Chapter # 07 (Oscillations)

Important Short Questions

1. What is harmonic oscillator? Give two examples.

Ans: Harmonic Oscillator:

A body executing simple harmonic motion is called harmonic oscillator.

Example:

- Mass spring system
- Simple pendulum

2. Define SHM. Give two examples.

Ans: Simple Harmonic Motion:

The oscillator motion, in which acceleration of the body at any instant is directly proportional to the displacement from the mean position and always directed towards the mean position is called simple harmonic motion.

Example:

- Motion of simple pendulum
- Motion of mass attached to spring

3. Define instantaneous displacement and amplitude.

Ans: Instantaneous Displacement:

The distance of the vibrating body at any instant from its mean position is called instantaneous displacement.

It is denoted by "x". The value of instantaneous displacement is zero at mean position while it has maximum value at the extreme position.

Amplitude:

The maximum value of displacement of the vibrating body on either sides from its mean position is called amplitude.

It is denoted by "x_o".

4. Define vibration, time period and frequency.

Ans: Vibration:

One complete round trip of a vibrating body about its mean position is called one vibration.

Time Period:

The time required to complete one vibration is called time period.

It is represented by "T". Its unit is "sec".

Frequency:

The number of vibrations completed in one second by the vibrating body is called frequency.

It is represented by "f". Its unit is Hertz (Hz)

$$\mathbf{f = \frac{1}{T}}$$

5. Define Hook's law. Write its formula.

Ans: Hook's Law:

The restoring force is directly proportional to the displacement from the mean position.

$$F \propto -x$$

$$F = -kx$$

6. Define spring constant. Write its formula and unit.

Ans: Spring Constant:

The ratio of restoring force to the displacement from the mean position is called spring constant.

$$K = \frac{F}{x}$$

Its unit is Nm^{-1}.

7. On which factors time period of mass spring system depends?

Ans: The formula for the time period of mass spring system is given as

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

It depends upon:

- Mass of the body
- Spring constant

8. Define simple pendulum. Write the formula of its time period.

Ans: Simple Pendulum:

An ideal simple pendulum consists of a small mass suspended by a weightless, flexible and inextensible string with a frictionless support and medium.

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

9. What is second pendulum? Calculate its frequency and length.

Ans: Second Pendulum:

The pendulum whose time period is 2 second is called second pendulum.

Frequency:

$$f = \frac{1}{T}$$

$$f = \frac{1}{2}$$

$$f = 0.5Hz$$

Length:

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

$$T^2 = 4\pi^2 \times \left(\frac{l}{g}\right)$$

$$l = \frac{gT^2}{4\pi^2}$$

As T = 2 sec

$$l = \frac{9.81 \times (2)^2}{4(3.14)^2}$$

l = 99.2 cm

10. What is the difference between free oscillations and forced oscillation?

Ans:

Free Oscillation	Forced Oscillation
• A body is said to be executing free vibrations if it oscillates with its natural frequency without the interference of an external force. • A simple pendulum vibrates freely with its natural frequency that depends only upon the length of the pendulum.	• A body is said to be executing forced oscillation if it oscillates with interference of an external force. • If the mass of vibrating pendulum is struck repeatedly, then forced oscillation is produced.

11. What is resonance? Explain it with examples.

Ans: Resonance:

"The phenomenon in which the amplitude of a vibrating body increases when the frequency of an applied force is equal to the natural frequency of the harmonic oscillator is called resonance."

(i) Suspension Bridge:

The column of soldiers, while marching on a bridge of long span are advised to break their steps. Their rhythmic march might set up oscillations of dangerously large amplitude in the bridge structure.

(ii) Turning of a radio:

Turning of radio is a good example of electrical resonance. We turn the knob of a radio. It changes the natural frequency of electrical circuit of receiver until it becomes equal to the frequency of the transmitter. So, resonance is produced and energy absorption is maximum. Hence, station is tuned.

12. What is difference between damped oscillations and un-damped oscillations?

Ans:

Damped Oscillations	Un-damped Oscillations
• The oscillation in which amplitude decreases with time due to energy dissipation are called damped oscillation. • Shock absorber is an example of damped oscillation.	• The oscillation in which amplitude remain same with time are called un-damped oscillation. • Oscillation of an ideal pendulum is an example of un-damped oscillation.

13. What is difference between simple harmonic oscillator and driven harmonic oscillator?

Ans:

Simple Harmonic Oscillator	Driven Harmonic Oscillator
• A harmonic oscillator is a system in which an object vibrates with a certain amplitude and frequency. • The amplitude of simple harmonic oscillator always remains same.	• A physical system under going forced vibrations is known as driven harmonic oscillator. • The amplitude of driven harmonic oscillator decreases gradually.

Exercise Short Questions

1. Name two characteristics of simple harmonic motion.

Ans: The characteristics of simple harmonic motion are given below:

- Restoring force is directly proportional to the displacement from mean position $\vec{F} \propto -\vec{x}$
- Acceleration is directly proportional to displacement from mean position and is directed towards the mean position. $\vec{a} \propto -\vec{x}$
- Total energy of system is conserved in SHM. [T.E = K.E + P.E]

2. Does frequency depends on amplitude for harmonic oscillations?

Ans: No, it does not depend upon amplitude of harmonic oscillator.

Reason:

In case of simple pendulum is,

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

In case of mass spring system,

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

These equations show that frequency of simple harmonic oscillator is independent of amplitude.

3. Can we realize an ideal simple pendulum?

Ans: No, we cannot realize an ideal simple pendulum.

Reason:

An ideal simple pendulum consists of point mass suspended by massless and inextensible string. In practical, it is not possible.

4. What is the total distance travelled by an object moving with SHM in a time equal to its period, if its amplitude is A?

Ans: The total distance covered by the body is 4A.

Explanation:

Time period is the time during which the vibrating body completes one round trip. In one round trip

Total distance covered = A + A + A + A = 4A

5. What happens to the time period of the simple pendulum if its length is doubled? What happens if the suspended mass is doubled?

Ans: The time period of the simple pendulum is,

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

Effect of doubling the length:

- If $l' = 2l$

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

$$T' = \sqrt{2}\left(2\pi\sqrt{\frac{l}{g}}\right)$$

$$T' = \sqrt{2}\ T$$

Effect of doubling the mass: -

When mass become doubled, the time period remains same. Because time period of simple pendulum is independent of mass. So, it does not change with mass.

6. Does the acceleration of a simple harmonic oscillator remain constant during its motion? Is the acceleration ever zero? Explain?

Ans: No, it does not constant.

Reason:

The acceleration of the body executing SHM is,

$$\vec{a} = -\omega^2\vec{x}$$

$$\vec{a} \propto -\vec{x}$$

This shows that acceleration varies directly with displacement.

Zero Acceleration:

Above equation shows that acceleration is zero at mean position where the value of displacement is zero (x = 0).

7. What is meant by phase angle? Does it define the angle between maximum displacement and the driving force?

Ans: Phase angle:

"The angle which specifies the displacement as well as direction of motion of point executing SHM. Is called phase angle.**"**

$$\boldsymbol{\theta = \omega t + \varphi}$$

No, it does not define the angle between maximum displacement and the driving force. It is the angle between the rotating vector and reference line. Phase angle $\theta = \omega t$, where ω is angular frequency and t is any instant od time.

8. Under what conditions does the addition of two simple harmonic motions produce a resultant, which is also simple harmonic?

Ans: The addition of two simple harmonic motions produce a resultant, which is also simple harmonic when,

Conditions:

The two simple harmonic motions have:

- Same frequency
- Same nature and parallel to each other (mechanical waves cannot be superposed with electromagnetic waves)
- Constant phase difference

9. Show that in SHM the acceleration is zero when the velocity is greatest and the velocity is zero where the acceleration is greatest?

Ans: Acceleration is zero where velocity is greatest: -

We know that $a = -\omega^2 x$ and $v = \omega\sqrt{x_o^2 - x^2}$

When $x = 0$ $a = 0$ and $v = \omega x_o$

Therefore, at mean position acceleration is zero and velocity is maximum.

Velocity is zero when acceleration is greatest:

When $x = x_o$ $a = -\omega^2 x_o$ and $v = 0$

Therefore, at extreme position acceleration is maximum and velocity is zero.

10. In relation to SHM, explain the equations;

(i) $y = A\sin(\omega t + \varphi)$ (ii) $a = -\omega^2 x$

Ans:

(i) $y = A\sin(\omega t + \varphi)$

Wave form of SHM is sinusoidal.

- Y = instantaneous displacement.
- A = amplitude
- φ = initial angle
- $\omega t + \varphi$ = phase angle

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

Acceleration of SHM depends directly proportional to displacement and directed towards mean position.

- a = instantaneous acceleration
- x = instantaneous displacement
- ω^2 = angular frequency

11. Explain the relation between total energy, potential energy for a body oscillating with SHM?

Ans: The total energy for a body oscillating with SHM remains constant.

- At extreme position, the whole energy is in the form of P.E. $(P.E)_{max} = \frac{1}{2}kx_o^2$
- At mean position, the whole energy is in the form of K.E. $(K.E)_{max} = \frac{1}{2}kx_o^2$
- At any point between mean and extreme position, total energy during SHM remains constant.

12. Describe some common phenomenon in which the resonance plays an important role?

Ans:

(i) Suspension Bridge:

The column of soldiers, while marching on a bridge of long span are advised to break their steps. Their rhythmic march might set up oscillations of dangerously large amplitude in the bridge structure.

(ii) Turning of a radio:

Turning of radio is a good example of electrical resonance. We turn the knob of a radio. It changes the natural frequency of electrical circuit of receiver until it becomes equal to the frequency of the transmitter. So, resonance is produced and energy absorption is maximum. Hence, station is tuned.

13. If a mass spring system is hung vertically and set into oscillation, why does motion eventually stop?

Ans: It eventually stops due to friction.

Reason:

When a mass spring system vibrates, it gradually loses its energy in doing work against frictional forces. So, amplitude of vibration becomes smaller and smaller and hence the motion eventually stops.