Semester 2 BSc Hns Physics

Oscillations and Waves – Introduction

Oscillations and waves form a fundamental part of classical physics and play a crucial role in understanding a wide range of physical phenomena, from the vibration of atoms and molecules to the propagation of sound and light.

An **oscillatory motion** is a type of periodic motion in which a physical quantity repeats itself about a mean (equilibrium) position at regular intervals of time. Examples include the motion of a simple pendulum, vibrations of a tuning fork, and oscillations of electrical circuits.

A **wave** is the propagation of oscillations through space and time, accompanied by the transfer of energy but not matter. Waves arise when oscillations at one point influence neighboring points through a restoring force and inertia of the medium.

The study of oscillations and waves helps in understanding sound, optics, quantum mechanics, solid-state physics, and many technological applications such as communication systems, musical instruments, and seismic studies.

2. Oscillatory Motion

When a body repeats its motion **periodically** about an equilibrium position under the action of a **restoring force**, the motion is called **oscillatory motion**.

The restoring force always acts **towards the mean position**.

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3. Periodic Motion

A motion that **repeats itself after equal intervals of time** is called **periodic motion**.

All oscillatory motions are periodic
But all periodic motions are **not** oscillatory
(e.g., uniform circular motion)

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4. Equilibrium (Mean) Position

The position where the **net force acting on the particle is zero** is called the **equilibrium position**.

- Stable equilibrium → oscillations occur
- Unstable equilibrium → oscillations do not occur

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5. Displacement

Displacement is the **distance of the particle from the mean position** at any instant.

- Denoted by **x**
- Can be positive or negative

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6. Amplitude

The **maximum displacement** of the particle from the mean position is called the **amplitude**.

- Denoted by **A**
- It indicates the **energy of oscillation**
- Larger amplitude → higher energy

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7. Time Period (T)

The **time taken to complete one full oscillation** is called the **time period**.

- Unit: second (s)

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8. Frequency (f or ν)

The **number of oscillations per second** is called **frequency**.

- Unit: hertz (Hz)

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9. Angular Frequency (ω)

Angular frequency is the rate of change of phase with time.

$\omega = 2\pi f$

- Unit: rad s^{-1}

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10. Phase

The **phase** describes the **state of motion** of the oscillating particle at any instant.

- Particles with same displacement and velocity are in the **same phase**
- Phase difference tells how much one oscillation leads or lags another

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