CHAPTER-14:WAVES

Part–1: Wave Motion • Wave Equation • Wave Parameters

1. Wave Motion

Wave motion is the propagation of a disturbance from one point to another without the actual transfer of matter.

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2. Types of Waves

(i) Mechanical Waves

Require a material medium.

Examples

- Sound Waves
- Water Waves
- Waves on a String

(ii) Electromagnetic Waves

Do not require any material medium.

Examples

- Light
- Radio Waves
- X-rays

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3. Transverse Waves

Particles vibrate **perpendicular** to the direction of wave propagation.

Examples

- Waves on a stretched string
- Electromagnetic Waves

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4. Longitudinal Waves

Particles vibrate **parallel** to the direction of propagation.

Examples

- Sound Waves
- Compression Waves

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5. Important Wave Parameters

Amplitude

Maximum displacement of particles.

$$\boxed{A}$$

Wavelength

Distance between two consecutive particles in the same phase.

$$\boxed{\lambda}$$

SI Unit: m

Time Period
Time taken to complete one oscillation.

$$\boxed{T}$$

Frequency
Number of oscillations per second.

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

Unit: Hz

Angular Frequency

$$\boxed{\omega = 2\pi f}$$

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6. Wave Speed

The speed of propagation of a wave is

$$\boxed{v = f\lambda}$$

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7. Wave Number

$$\boxed{k = \frac{2\pi}{\lambda}}$$

Unit: rad/m

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8. Phase

Phase of a wave

$$\boxed{\phi = \omega t - kx}$$

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9. Progressive Wave Equation

For a wave travelling in the positive x-direction,

$$\boxed{y = A\sin(\omega t - kx)}$$

For a wave travelling in the negative x-direction,

$$\boxed{y = A\sin(\omega t + kx)}$$

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10. Phase Difference

$$\boxed{\Delta\phi = \frac{2\pi x}{\lambda}}$$

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11. Relation Between Phase Difference and Path Difference

$$\boxed{\Delta\phi = \frac{2\pi}{\lambda}\Delta x}$$

Part–2: Standing Waves • Harmonics • Organ Pipes • Doppler Effect

12. Principle of Superposition

When two or more waves travel simultaneously through a medium, the resultant displacement is the algebraic sum of individual displacements.

$$\boxed{y = y_1 + y_2}$$

13. Standing (Stationary) Waves

Standing waves are formed by the superposition of two waves of the same frequency, amplitude and speed travelling in opposite directions.

Equation

$$\boxed{y = 2A\sin kx\cos\omega t}$$

14. Node (N)

A point where displacement is always zero.
Distance between two consecutive nodes

$$\boxed{\frac{\lambda}{2}}$$

15. Antinode (A)

A point where displacement is maximum.
Distance between two consecutive antinodes

$$\boxed{\frac{\lambda}{2}}$$

16. Distance Between Node and Adjacent Antinode

$$\boxed{\frac{\lambda}{4}}$$

17. Fundamental Frequency

Lowest possible frequency of vibration.

Also called First Harmonic

18. Harmonics

Frequency of nth Harmonic

$$\boxed{f_n = nf_1}$$

19. Vibrating String

For a stretched string,
Fundamental Frequency

$$\boxed{f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}}$$

Where

- L = Length
- T = Tension
- μ = Mass per Unit Length

20. Open Organ Pipe

Fundamental Frequency

$$\boxed{f = \frac{v}{2L}}$$

nth Harmonic

$$\boxed{f_n = \frac{nv}{2L}}$$

All harmonics are present.

21. Closed Organ Pipe

Fundamental Frequency

$$\boxed{f = \frac{v}{4L}}$$

Only Odd Harmonics are present.

$$\boxed{f_n = \frac{(2n-1)v}{4L}}$$

22. Beats

Beat Frequency

$$\boxed{f_b = |f_1 - f_2|}$$

23. Doppler Effect (Basic Formula)

Observed Frequency

$$\boxed{f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)}$$

Where

- v_0 = Observer Speed
- v_s = Source Speed
- v = Speed of Sound

Exam Tips

□ Wave Speed→ depends on Medium
□ Frequency→ is determined by Source
□ Changing Medium→**Frequency does not change** whereas **Speed and Wavelength changes**
□ Open Organ Pipe → Odd & Even Harmonics
□ Closed Organ Pipe → only Odd Harmonics
□ Distance between Node and Antinode

$$\boxed{\frac{\lambda}{4}}$$
