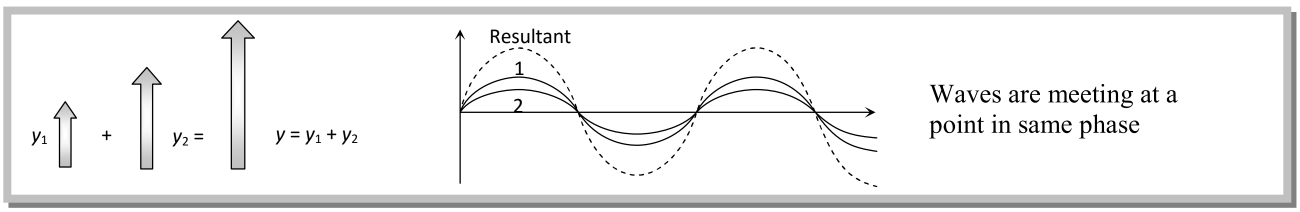
Principle of Super Position.

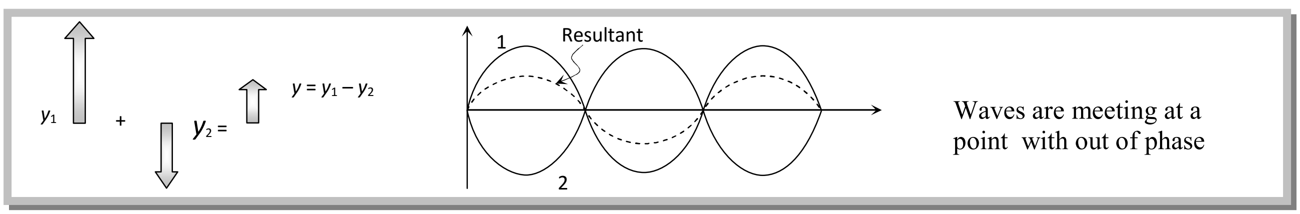
When two or more than two waves superimpose over each other at a common particle of the medium then the resultant displacement (y) of the particle is equal to the vector sum of the displacements (y1 and y2) produced by individual waves. i.e. $\vec{y} = \vec{y}_1 + \vec{y}_2$

(1) Graphical view:

(i)



(ii)



(2) Phase / Phase difference / Path difference / Time difference

(i) Phase: The argument of sine or cosine in the expression for displacement of a wave is defined as the phase. For displacement y = a sin ωt; term ω t = phase or instantaneous phase

(ii) Phase difference (ϕ): The difference between the phases of two waves at a point is called phase difference i.e. if $y_1 = a_1 \sin \omega t$ and $y_2 = a_2 \sin(\omega t + \phi)$ so phase difference = ϕ

(iii) Path difference (Δ): The difference in path lengths of two waves meeting at a point is called path difference between the waves at that point. Also $\Delta = \frac{\lambda}{2\pi} \times \phi$

(iv) Time difference (T.D.): Time difference between the waves meeting at a point is

$$T.D. = \frac{T}{2\pi} \times \phi$$

(3) Resultant amplitude and intensity

If suppose we have two waves $y_1 = a_1 \sin \omega t$ and $y_2 = a_2 \sin(\omega t + \phi)$; where $a_1, a_2 =$ Individual amplitudes, ϕ = Phase difference between the waves at an instant when they are meeting a point. I1, I2 = Intensities of individual waves

Resultant amplitude: After superimposition of the given waves resultant amplitude (or the amplitude of resultant wave) is given by $A = \sqrt{a_1^2 + a_2^2 + 2a_1 a_2 \cos \phi}$

For the interfering waves y1 = a1 sinω t and y2 = a2 cosω t, Phase difference between them is 90o. So resultant amplitude $A = \sqrt{a_1^2 + a_2^2}$

Resultant intensity: As we know intensity ∝ (Amplitude) 2⇒ $I_1 = ka_1^2, I_2 = ka_2^2$ and $I = kA^2$ (k is a proportionality constant). Hence from the formula of resultant amplitude, we get the following formula of resultant intensity $I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos \phi$

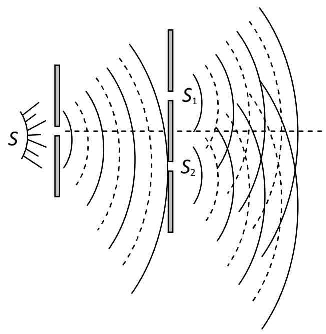
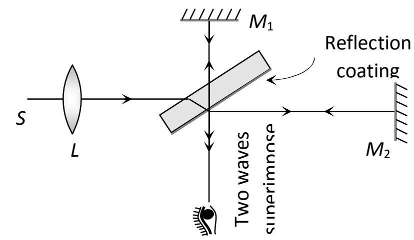
Note: The term $2\sqrt{I_1 I_2} \cos \phi$ is called interference term. For incoherent interference this term is zero so resultant intensity $I = I_1 + I_2$

(4) Coherent sources

The sources of light which emits continuous light waves of the same wavelength, same frequency and in same phase or having a constant phase difference are called coherent sources.

Two coherent sources are produced from a single source of light by adopting any one of the following two methods

Division of wave front	Division of amplitude
The light source is narrow	Light sources is extended. Light wave partly reflected (50%) and partly transmitted (50%)
The wave front emitted by a narrow source is	The amplitude of wave emitted by an extend source

divided in two parts by reflection of refraction.	of light is divided in two parts by partial reflection and partial refraction.
The coherent sources obtained are imaginary e.g. Fresnel's Biprism, Lloyd's mirror Young's' double slit etc.  	The coherent sources obtained are real e.g. Newton's rings, Michelson's interferometercolors in thin films 

Note: Laser light is highly coherent and monochromatic.

Two sources of light, whose frequencies are not same and phase difference between the waves emitted by them does not remain constant w.r.t. time are called non-coherent.

The light emitted by two independent sources (candles, bulbs etc.) is non-coherent and interference phenomenon cannot be produced by such two sources.

The average time interval in which a photon or a wave packet is emitted from an atom is defined as the time of coherence. It is $\tau_c = \frac{L}{c} = \frac{\text{Distance of coherence}}{\text{Velocity of light}}$, its value is of the order of 10–10 sec.