Class XI: Physics
Chapter 14: Oscillations

Key Learning:

1. The motion which repeats itself is called periodic motion.

2. The period T is the time required for one complete oscillation, or cycle. It is related to the frequency ν by, $\nu = 1/T$.

3. The frequency ν of periodic or oscillatory motion is the number of oscillations per unit time.

4. The force acting in simple harmonic motion is proportional to the displacement and is always directed towards the centre of motion.

5. In Simple harmonic motion, the displacement x (t) of a particle from its equilibrium position is given by,

$$x(t) = A \cos(\omega t + \Phi)$$

6. $(\omega t + \Phi)$ is the phase of the motion and Φ is the phase constant. The angular frequency ω is related to the period and frequency of the motion by,

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

7. Two perpendicular projections of uniform circular motion will give simple harmonic motion for projection along each direction with center of the circle as the mean position.

8. The motion of a simple pendulum swinging through small angles is approximately simple harmonic. The period of oscillation is given by

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

9. The motion of a simple pendulum is simple harmonic for small angular displacement.

10. A particle of mass *m* oscillating under the influence of a Hooke's law restoring force given by $F = -k\,x$ exhibits simple harmonic motion with

$$\omega = \sqrt{\frac{k}{m}} = \text{Angular frequency}$$

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

11. The restoring force in case of wooden cylinder floating on water is due to increase in up thrust as it is pressed into the water.

12. The restoring force in case of Liquid in U tube arises due to excess pressure in the liquid column when the liquid levels in the two arms are not equal.

13. A simple pendulum undergoing SHM in the plane parallel to the length of the wire is due to restoring force that arises due to increase in tension in the wire

14. The mechanical energy in a real oscillating system decreases during oscillations because external forces, such as drag, inhibit the oscillations and transfer mechanical energy to thermal energy. The real oscillator and its motion are then said to be damped.

15. If an external force with angular frequency ω_d acts on an oscillating system with natural angular frequency ω, the system oscillates with angular frequency ω_d. The amplitude of oscillations is the greatest when

$$\omega_d = \omega$$

This condition is called resonance.

Top Formulae:

1. Displacement in S.H.M., $y = a \sin (w t \pm \phi_0)$

2. Velocity in S.H.M., $V = \omega \sqrt{a^2 - y^2}$

3. Acceleration in S.H.M., $A = - \omega^2 y$ and $\omega = 2 \pi \nu = 2 \pi / T$

4. Potential energy in S. H. M., $U = \frac{1}{2} m \omega^2 a^2 = \frac{1}{2} k y^2$

5. Kinetic energy in S. H. M., $K = \frac{1}{2} m \omega^2 (a^2 - y^2) = \frac{1}{2} k (a^2 - y^2)$

6. Total energy, $E = \frac{1}{2} m \omega^2 a^2 = \frac{1}{2} k a^2$

7. Spring constant $k = F/y$

8. Spring constant of parallel combination of springs

$$K = k_1 + k_2$$

9. Spring constant of series combination of spring $\frac{1}{K} = \frac{1}{k_1} + \frac{1}{k_2}$

10. Time period, $T = 2 \pi \sqrt{\frac{m}{K}}$

11. If the damping force is given by $F_d = -b v$, where v is the velocity of the oscillator and b is it damping constant, then the displacement of the oscillator is given by

$$x(t) = A e^{-bt/2m} \cos (\omega' t + \Phi)$$

where ω' the angular frequency of the damped oscillator, is given by

$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

12. The mechanical energy E of damped oscillator is given by

$$E(t) = \frac{1}{2} k A^2 e^{-bt/m}$$