Interference of Light.

When two waves of exactly same frequency (coming from two coherent sources) travels in a medium, in the same direction simultaneously then due to their superposition, at some point's intensity of light is maximum while at some other point's intensity is minimum. This phenomenon is called Interference of light.

(1) Types: It is of following two types

Constructive interference	Destructive interference
(i) When the waves meets a point with same phase, constructive interference is obtained at that point (i.e. maximum light)	(i) When the wave meets a point with opposite phase, destructive interference is obtained at that point (i.e. minimum light)
(ii) Phase difference between the waves at the point of observation $\phi = 0^o$ or $2n\pi$	(ii) $\phi = 180^o$ or $(2n-1)\pi$; n = 1, 2, ... or $(2n+1)\pi$; $n = 0,1,2.....$
(iii) Path difference between the waves at the point of observation $\Delta = n\lambda$ (i.e. even multiple of $\lambda/2$)	(iii) $\Delta = (2n-1)\frac{\lambda}{2}$ (i.e. odd multiple of $\lambda/2$)
(iv) Resultant amplitude at the point of observation will be maximum $a_1 = a_2 \Rightarrow A_{min} = 0$ If $a_1 = a_2 = a_0 \Rightarrow A_{max} = 2a_0$	(iv) Resultant amplitude at the point of observation will be minimum $A_{min} = a_1 - a_2$ If $a_1 = a_2 \Rightarrow A_{min} = 0$
(v) Resultant intensity at the point of observation will be maximum $I_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2}$ $I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$ If $I_1 = I_2 = I_0 \Rightarrow I_{max} = 2I_0$	(v) Resultant intensity at the point of observation will be minimum $I_{min} = I_1 + I_2 - 2\sqrt{I_1 I_2}$ $I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$ If $I_1 = I_2 = I_0 \Rightarrow I_{min} = 0$

(2) Resultant intensity due to two identical waves:

For two coherent sources the resultant intensity is given by $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

For identical source $I_1 = I_2 = I_0 \Rightarrow I = I_0 + I_0 + 2\sqrt{I_0 I_0}\cos\phi = 4I_0\cos^2\frac{\phi}{2}$ [1 + cosθ $= 2\cos^2\frac{\theta}{2}$]

Note: In interference redistribution of energy takes place in the form of maxima and minima.

Average intensity: $I_{av} = \frac{I_{max} + I_{min}}{2} = I_1 + I_2 = a_1^2 + a_2^2$

Ratio of maximum and minimum intensities:

$$\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{I_1} + \sqrt{I_2}}{\sqrt{I_1} - \sqrt{I_2}}\right)^2 = \left(\frac{\sqrt{I_1 / I_2} + 1}{\sqrt{I_1 / I_2} - 1}\right)^2 = \left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2 = \left(\frac{a_1 / a_2 + 1}{a_1 / a_2 - 1}\right)^2$$

Also $\sqrt{\frac{I_1}{I_2}} = \frac{a_1}{a_2} = \left(\frac{\sqrt{\frac{I_{max}}{I_{min}}} + 1}{\sqrt{\frac{I_{max}}{I_{min}}} - 1}\right)$

If two waves having equal intensity (I1 = I2 = I0) meets at two locations P and Q with path difference Δ1 and Δ2 respectively then the ratio of resultant intensity at point P and Q will be

$$\frac{I_P}{I_Q} = \frac{\cos^2\frac{\phi_1}{2}}{\cos^2\frac{\phi_2}{2}} = \frac{\cos^2\left(\frac{\pi\Delta_1}{\lambda}\right)}{\cos^2\left(\frac{\pi\Delta_2}{\lambda}\right)}$$