1. Resultant Displacement

If two waves with displacements $y_1 = A_1 \sin(kx - \omega t)$ and $y_2 = A_2 \sin(kx - \omega t + \phi)$ are superposed, the resultant displacement y is:

$$
\begin{aligned}
y &= y_1 + y_2 \\
&= A_1 \sin(kx - \omega t) + A_2 \sin(kx - \omega t + \phi) \\
&= A_R \sin(kx - \omega t + \delta)
\end{aligned}
$$

where

$$
\begin{aligned}
A_R &= \sqrt{A_1^2 + A_2^2 + 2A_1 A_2 \cos\phi} \\
\tan\delta &= \frac{A_2 \sin\phi}{A_1 + A_2 \cos\phi}
\end{aligned}
$$

2. Constructive and Destructive Interference

- **Constructive interference** occurs when $\phi = 2n\pi$ (waves in phase), resultant amplitude:

$$A_R = A_1 + A_2$$

- **Destructive interference** occurs when $\phi = (2n+1)\pi$ (waves out of phase), resultant amplitude:

$$A_R = |A_1 - A_2|$$

where $n = 0, 1, 2, \ldots$

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3. Path Difference and Phase Difference

- Phase difference ϕ related to path difference Δx:

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

where λ is the wavelength.

4. Intensity and Amplitude

- Intensity I is proportional to the square of amplitude:

$$I \propto A^2$$

- For two waves of equal amplitude A, the resultant intensity:

$$I = 4I_0 \cos^2\left(\frac{\phi}{2}\right)$$

where I_0 is the intensity of one wave.