Unit 10 Simple Harmonic Motion and Waves

1. Define vibratory (oscillatory) motion. *(ALP)*
The to and fro motion of a body about its mean position is known as vibratory motion. For example, motion of simple pendulum about its mean position.

****2. Define simple harmonic motion.** *(ALP)*
Simple harmonic motion occurs when the net force is directly proportional to the displacement from the mean position and is always directed towards the mean position. Mathematically,

$$a \propto -x$$

Where a is acceleration. It is always directed towards mean position and x is displacement from mean position.

***3. Define Hooks law.** *(ALP)*
According to Hook's law the exerted force is directly proportional to change in length.

$$F \propto x$$

****4. What are the necessary conditions for a body to execute simple harmonic motion?** *(ALP)*

(i) A body should always vibrate about its mean position.
(ii) Acceleration is always directed towards mean position.
(iii) Magnitude of acceleration is directly proportional to the displacement from the mean position. $i.e.$, acceleration will be zero at the mean position while it will be maximum at the extreme positions.
(iv) Its velocity is maximum at the mean position and zero at the extreme positions.

***5. Define restoring force.** *(ALP)*
The force which pushes or pulls the object performing oscillatory motion towards the mean position is called restoring force. Mathematically restoring force is defined as

$$F = -kx$$

Where negative sign shows that the force is always directed towards mean position.

***6. Define spring constant and write its formula.** *(ALP)*
Spring constant is defined as the ratio of applied force to the change in length of spring. Spring constant written as

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

***7. Define vibration.** *(ALP)*
One complete round trip of a vibrating body about its mean position is called one vibration.

***8. Define time period.** *(ALP)*
The time taken by a vibrating body to complete one vibration is called time period.

***9. Define frequency.** *(ALP)*
The number of vibrations or cycles of a vibrating body in one second is called its frequency. It is reciprocal of time period i.e.

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

***10. Define amplitude.** *(ALP)*
The maximum displacement of a vibrating body on either side from its mean position is called its amplitude.

11. When ball is at the center of bowl what will be the net force?
When ball is at the center of bowl the net force acting on the ball is zero because at this position weight of the ball acts downward and is equal to the upward normal force of the surface of the bowl.

****12. What is simple pendulum?** *(ALP)*
A simple pendulum consists of a small bob of mass m suspended from a light string of length l fixed at its upper end. Time period of simple pendulum is given as

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

13. If the length of a simple pendulum is doubled, what will be the change in its time period?
If the length of pendulum is doubled then time period will increase by $\sqrt{2}$ times. Time period of simple pendulum is given by

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

Here $l = 2l$

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

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

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

****14. Define damped oscillations?**
The oscillations of a system in the presence of some resistive force are damped oscillations.

15. Explain damped motion with practical example.
Damped Motion: The friction reduces the mechanical energy of the system as time passes, and the motion is said to be damped.

Example: Shock absorbers in automobiles are one practical application of damped motion. A shock absorber consists of a piston moving through a liquid such as oil. The upper part of the shock absorber is firmly attached to the body of the car. When the car travels over a bump on the road, the car may vibrate

violently. The shock absorbers damp these vibrations and convert their energy into heat energy of the oil.

16. What is wave?** ***(ALP)

A wave is a disturbance in the medium which causes the particles of the medium to undergo vibratory motion about their mean position in equal intervals of time. For example, water waves, waves produced in string etc.

****17. In which categories waves are divided? Also define them with examples.** ***(ALP)***

There are two categories of waves:

(i) Mechanical waves

(ii) Electromagnetic waves

Mechanical Waves: Waves which require any medium for their propagation are called mechanical waves.

Examples of mechanical waves are water waves, sound waves and waves produced on the strings and springs.

Electromagnetic Waves: Waves which do not require any medium for their propagation are called electromagnetic waves.

Radiowaves, television waves, X-rays, heat and light waves are some examples of electromagnetic waves.

****18. What are the types of mechanical waves? Also define them.** ***(ALP)***

Mechanical waves may be classified as

(i) Longitudinal waves

(ii) Transverse waves

Longitudinal Waves	Transverse Waves
In longitudinal waves the particles of the medium move back and forth along the direction of propagation of wave.	In case of transverse waves, the vibratory motion of particles of the medium is perpendicular to the direction of propagation of waves.
Longitudinal waves propagate in form of compression and rarefactions.	Transvers waves propagate in form of crests and troughs.
Examples: Sound wave, waves produced mass attached to string.	Examples: Water waves, waves produced in slinky by up and down motion.

19. What is meant by compression and rarefaction?** ***(ALP)

Compression: The region of wave where particles of medium are closed to each other is called compression of wave. **OR**

The region of wave where loops of slinky are closed together is called compression.

Rarefaction: The region of wave where particles of medium are space apart is called rarefaction. **OR**

The region of wave where loops of slinky are space apart is called rarefaction.

20. What is meant by crest and trough? How crest and trough produced in water wave?** ***(ALP)

Crest: In transverse waves crests are the highest points of particles of the medium from mean position.

Trough: In transverse waves troughs are the lowest points of particles of the medium from mean position.

Crests and Troughs in Water Wave: By using rippal tank the crests and troughs in water waves appear as bright and dark lines respectively.

21. Define wavelength.

The distance between two consecutive crests or troughs is called wavelength. It is denoted by λ. **OR**

The distance between two consecutive compressions is called wavelength.

22. Can mechanical waves go through space? ***(ALP)***

Mechanical waves are waves that require a medium in order to transport their energy from one place to another. Therefore, they cannot travel through regions of space that are void of particles.

23. How energy can be transferred from one place to another? ***(ALP)***

Energy can be transferred from one place to another through waves.

24. What are seismic waves? ***(ALP)***

Earthquake produces waves through the crust of the Earth in the form of seismic waves. By studying such waves, the geophysicists learn about the internal structure of the Earth and information about the occurrence of future Earth activity.

****25. Prove that $v = f\lambda$. OR What is meant by wave equation?** ***(ALP)***

Wave Equation: The relation between the velocity, frequency and wavelength of the wave is known as wave equation.

Derivation: Wave is a disturbance in a medium which travels from one place to another and hence has a specific velocity of travelling. This is called the velocity of wave which is defined by

$$Velocity = \frac{Displacement}{time}$$

$$v = \frac{d}{t}$$

If time taken by the wave in moving from one point to another is equal to its time period T, then the distance covered by the wave will be equal to one wavelength λ, hence we can write it as

$$v = \frac{\lambda}{T}$$

But time period T, is reciprocal of the frequency f, i.e., $T = \frac{1}{f}$

Therefore,

$$v = \frac{\lambda}{1/f}$$

$$\Rightarrow \qquad v = f\lambda \quad \ldots\ldots (i)$$

Equation (i) called wave equation and is true both longitudinal and transverse waves.

26. What is a ripple tank?

Ripple tank is a device to produce water waves and to study their characteristics.

****27. Define reflection of wave.**

When waves moving in one medium fall on the surface of another medium they bounce back into the first medium such that the angle of incidence is equal to the angle of reflection.

****28. Define refraction of wave.**

When a wave from one medium enters into the second medium at some angle, its direction of travel changes.

****29. Define diffraction.**

The bending or spreading of waves around the sharp edges or corners of obstacles or slits is called diffraction.

30. Think of several examples of motion in everyday life that are simple harmonic. ***(ALP)***

The common examples are up and down motion of leaf in pond, motion of swing, motion of simple pendulum and motion of ball in bowl etc.

31. Does increasing the frequency of a wave also increase its wavelength? If not, how are these quantities related?

As we know $v = f\lambda \qquad \Rightarrow f = \frac{v}{\lambda}$

According to this relation if wave speed is constant then wavelength λ will decrease as the frequency increases. The frequency and wavelength of a wave have inverse relation with each other.

Important Long Questions

(1) Define SHM and also prove that the mass attached to spring shows SHM.

(2) Prove that motion of simple pendulum is SHM.

(3) Define SHM and prove that motion of ball and bowl system is SHM.

(4) Define SHM and what are the necessary conditions for a body to execute SHM.

(5) How can you define the term wave? Elaborate the difference between types of waves with examples.

(6) Explain with activity that waves are carrier of energy.

(7) Explain the types of mechanical waves with examples.

(8) What are damped oscillations? Explain.

(9) What is ripple tank? Write construction and working of ripple tank.

(10) What is ripple tank? Explain refraction of wave with reference to ripple tank.

(11) Define reflection and diffraction of wave. Discuss this phenomenon with the help of ripple tank.