1 LAQ = 8 MARKS

7. OSCILLATIONS

• SHM • Simple Pendulum • Simple Harmonic Oscillator
• Reference Circle • T.E & K.E of SHM

SMART SYNOPSIS

1. **Periodic Motion** is the motion that repeats itself at 'regular intervals of time.'

   Ex: Motion of a pendulum in a wall clock; revolution of Earth around the Sun.

2. **Oscillation** in simple words is ‘To & Fro’ motion .

   If frequency is very small, we call it an oscillation. **Ex:** Oscillation of a branch of tree.

   If the frequency is high, we call it a vibration. **Ex:** Prongs of a tuning tork.

3. **Harmonic motion** is a 'to & fro' motion with displacement in sinewave pattern.

4. **Simple Harmonic Motion(SHM)** of a body is a harmonic periodic motion in which the body moves about a mean (equilibrium) position, and the restoring force (or acceleration) always directed towards the mean position and is proportional to its displacement.

   Ex : Oscillations of a simple pendulum with small displacement,

   motion of a loaded spring which is stretched and released.

5. **Expression for the Time period of a simple pendulum:**

   If l is the length of simple pendulum, then time period $T = 2\pi\sqrt{\frac{l}{g}}$

   Note 1: $T \propto \sqrt{l}$; $T \propto \frac{1}{\sqrt{g}}$ **Note 2 :**.Frequency $n = \frac{1}{T}$. Hence $n \propto \frac{1}{\sqrt{l}}$; $n \propto \sqrt{g}$

   Note 3 : Time period is independent of the “mass of the bob” and “amplitude”

6. **Seconds pendulum** is a pendulum with time period is 2 seconds .

7. **Law of conservation of energy :** During the oscillations of a simple pendulum, the total energy remains constant. PE + KE = constant

8. The **force constant (k)** of a spring is the restoring force produced per unit displacement of the body from its mean position.

   Formula : $k = \frac{F}{x}$ **SI unit:** Nm^{-1}.

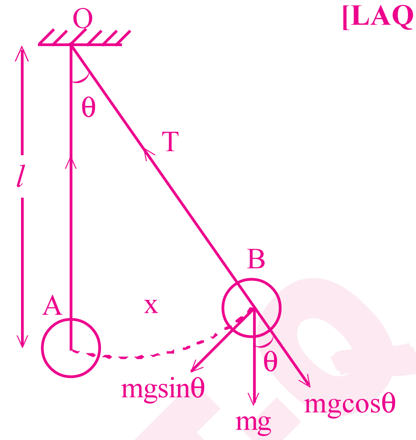
Imp.Formulae

I. Simple Pendulum : [LAQ 2]

(i) Time period of a simple pendulum $T = 2\pi\sqrt{\frac{l}{g}}$

(i) Time period of a seconds pendulum is T=2s

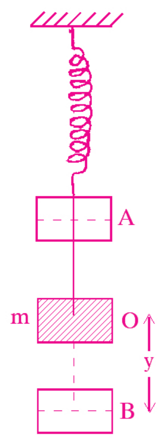
(ii) Length of Seconds pendulum $l = \frac{g}{\pi^2} \approx 1\text{m}$



II. Loaded Spring: [LAQ 4]

(i) Time period $T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{k}{m}}} = 2\pi\sqrt{\frac{m}{k}}$

(ii) Frequency $n = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$



III. Reference Circle (Simple Harmonic Oscillator) : [LAQ 1 & 3]

(i) Displacement $y = A\sin(\omega t)$

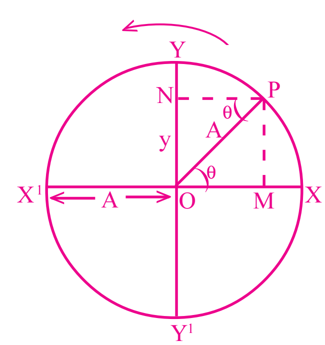
(ii) Velocity $v = A\omega\cos\omega t$ (or) $v = \omega\sqrt{A^2 - y^2}$

(iii) Acceleration $a = -\omega^2 y$

(iv) $KE = \frac{1}{2}m\omega^2(A^2 - y^2)$

(v) $PE = \frac{1}{2}m\omega^2 y^2$

(vi) $TE = \frac{1}{2}m\omega^2 A^2$



7. OSCILLATIONS
CONCEPTS & FORMULAS

1. SIMPLE HARMONIC MOTION (SHM)

SHM of a body is a harmonic periodic motion in which the body moves about a mean (equilibrium) position, and the restoring force (or acceleration) always directed towards the mean position and is proportional to its displacement.

Ex :

- Oscillations of a simple pendulum with small displacement.
- Motion of a loaded spring which is stretched and released.

2. TIME PERIOD OF A SIMPLE PENDULUM

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

3. SECONDS PENDULUM

A pendulum with time period is 2 seconds.

5. THE FORCE CONSTANT (k) OF A SPRING

is the restoring force produced per unit displacement of the body from its mean position.

Formula :

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

SI unit: Nm^{-1}.

4. LAW OF CONSERVATION OF ENERGY :

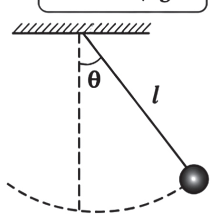
During the oscillations of a simple pendulum, the total energy remains constant.

$$\boxed{PE + KE = \text{constant}}$$

6. SIMPLE PENDULUM

(i) Time period of a simple pendulum

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



(ii) Time period of a seconds pendulum is $T = 2s$

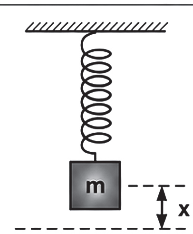
(iii) Length of Seconds pendulum

$$\boxed{l = \frac{g}{\pi^2} \approx 1\ \text{m}}$$

7. LOADED SPRING

(i) Time period

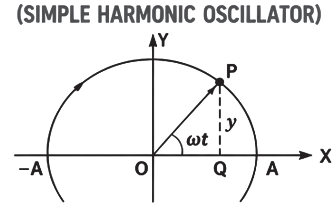
$$\boxed{T = 2\pi\sqrt{\frac{m}{k}} = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{k}{m}}} = \frac{2\pi}{\omega}}$$



(ii) Frequency

$$\boxed{n = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}}$$

8. REFERENCE CIRCLE (SIMPLE HARMONIC OSCILLATOR)



(i) Displacement $y = A\sin(\omega t)$

(ii) Velocity $v = A\omega\cos\omega t$

(or) $v = \omega\sqrt{A^2 - y^2}$

(iii) Acceleration $a = -\omega^2 y$

(iv) KE $= \frac{1}{2} m\omega^2 (A^2 - y^2)$

(v) PE $= \frac{1}{2} m\omega^2 y^2$

(vi) TE $= \frac{1}{2} m\omega^2 A^2$