Class : 11th Physics
Chapter- 14 : Oscillations

Oscillations

SHM

Simple Harmonic Motion is the simplest form of oscillatory motion.

Velocity in SHM
$$v=\frac{dx}{d(t)}=-\omega A\sin(\omega t+\varphi)$$
$$v_{max}=\omega A$$

Acceleration in SHM
$$a=\frac{dv}{dt}=-\omega^2 A\cos(\omega t+\varphi)$$
$$a_{max}=\omega^2 A$$

Energy in SHM
Kinetic Energy
$$K.E=\frac{1}{2}m\omega^2A^2\sin^2(\omega t+\varphi)$$
Potential Energy
$$P.E=\frac{1}{2}m\omega^2A^2\cos^2(\omega t+\varphi)$$
Total energy, T.E.=K.E.+ P.E.
$$=\frac{1}{2}kA^2\left[\cos^2(\omega t+\varphi)+\sin^2(\omega t+\varphi)\right]$$

Force law equation for SHM
$$F=-k(x),\ k=m\omega^2$$
$$\therefore \omega=\sqrt{\frac{k}{m}}$$

Displacement in SHM
x(t)= A(cosωt+φ)

A= Amplitude i.e.,maximum displacement of particles.

Phase
Time varying quantity(ωt + φ)

Phase constant or Phase angle (φ)
- It depends upon velocity (v) and displacement of particle at t = 0

Time period(T).
The smallest interval of time after which the motion is repeated

Frequency
The number of oscillations per second.

i.e., $f=\frac{1}{T}=\frac{\omega}{2\pi}$

- Every oscillatory motion is periodic,
but every periodic motion need not be oscillatory.
- To and from motion repeatedly about
a fixed point in a definite interval of time.

Oscillations due to a spring
$$\text{Time period } T=2\pi\sqrt{\frac{m}{k}}$$
$$\text{Here, } k=\frac{F}{x}=\text{spring constant}$$

Simple pendulum
$$\text{Time period } T=2\pi\sqrt{\frac{I}{mgl}}=2\pi\sqrt{\frac{l}{g}}$$

Damped Oscillations
Oscillation of a body whose amplitude goes on decreasing with time.

Damping force $F_d=-bv$, b = damping constant

Displacement of damped oscillator
$$x=x_m e^{-bt/2m}\sin(\omega t+\varphi)$$
Amplitude decreases with time as
$$x=x_m e^{-(b/2m)t}$$

Forced Oscillations
Driving force, $F(t)=F_o\cos\omega_d t$

Displacement, $x(t)=A\cos(\omega_d+\varphi)$

$$\text{Amplitude, } A=\frac{F_o}{\left\{m^2(\omega^2-\omega_d^2)^2+\omega_d^2b^2\right\}^{\frac{1}{2}}}$$
$$\tan\varphi=\frac{-v_o}{\omega_d x_o}$$

Resonance
When frequency of external force is equal to natural frequency of oscillator.