$Potential\ energy = 1.44J$

$\text{Kinetic energy} = \text{K.E} = \frac{1}{2}k\left(a^2 - y^2\right)$

$\text{K.E} = \frac{1}{2}(200)\left(0.3^2 - 0.12^2\right)$

$\text{K.E} = 7.56\text{J}$

5. A particle executing SH.M has a maximum displacement of 4 cm and its acceleration at a distance of 1 cm from its mean position is $3\ cm/s^2$. What will be its velocity when it is at a distance of 2cm from its mean position?

Ans: In the above question it is given that:

Acceleration, $A = 3\ cm/s^2$

$Y = 1cm$

The acceleration of a particle executing S.H.M is given by:

$A = \omega^2 Y$

$3 = \omega^2(1)$

$\omega = \sqrt{3}rad/s$

The velocity of a particle executing S.H.M is given by:

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

$v = \sqrt{3}\sqrt{4^2 - 2^2}$

$v = \sqrt{3} \times \sqrt{12} = 6cm/s$

6. What is the ratio of frequencies of the vertical oscillations when two springs of spring constant K are connected in series and then in parallel?

Ans: When two spring of spring constant K are connected in parallel, then effective resistance in Parallel is given by:

$$K_P = K + K = 2K$$

Let $f_p = frequency\ in\ parallel\ combination.$

$$f_p = \frac{1}{2\pi}\sqrt{\frac{K_P}{M}} \quad \ldots\ldots (1)$$

In Series combination, effective spring constant for 2 springs of spring constant K is given by:

$$\frac{1}{K_S} = \frac{1}{K} + \frac{1}{K}$$

$$\frac{1}{K_S} = \frac{2}{K}$$

$$K_S = \frac{K}{2}$$

Let $f_s = frequency\ in\ series\ combination$

$$f_s = \frac{1}{2\pi}\sqrt{\frac{K_s}{M}}$$

$$f_s = \frac{1}{2\pi}\sqrt{\frac{\frac{K}{2}}{M}}$$

$$f_s = \frac{1}{2\pi}\sqrt{\frac{K}{2M}} \quad \ldots\ldots (2)$$

Dividing equation (2) by (1),

$$\frac{f_s}{f_p} = \frac{\frac{1}{2\pi}\sqrt{\frac{K}{2M}}}{\frac{1}{2\pi}\sqrt{\frac{K_P}{M}}}$$

$$\frac{f_s}{f_p} = \frac{1}{2\pi}\sqrt{\frac{K}{2M}} \times 2\pi\sqrt{\frac{M}{K_P}}$$

$$\frac{f_s}{f_p} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

$$f_s : f_p = 1 : 2$$

7. The kinetic energy of a particle executing S.H.M. is 16J when it is in its mean position. If the amplitude of oscillations is 25cm and the mass of the particle is 5.12kg. Calculate the time period of oscillations?

Ans: In the above question it is given that:

$K.\ E.\ =\ Kinetic\ energy\ =\ 16J.$

Now, $m\ =\ Mass\ =\ 5.12kg.$

$\omega\ =\ Angular\ frequency$

$a\ =\ amplitude\ =\ 25cm\ or\ 0.25m$

The Maximum value of K. E. is at mean position is given by:

$$\text{K.E} = \frac{1}{2}m\omega^2a^2$$

$$16 = \frac{1}{2}m\omega^2a^2$$

$$32 = m\omega^2a^2$$

$$32 = (5.12)\,\omega^2(0.25)^2$$

$$\omega^2 = \frac{32}{5.12 \times (0.25)^2}$$

$$\omega^2 = 100$$

$$\Rightarrow \omega = 10rad/s$$

Now, $T\ =\ Time\ Period = \frac{2\pi}{\omega} = \frac{2\pi}{10} = \frac{\pi}{5}s.$

8. The time period of a body suspended by a spring is T. What will be the new time period if the spring is cut into two equal parts and

1) the body is suspended by one part?

2) suspended by both parts in parallel?

Ans: The time period of oscillation of a body of mass 'm' suspended from a spring with force constant 'k' is given by:

$T = 2\pi\sqrt{\frac{m}{K}}$ ...... (1)

1) On cutting the spring in two equal parts, the length of one part is halved and the force constant of each part will be doubled (2k). Therefore, the new time period will be:

$T_1 = 2\pi\sqrt{\frac{m}{2K}}$ ...... (2)

From (1) and (2),

$T_1 = \frac{T}{\sqrt{2}}$

2) If the body is suspended from both parts in parallel, then

the effective force constant of parallel combination $=\ 2k\ +\ 2k\ =\ 4k.$

Therefore, time period will be:

$T_2 = 2\pi\sqrt{\frac{m}{4K}}$ ...... (3)

From (1) and (3),

$T_2 = \frac{T}{2}$

9. A simple pendulum is executing Simple harmonic motion with a time T. If the length of the pendulum is increased by 21 %. Find the increase in its time period?

Ans: The time period of simple pendulum with

$l = length\ of\ simple\ pendulum$

$g = acceleration\ due$ to $gravity$

Is given by: $T = 2\pi\sqrt{\frac{l}{g}}$

Consider

$T_2 = Final\ time\ period$

$T_1 = Initial\ time\ period$

Therefore,

$$T_1 = 2\pi\sqrt{\frac{l_1}{g}}$$

$$T_2 = 2\pi\sqrt{\frac{l_2}{g}}$$

Hence,

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

If $l_1 = l$

$l_2 = l_1 + l_1\left(\frac{21}{100}\right)$

$\Rightarrow l_2 = 1.21l$

$$\Rightarrow \frac{T_2}{T_1} = \frac{\sqrt{1.21l}}{\sqrt{l}}$$

$$\Rightarrow \frac{T_2}{T_1} = 1.1$$

10. A particle is executing S H M of amplitude 4 cm and T = 4 sec. find the time taken by it to mov from positive extreme position to half of its amplitude?

Ans: Consider

$Y = displacement$

$t = time$

$a = amplitude$

$\omega = Angular\ frequency$

Now, $Y = acos\omega t$

Given $Y = \frac{a}{2}$

$\Rightarrow \frac{a}{2} = acos\omega t$

$\Rightarrow cos\omega t = \frac{1}{2}$

Now, $T = Time\ Period$

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

$\Rightarrow cos\frac{2\pi}{T}t = \frac{1}{2}$

$\Rightarrow cos\frac{2\pi}{4}t = \frac{1}{2}$

Let W_A is work done by spring A & $k_A = Spring\ Constant$ and

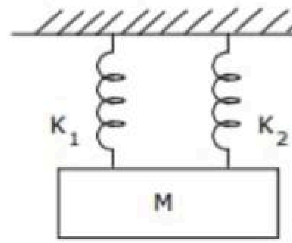
W_B is work done by spring B & $k_B = Spring\ Constant$.

$\frac{W_A}{W_B} = \frac{k_A}{k_B} = \frac{1}{3}$

$W_A : W_B = 1 : 3$

3 Marks Questions

1. A mass = m suspended separately from two springs of spring constant k_1 and k_2 gives time period t_1 and t_2 respectively. If the same mass is connected to both the springs as shown in figure Calculate the time period of the combined system?



Ans: If

$T = Time\ Period\ of\ simple\ pendulum$

$m = Mass$

$k = Spring\ constant$

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

And $k = \frac{4\pi^2 m}{T^2}$

And $k = \frac{4\pi^2 m}{T^2}$

Thus,

For 1st spring: $k_1 = \frac{4\pi^2 m}{T_1^2}$

For 2nd spring: $k_2 = \frac{4\pi^2 m}{T_2^2}$

When springs is connected in parallel, effective spring constant is given by:

$k = k_1 + k_2$

$\frac{4\pi^2 m}{T^2} = \frac{4\pi^2 m}{T_1^2} + \frac{4\pi^2 m}{T_2^2}$

$\Rightarrow \frac{1}{T^2} = \frac{1}{T_1^2} + \frac{1}{T_2^2}$, where T is the time period of the combined system.

2. Show that the total energy of a body executing SHM is independent of time.

Ans: Let

$y = displacement\ at\ any\ timet$

$a = amplitude$

$\omega = Angular\ frequency$

$v = velocity,$

$y = asin\omega t$

Therefore,

$v = \frac{dy}{dt}$

$v = \frac{d(asin\omega t)}{dt}$

$\mathbf{v} = a\omega cos\omega t$

Now, $kinetic\ energy = K.E = \frac{1}{2}mv^2$

$\Rightarrow K.E = \frac{1}{2}ma^2\omega^2cos^2\omega t$ ...... (1)

$Potential\ energy = \frac{1}{2}ky^2$

$P.E. = \frac{1}{2}ka^2sin^2\omega t$ ...... (2)

Adding (1) and (2),

$$\text{total energy} = K.E + P.E = \frac{1}{2}ma^2\omega^2cos^2\omega t + \frac{1}{2}ka^2sin^2\omega t$$

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

$k = \omega^2 m$

$\text{total energy} = \frac{1}{2}ka^2cos^2\omega t + \frac{1}{2}ka^2sin^2\omega t$

$\text{total energy} = \frac{1}{2}ka^2\left(sin^2\omega t + cos^2\omega t\right)$

$\text{total energy} = \frac{1}{2}ka^2$

Thus, total mechanical energy is always constant is equal to $\frac{1}{2}ka^2$. The total energy is independent of time.

The potential energy oscillates with time and has a maximum value of $\frac{1}{2}ka^2$.

Similarly, K. E. oscillates with time and has a maximum value of $\frac{1}{2}ka^2$. At any instant total energy is constant i.er. $\frac{1}{2}ka^2$.

3. A particles moves such that its acceleration 'a' is given by a = -b x where x = displacement from equilibrium position and b is a constant. Find the period of oscillation.

Ans: In the above question it is given that $a = -b\,x$.

Since $a \propto x$ and is directed opposite to x, the particle moves in S.H. M.

If we consider only magnitude $a = b\,x$

Or $\frac{x}{a} = \frac{1}{b}$

Thus, $\frac{displacement}{acceleration} = \frac{1}{b}$ ...... (1)

Time period, $T = 2\pi\sqrt{\frac{displacement}{acceleration}}$

Therefore, $T = 2\pi\sqrt{\frac{1}{b}}$

4. A particle is S.H.M. is described by the displacement function:

$x = A\cos(\omega t + \phi), \omega = \frac{2\pi}{T}$

If the initial (t=0) position of the particle is 1cm and its initial velocity is, $\pi cm/s$, What are its amplitude and phase angle?

Ans: At $t = 0$, $x = 1cm$, $\omega = \pi cm/s$ and $v = \pi cm/s$

A particle is S.H.N. is described by the displacement function:

$x = A\cos(\omega t + \phi) \Rightarrow 1 = A\cos\phi$

$v = \frac{dx}{dt}$

$v = \frac{d(A\cos(\omega t+\phi))}{dt}$

$v = -A\omega\sin(\omega t + \phi)$

$\pi = -A\pi\sin\phi$

$-1 = A\sin\phi$ ...... (2)

Squaring (10 and (2) and adding,

$A^2\cos^2\phi + A^2\sin^2\phi = 2$

$A^2 = 2$

$A = \sqrt{2}cm$, which is the required amplitude.

Dividing (1) by (2) we get,

$\left(\frac{A\sin\phi}{Aco\,s\,\phi}\right) = -1$

$\tan\phi = -1$

$\phi = \frac{3\pi}{4}$, which is the required phase angle.

5. Determine the time period of a simple pendulum of length = l when mass of bob = m kg.

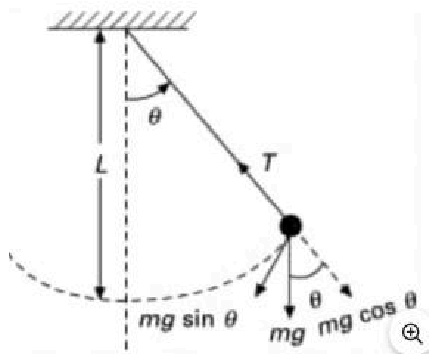
Ans: A simple pendulum consists of a heavy point mass body suspended by a weightless inextensible and perfectly flexible string from a rigid support which is free to oscillate.

The distance between the point of suspension and the point of oscillation is the effective length of the pendulum.

$M = Mass\ of\ Bob$

$x = Displacement = OB$

$l = length\ of\ simple\ pendulum$



Let the bob is displaced through a small angle θ the forces acting on it:-

1) $weight = Mg\ acting\ vertically\ downwards.$

2) $Tension = T$ acting upwards.

Dividing Mg into its components $mgcos\ \theta\ \&\ \text{m}gsin\ \theta$

$T = \text{m}gcos\ \theta$

$F = \text{m}gsin\ \theta$

- ve sign shows force is divested towards the ocean positions. If θ is Small,

$\sin\theta \approx \theta = \frac{\text{Arc OB}}{l} = \frac{x}{l}$

$F = -mg\frac{x}{l}$

In S.H.M restoring force, $-mg\sin\theta = -mg\theta = -\frac{mgx}{l}$

When, $k = springconstant$

$F = -kx$

$-\frac{mgx}{l} = -kx$

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

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

$T = 2\pi\sqrt{\frac{ml}{mg}}$

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

6. Which of the following examples represent periodic motion?

a) A swimmer completing one (return) trip from one bank of a river to the other and back.

Ans: As motion of the swimmer between the banks of the river is to and fro, it does not have a definite period. The time taken by the swimmer during his back-and-forth journey may not be the same. Hence, the swimmer's motion is not periodic.

b) A freely suspended bar magnet displaced from its N-S direction and released.

Ans: If a magnet is displaced from its N-S direction and released, then the motion of the freely-suspended magnet is periodic. This is because the magnet oscillates about its position with a definite period of time.

c) A hydrogen molecule rotating about its centre of mass.

Ans: If we consider a hydrogen molecule rotating about its centre of mass, it is observed that it comes to the same position after an equal interval of time. This type of motion is periodic motion.

d) An arrow released from a bow.

Ans: When an arrow is released from a bow, it moves only in the forward direction. There is no motion repeated in equal intervals of time. Therefore, this motion is not periodic.

7. Which of the following examples represent (nearly) simple harmonic motion and which represent periodic but not simple harmonic motion?

a) The rotation of earth about its axis.

Ans: When the earth rotates about its axis, it comes to the same position in fixed intervals of time. Hence, it is a periodic motion. However, earth does not have a to and fro motion about its axis. Hence, it is not a simple harmonic.

b) Motion of an oscillating mercury column in a U-tube.

Ans: In an oscillating mercury column in a U-tube, mercury moves to and from on the same path, about the fixed position, with a certain period of time. Hence, it is a simple harmonic motion.

c) Motion of a ball bearing inside a smooth curved bowl, when released from a point slightly above the lowermost point.

Ans: When a ball is released from a point slightly above the lowermost point, it moves to and from about the lowermost point of the bowl. Also, the ball comes back to its initial position in the fixed interval of time, again and again. Thus, this motion is periodic as well as simple harmonic.

d) General vibrations of a polyatomic molecule about its equilibrium position.

Ans: A polyatomic molecule possesses many natural frequencies of oscillation. Its vibration is the superposition of individual simple harmonic motions of a number of different molecules. Thus, it is not simple harmonic, but periodic.

Benefits of Using Important Questions for Class 11 Physics Chapter 13

Using Important Questions for Class 11 Physics Chapter 13 "Oscillations" offers several benefits:

Concept Reinforcement: These questions help reinforce key concepts like simple harmonic motion, energy in oscillations, and oscillatory systems.

Exam Preparation: Practicing these questions prepares you for exams by covering important topics and ensuring you understand the core principles.

Problem-Solving Skills: It enhances your problem-solving skills by providing varied and challenging questions.

Time Management: Helps you practice under exam-like conditions, improving time management for the actual test.

Confidence Building: Regular practice boosts confidence and reduces exam anxiety, ensuring you approach the subject with a clear understanding.