Semester IV BSc Hns Physics MJC-7

Superposition principle

When two or more waves overlap at a point, the resultant displacement is the algebraic (vector) sum of individual displacements.

Mathematically:

y=y1+y2y = y_1 + y_2y=y1+y2

Interference is simply a special case of superposition where the pattern is stable and observable.

Conditions for sustained (observable) interference

For two waves to produce clear and steady interference, these conditions must be satisfied:

1. Coherent sources (MOST IMPORTANT)

- **Waves must have:**
  - **Same frequency**
  - **Constant phase difference**
- **Usually achieved by splitting light from a single source.**

Without coherence → interference pattern keeps changing → no fringes.

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2. Same wavelength

λ1=λ2\lambda_1 = \lambda_2λ1=λ2

If wavelengths differ, maxima and minima won't stay fixed.

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3. Same type of waves

- **Both must be light, or sound, etc.**
- **Light + sound (no interference)**

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4. Nearly equal amplitudes (for good contrast)

- **For sharp bright & dark fringes:**

A1≈A2A_1 \approx A_2A1≈A2

If one wave is much stronger → fringes become faint.

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5. Path difference should be stable

- **For constructive interference:**

Δx=nλ (n=0,1,2,…)\Delta x = n\lambda \quad (n = 0,1,2,\dots)Δx=nλ(n=0,1,2,…)

- **For destructive interference:**

Δx=(2n+1)λ2\Delta x = (2n+1)\frac{\lambda}{2}Δx=(2n+1)2λ

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6. Same state of polarization (for light)

- **Waves must vibrate in the same plane.**
- **Perpendicular polarizations → no interference.**

Result of interference

- **Constructive interference → maximum intensity**
- **Destructive interference → minimum or zero intensity**