WAVE OPTICS

Huygen's wave Theory

According to Huygen's principle a body emits light in the form of waves. Each points source of light is a center of disturbance from which waves propagates in all direction.

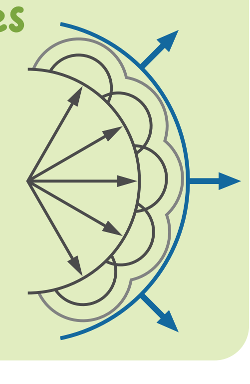
Wave Front

A wavefront is a surface along which the waves phase remains constant.

(i) The energy of wave travels in a direction perpendicular to wavefront.

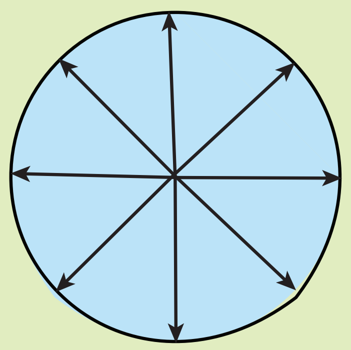
(ii) Rays are perpendicular to wavefront.

(iii) The time taken by light to travel from one wavefront to another is the same along anyray.



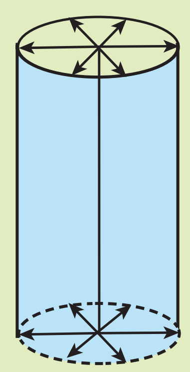
Types of wavefronts

Spherical wavelength



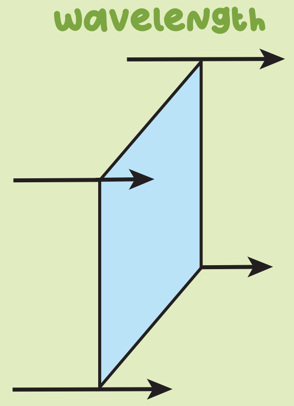
(Due to point source of light).

Cylindrical wavelength



(Due to line source of Light).

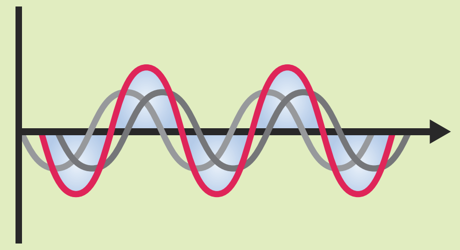
Plane wavelength



(Due to line source of Light).

INTERFERENCE

Interference is a phenomenon of superposition of two coherent waves through which they transfer energy and momentum.



MATHEMATICAL INTERPRETATION OF INTERFERENCE OF TWO WAVES

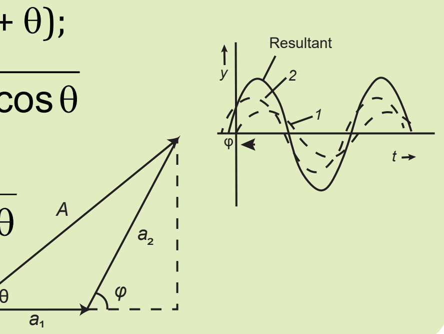
Let a1 and a2 be amplitudes of the waves and φ the phase difference between them.

Then $y_1 = a_1 \sin \omega t$; $y_2 = a_2 \sin(\omega t + \phi)$;

$Y = y_1 + y_2 = A \sin(\omega t + \theta)$;

$$A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\theta}$$

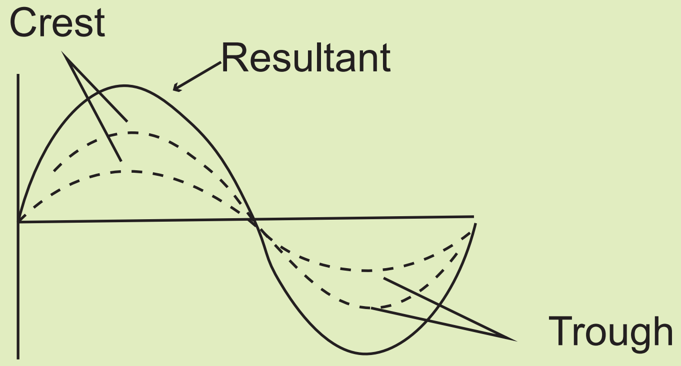
$$\tan\theta = \frac{a_2 \sin\theta}{a_1 + a_2 \cos\theta}$$



TYPES OF INTERFRENCE

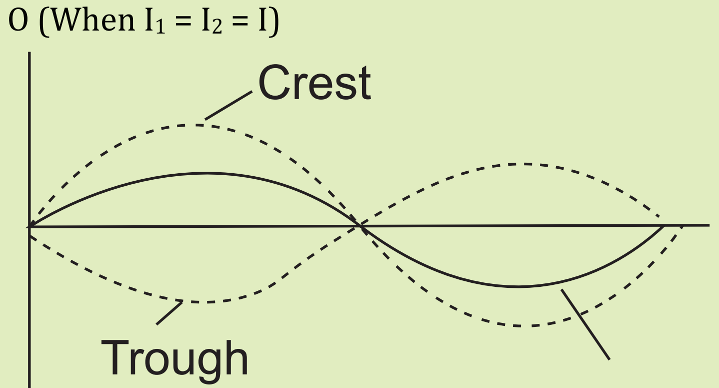
Constructive Interference

- Phase difference $\rightarrow (\Delta\phi) = 2n\pi$; n = 0,1,2,......
- Path difference $\rightarrow \Delta X = 2n\left(\frac{\lambda}{2}\right)$
- Time Interval $\rightarrow \Delta T = 2n\left(\frac{T}{2}\right)$
- Resultant Amplitude $\rightarrow A = a_1 + a_2$; if $\phi = 0, 2\pi, 4\pi$............$2n\pi$
- Resultant Intersity $\rightarrow I_{max} = I_1 + I_2 + 2\sqrt{I_1I_2} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$
- $I_{max} = 4I$ where $(I_1 = I_2 = I)$

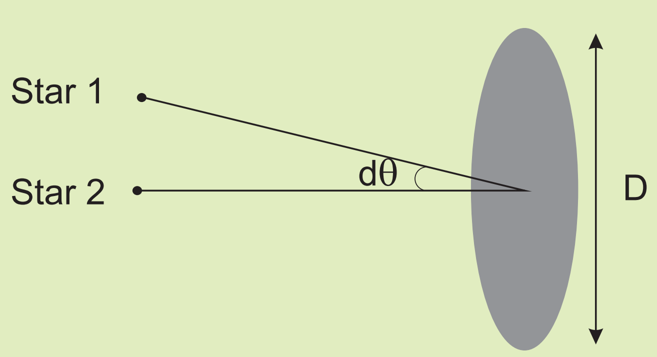


Destructive Interference

- Phase difference $\rightarrow (\Delta\phi) = (2n-1)\pi$, Where n = 1,2,3,...
- Path difference $\rightarrow \Delta x = (2n-1)\frac{\lambda}{2}$
- Time Interval $\rightarrow \Delta T = (2n-1)\frac{T}{2}$
- Resultant Amplitude $\rightarrow A = a_1 - a_2$; If $\phi = \pi, 3\pi, 5\pi$ .... $(2n-1)\pi$
- Resultant Intensity $\rightarrow I_{max} = I_1 + I_2 - 2\sqrt{I_1I_2} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$
- $I_{min} = 0$ (When $I_1 = I_2 = I$)



R.P for Telescope



Resolving limit of a telescope is smallest angular separation (dθ) between two distant objects.

$\rightarrow d\theta = \frac{1.22\lambda}{D}$; (i) $R.P = \frac{1}{d\theta} = \frac{D}{1.22\lambda}$; $D = A_{perture}$ of objective Lens.

YOUNG'S DOUBLE SLIT EXPERIMENT

(i) For Bright Fringes

$$S_2P - S_1P = \frac{X_n d}{D} = n\lambda \text{ ; } d = \text{slit width}$$

$$X_n = \frac{n\lambda D}{d} \text{ ; } X_n =$$

Distance between central fringe and nth Bright fringe : l = wavelength

= Bright fringes are also called maxima's.

(ii) For Dark Fringes $S_2P - S_1P = \frac{X_n d}{D} = \frac{(2n-1)}{2}\lambda$

$$\Rightarrow X_n = \frac{(2n-1)D}{d}$$

Xn = Distance between central fright and nth dark fringe

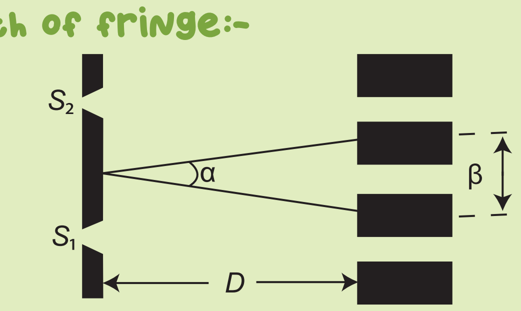
= Dark fringes are also called minima's

Fringe width:-

Fringe width of dark & bright fringes are same and given by $\beta = X_n - X_{n-1} = \frac{\lambda D}{d}$

Angular width of fringe:-

$$\propto = \frac{\beta}{d} = \frac{\lambda}{d}$$



Resolving Power (R.P)

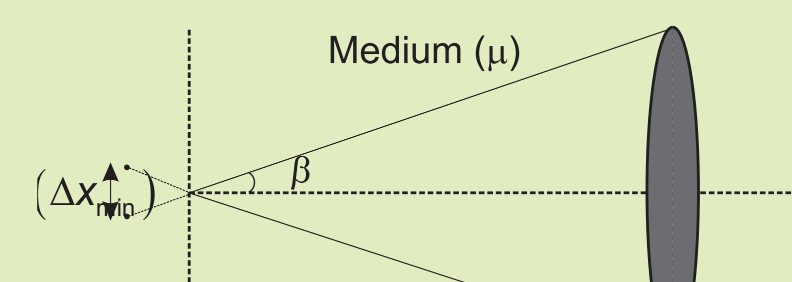
Resolving power an optical instrument is its ability to distinguish two closely placed point.

R.P for Microscope

(i) The minimum distance to form separate images of two objects.

$$\Delta X_{min} = \frac{1.22\lambda}{2\mu \sin\beta}$$

$$R.P = \frac{1}{\Delta X_{min}} = \frac{2\mu \sin\beta}{1.22\lambda}$$

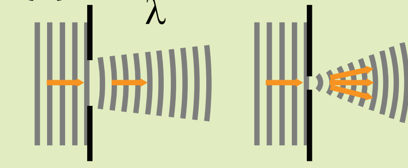


DIFFRACTION

Bending of light waves around the sharp edges of opaque obstacles or aperture and their encroachment in the geometrical shadow of obstacles or aperture.

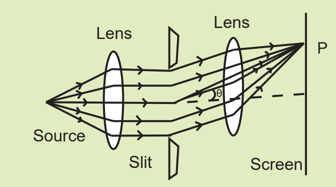
(i) Necessary Condition:- Size of obstacle

(a) must be the order of wavelength (λ). i.e $\frac{a}{\lambda} > 1$

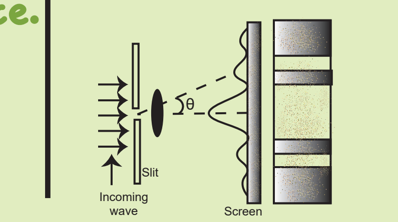


TYPES OF Diffraction

Fresenel Diffraction:- Fresnel Diffraction involves spherical wavefronts. so that source 'S' and point 'P' are at finite distance.



Fraunhofer Diffraction :- It deals with plane wavefronts and an effective viewing distance of infinity.



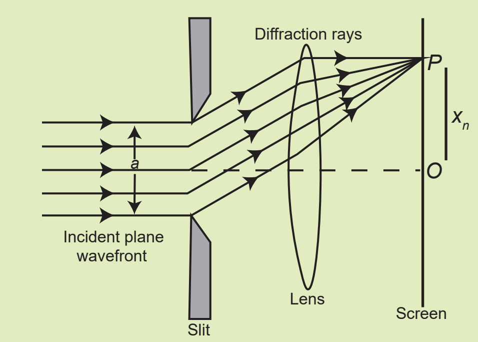
FRAVNHUFER DIFFRACTION FOR SINGLE SLIT

In this diffraction pattern central maxima is bright on the both side of it, maxima & minima occurs symmetrically.

(i) Position of Secondary Maxima in diffraction $\alpha \sin\theta = (2n-1)\frac{\lambda}{2}$

$$\Rightarrow X_n = \frac{(2n-1)D}{2a}\lambda$$

(ii) Position of Secondary Minima in diffraction:- $\alpha \sin\theta = n\lambda \Rightarrow X_n = \frac{n\lambda D}{\alpha}$



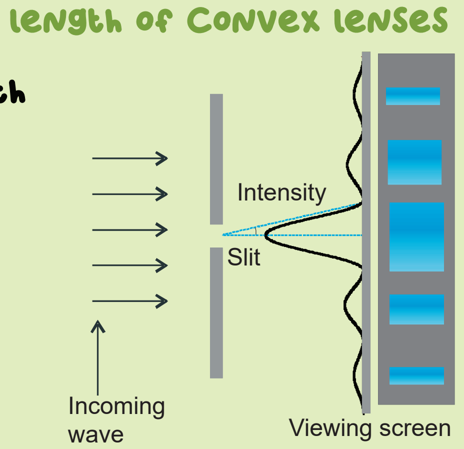
WIDTH OF CENTRAL MAXIMUM

The distance between two secondary minima formed on two sides of central maximum is known as width of central maximum.

$$W = \frac{2f\lambda}{\alpha}$$

f = focal length of convex lenses

α= Slit width

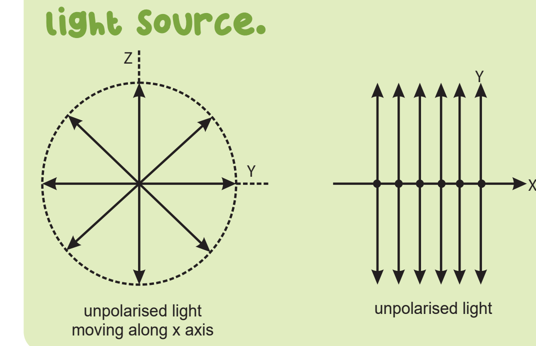


POLARISATION

The process of confining the vibrations of unpolarised light in one single plane using polariser is called polarisation.

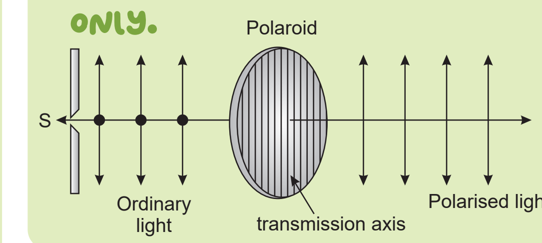
Unpolarised light

An ordinary beam of light consists of a large number of waves emitted by the atoms or molecules of the light source.



Plane Polarised light

Beam of light in which vibration of electric field vector are perpendicular to wave motion and confined to single plane only.

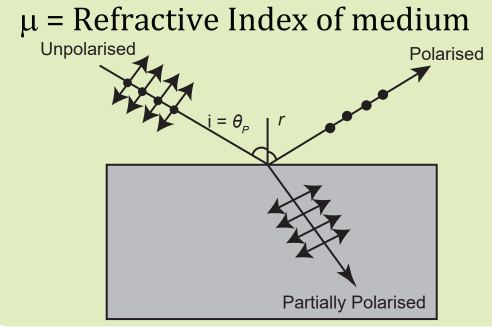


BREWSTER'S LAW

This law state that when light is incident on a transparent sustenance at polarising angle QP. the reflected light is completely plane polarised.

$\mu = \tan\theta_P$; θ_P = Polarising angle.

μ = Refractive Index of medium



MALUS' LAW

$I_2 = K(A\cos\theta)^2 = K A^2 \cos^2\theta$

$I_2 = I_1 \cos^2\theta$; I = intensity

(i) $I_{Polarised} = \frac{I_{unpolarised}}{2}$