# PHYSICS CLASS XI
# CHAPTER – 14 OSCILLATIONS



**Q.1. What is the ratio between the distance travelled by the oscillator in one time period and amplitude?**

**Ans.** Total distance travelled by an oscillator in one time period, from its mean position to one extreme position then to other extreme position and finally back to mean position is 4 A, where A is the amplitude of oscillation.

**Q.2. Name the trigonometric functions which are suitable for analytical treatment of periodic and/or oscillatory motions.**

**Ans.** Sine and/or cosine functions of time or their combinations may represent analytically periodic/oscillatory motions.

**Q.3. What is the force equation of a SHM?**

**Ans.** According to force equation of SHM, F = - $kx$,

where k is a constant known as force constant.

**Q.4. Under what condition is the motion of a simple pendulum be simple harmonic?**

**Ans.** When the displacement amplitude of the pendulum is extremely small as compared to its length.

**Q.5. A simple pendulum is transferred from earth to the surface of moon. How will its time period be affected?**



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**Ans.** As value of g on moon is less than that on earth, in accordane with the relation T = $2\pi\sqrt{l/g}$, the time period of oscillations of a simple pendulum on moon will be greater.

**Q.6. A body of mass m, when hung on a spiral spring, stretches it by 20 cm. what is its period of oscillation when pulled down and then released?**

**Ans.** As time period, T = $2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{20}{980}} = \frac{2\pi}{7}$

**Q.7. How much is KE for diaplacement equal to half the amplitude?**

**Ans.** It is ¾ th of maximum KE

i.e., KE = $\frac{1}{2}m\omega^2(A^2 - x^2) = \frac{1}{2}m\omega^2\,[A^2 - (A/2)^2]$

$= \frac{1}{2} \times \frac{3}{4}\,[m\omega^2 A^2] = \frac{3}{4}\,(KE)_{max}$

**Q.8. Define and explain restoring force in case of an oscillating body.**

**Ans.** The force responsible for maintaining the SHM is called restoring force. This force is directly proportional to negative of displacement.

e.g., $F \propto -x \Longrightarrow F = -kx$

$k$ is called force constant. Also, F = $-m\omega^2 x$ for SHM. Therefore, $k = m\omega^2$

**Q.9. The maximum acceleration of a simple harmonic oscillator is $a_0$ and the maximum velocity is $v_0$ and the maximum velocity is $v_0$. What is the displacement amplitude?**

**Ans.** Let A be the displacement amplitude and $\omega$ be the angular frequency of the simple harmonic oscillator.

Then, $a_0 = \omega^2 A$ and $v_0 = \omega A$





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On dividing, $\frac{v_0^2}{a_0} = \frac{\omega^2 A^2}{\omega^2 A} = A$ or $A = \frac{v_0^2}{a_0}$

**Q.10. In case of an oscillating simple pendulum what will be the direction of acceleration of the bob at (a) the mean position, (b) the end points?**

**Ans.** The direction of acceleration of the bob at its mean position is radial i.e., towards the point of suspension.

At extreme points, however, the acceleration is tangential towards the mean position.

**Q.11. Show that when a particle is moving in SHM, its velocity at a distance $\sqrt{\frac{3}{2}}$ of its amplitude from the central position is half of its velocity in central position.**

**Ans.** Here, $y = \frac{\sqrt{3}}{2} a$

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

$$= \omega\sqrt{a^2 - \frac{3a^2}{4}} = \frac{\omega a}{2} = \frac{v_m}{2}$$

**Q.12. A particle executes SHM of period 8 s. After what time of its passing through the mean position will be energy be half kinetic and half potential?**

**Ans.** Given, PE = KE

i.e., $\frac{1}{2} m\omega^2 x^2 = \frac{1}{2} m\omega^2(A^2 - x^2)$

$$x^2 = A^2 - x^2 \Rightarrow x = \frac{A}{\sqrt{2}}$$

Now, $x = A \sin \omega t = A \sin\left(\frac{2\pi}{T}\right) t$





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So, $\frac{A}{\sqrt{2}} = A \sin 2\pi \frac{t}{8}$

or $\sin\frac{\pi t}{4} = \frac{1}{\sqrt{2}} = \sin \frac{\pi}{4}$

or $\frac{\pi t}{4} = \frac{\pi}{4}$ or t = 1 s

**Q.13. A circular disc of mass 10 kg is suspended by a wire attached to its centre. The wire is twisted by rotating the disc and released. The period of torsional oscillations is found to be 1.5 s. The radius of the disc is 15 cm. Determine the torsional spring constant of the wire. (Torsional spring constant $\alpha$ is defined by the relation J = - $\alpha\theta$, where J is the restoring couple and $\theta$ the angle of twist.)**

**This is a question based on torsion pendulum for which T = $2\pi\sqrt{\frac{1}{\alpha}}$**

**Where, I = moment of inertia of the disc about axis of rotation, $\alpha$ = torsion constant which is restoring couple per unit twist.**

**Ans.** Mass of the disc, m = 10 kg

Radius of the disc, r = 15 cm = 0.15 m

T = 1.5 s

$I$ is the moment of inertia of the disc about the axis of rotation which is perpendicular to the plane of the disc and passing through its centre.

$\therefore l = \frac{1}{2} mr^2 = \frac{1}{2}\times(10)\times(0.15)^2 = 0.1125$ kg-m$^2$

Time period T = $2\pi\sqrt{\frac{I}{\alpha}}$

$$\alpha = \frac{4\pi^2 I}{T^2} = \frac{4\times(3.14)^2\times0.1125}{(1.5)^2}$$

= 1.972 N-m/rad





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**Q.14. A spring compressed by 0.1 m develops a restoring force 10 N. A body of mass 4 kg placed on it. Deduce**

**(i) the force constant of the spring.**

**(ii) the depression of the spring under the weight of the body (take g = 10 N/kg)**

**(iii) the period of oscillation, the body is distributed and**

**(iv) frequency of oscillation**

**Ans.** Here, F = 10 N, $\Delta l$ = 0.1 m, m = 4 kg

(i) $k = \frac{F}{\Delta l} = \frac{10}{0.1} = 100\ \text{Nm}^{-1}$

(ii) $y = \frac{mg}{k} = \frac{4 \times 10}{100} = 0.4$ m

(iii) $T = 2\pi \sqrt{\frac{m}{k}} = 2 \times \frac{22}{7} \sqrt{\frac{4}{100}} = 1.26$ s

(iv) Frequency, $v = \frac{1}{T} = \frac{1}{1.26} = 0.8$ Hz

**Q.15. A body mass 12 kg is suspended by coil spring of natural length 50 cm and force constant 2.0 × $10^3$ Nm$^{-1}$. What is the stretched length of the spring? If the body is pulled down further stretching the spring to a length of 5.9 cm and then released, what is the frequency of oscillation of the suspended mass? (Neglect the mass of the spring)**

**Ans.** Given, m = 12 kg, original length $l$ = 50 cm

$k = 2.0 \times 10^3\ \text{Nm}^{-1}$

As, $F = ky$

∴ $y = \frac{F}{k} = \frac{mg}{k} = \frac{12 \times 9.8}{2 \times 10^3} = 5.9 \times 10^{-2}$ m = 5.9 cm



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∴ Stretched length of the spring = $l$ + y = 50 + 55.9 cm

Frequency of oscillation, v = $\frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$= \frac{1}{2\times3.14}\sqrt{\frac{2\times10^3}{12}}$ = 2.06s$^{-1}$

**Q.16. A spring balance has a scale that reads from 0 to 50 kg. the length of the scale is 20 cm. A body suspended from this spring, when displaced and released, oscillates with a period of 0.60 s. What is the weight of the body?**

**Ans.** The 20 cm length of the scale reads upto 50 kg

So, F = mg = 50 × 9.8 N and y = 20 cm = 0.20 m

Now, force constant, $k = \frac{F}{y} = \frac{50\times9.8}{0.20}$ = 2450 Nm$^{-1}$

Suppose the spring oscillates with time period of 0.60 s when loaded with a mass of M kg. Then,

$$T = 2\pi\sqrt{\frac{M}{k}} \quad \text{or} \quad T^2 = 4\pi^2\frac{M}{k}$$

$$M = \frac{T^2K}{4\pi^2} = \frac{(0.60)^2\times2450}{4\times(3.14)^2} = 22.36 \text{ kg}$$

∴ Weight = Mg = 22.36 × 9.8 = 219.13 N

**Q.17. A body weighing 10 g has a velocity of 6 cm s$^{-1}$ after one second of its starting from mean position. If the time period is 6 s, find the kinetic energy, potential energy and the total energy.**

**Ans.** Here, m = 10 g, T = 6 s

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{6} = \frac{\pi}{3} \text{ rad s}^{-1}$$





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When t = 1 s, v = 6 cm $s^{-1}$

As $v = A\,\omega \cos \omega t$

$$6 = A \times \frac{\pi}{3} \cos\frac{\pi}{3} \times 1 = A \times \frac{\pi}{3} \cos 60°$$

$$= A \times \frac{\pi}{3} \times \frac{1}{2} = \frac{\pi A}{6}$$

or $A = \frac{36}{\pi}$ cm

Total energy, $E = \frac{1}{2} mA^2 \omega^2$

$$= \frac{1}{2} \times 10 \times \left(\frac{36}{\pi}\right)^2 \times \left(\frac{\pi}{3}\right)^2$$

= 720 erg

Kinetic energy = $\frac{1}{2} m v^2$

$$= \frac{1}{2} \times 10 \times 6^2 = 180 \text{ erg}$$

∴ Potential energy = Total energy – Kinetic energy

= 720 – 180 = 540 erg





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