ENGINEERING PHYSICS

Dr. Narender Singh

Associate Professor in Physics

Department of Basic Sciences

Diffraction and Single Slit Diffraction

Diffraction

(1) Diffraction

(2) Types of Diffraction

(3) Single Slit Fraunhofer Diffraction.

Diffraction

Diffraction:

The phenomena of bending of light round the corner of obstacle and their spreading into the geometrical shadow is called **diffraction** and their distribution of light intensity resulting in dark and bright fringes is known as diffraction pattern. For diffraction the size of the slit should be smaller than the wavelength of light.

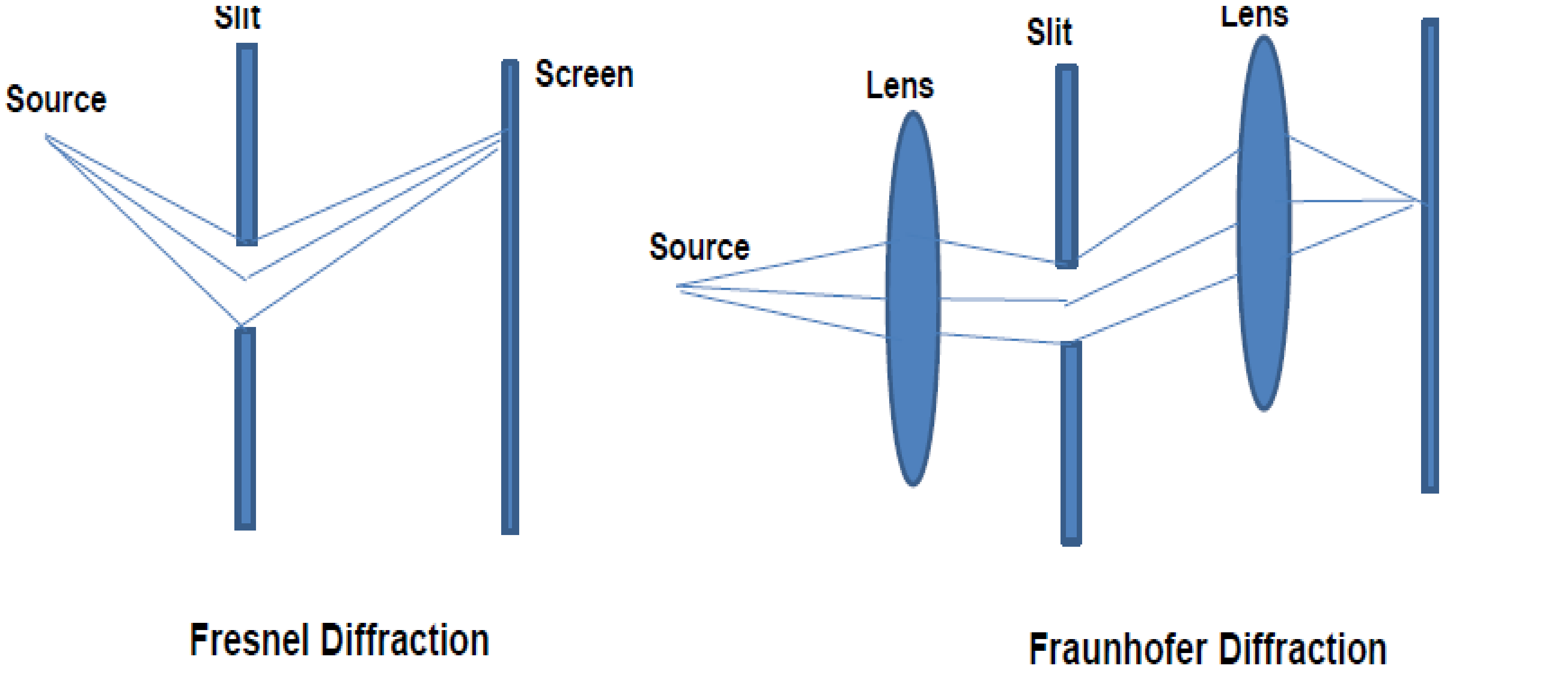
(1) Fresnel Diffraction:

In Fresnel diffraction the source of light or screen or both are in general at a finite distances from the diffraction element but no lenses are needed for rendering the ray parallel or convergent.

Diffraction

(2) Fraunhofer Diffraction:

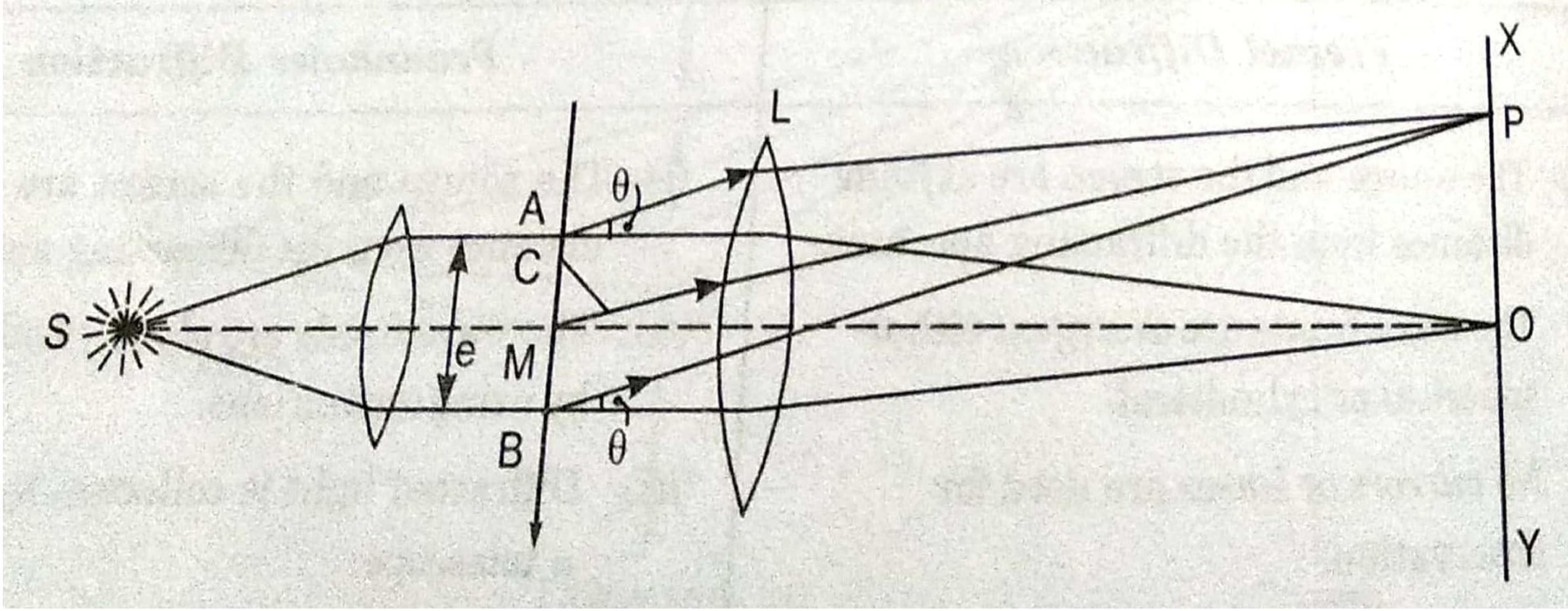
In Fraunhofer Diffraction the source and screen are effectively at infinite distances from the diffraction element. It is observed by employing two convergent lenses. One to render the incoming light parallel and other to focus are parallel diffracted ray on the screen.



Single Slit Diffraction

Single Slit Fraunhofer Diffraction:

According to Huygen's theory, a plane wave front is incident on a slit AB=e then each point of slit AB sends out secondary wavelets in all directions. The rays proceeding in the same direction as the incident ray are focused at O; while those diffracted at angle θ are focused at P with the help of convex lens as shown in fig. below.



Single Slit Diffraction

Let the disturbance caused at P by the wavelet from unit width of the slit at M be;

$$y_0 = A\cos\omega t$$

Then the wavelet from point dx at C when reaches P has the amplitude Adx and phase is;

$$\left(\omega t + \frac{2\pi}{\lambda} x\sin\theta\right)$$

Let this small disturbance be dy, we have

$$dy = Adx\cos\left\{\omega t + \frac{2\pi}{\lambda} x\sin\theta\right\}$$

Therefore the total disturbance at the point of observation at angle θ is;

$$y = \int_{-e/2}^{+e/2} dy = \int_{-e/2}^{+e/2} A\cos\left\{\omega t + \frac{2\pi}{\lambda} x\sin\theta\right\} dx$$

or $$y = A\cos\omega t \int_{-e/2}^{+e/2} \cos\frac{2\pi x\sin\theta}{\lambda} dx - A\sin\omega t \int_{-e/2}^{+e/2} \sin\frac{2\pi x\sin\theta}{\lambda} dx$$

Single Slit Diffraction

or $$y = \left[A \frac{\sin \frac{\pi e \sin\theta}{\lambda}}{\frac{\pi \sin\theta}{\lambda}} \right] \cos\omega t$$ or $$y = Ae \left[\frac{\sin \frac{\pi e \sin\theta}{\lambda}}{\frac{\pi e \sin\theta}{\lambda}} \right] \cos\omega t$$

or $$y = A_0 \frac{\sin\alpha}{\alpha} \cos\omega t \text{ --------- } (1)$$ where $$\alpha = \frac{\pi e \sin\theta}{\lambda} \text{ --------- } (2)$$

$$A_0 = Ae = amplitude, when \theta = 0$$

Resultant amplitude is; $$\mathrm{R} = A_0 \frac{\sin\alpha}{\alpha}$$

Resultant intensity at P is given as; $$I = \mathrm{R}^2 = A_0^2 \left(\frac{\sin\alpha}{\alpha} \right)^2 \text{ ------- } (3)$$

Single Slit Diffraction

(1) Position of Central Maxima: For the central point O

$$\alpha = 0 \qquad \therefore \lim_{\alpha \to 0} \frac{\sin \alpha}{\alpha} = 1$$

Hence intensity at O

$$I = I_0 \left(\frac{\sin^2 \alpha}{\alpha^2} \right) = I_0$$

Again $\alpha = 0$ or $\dfrac{\pi e \sin \theta}{\lambda} = 0$ or $\theta = 0$

(2) Position of Minima: The intensity is minimum(zero) when

$$\frac{\sin \alpha}{\alpha} = 0 \quad \text{or} \quad \sin \alpha = o(but, \alpha \neq 0)$$

$$\alpha = \pm m\pi \quad \text{or} \quad Where, m = 1, 2, 3, 4, ----- except, zero$$

Single Slit Diffraction

Again $\alpha = \pm m\pi$ or $\frac{\pi e \sin\theta}{\lambda} = \pm m\pi$ or $e\sin\theta = \pm m\lambda$

(3) Secondary Maxima: The direction of mth secondary maxima is given by

$$e\sin\theta = \pm\left(m + \frac{1}{2}\right)\lambda$$

as

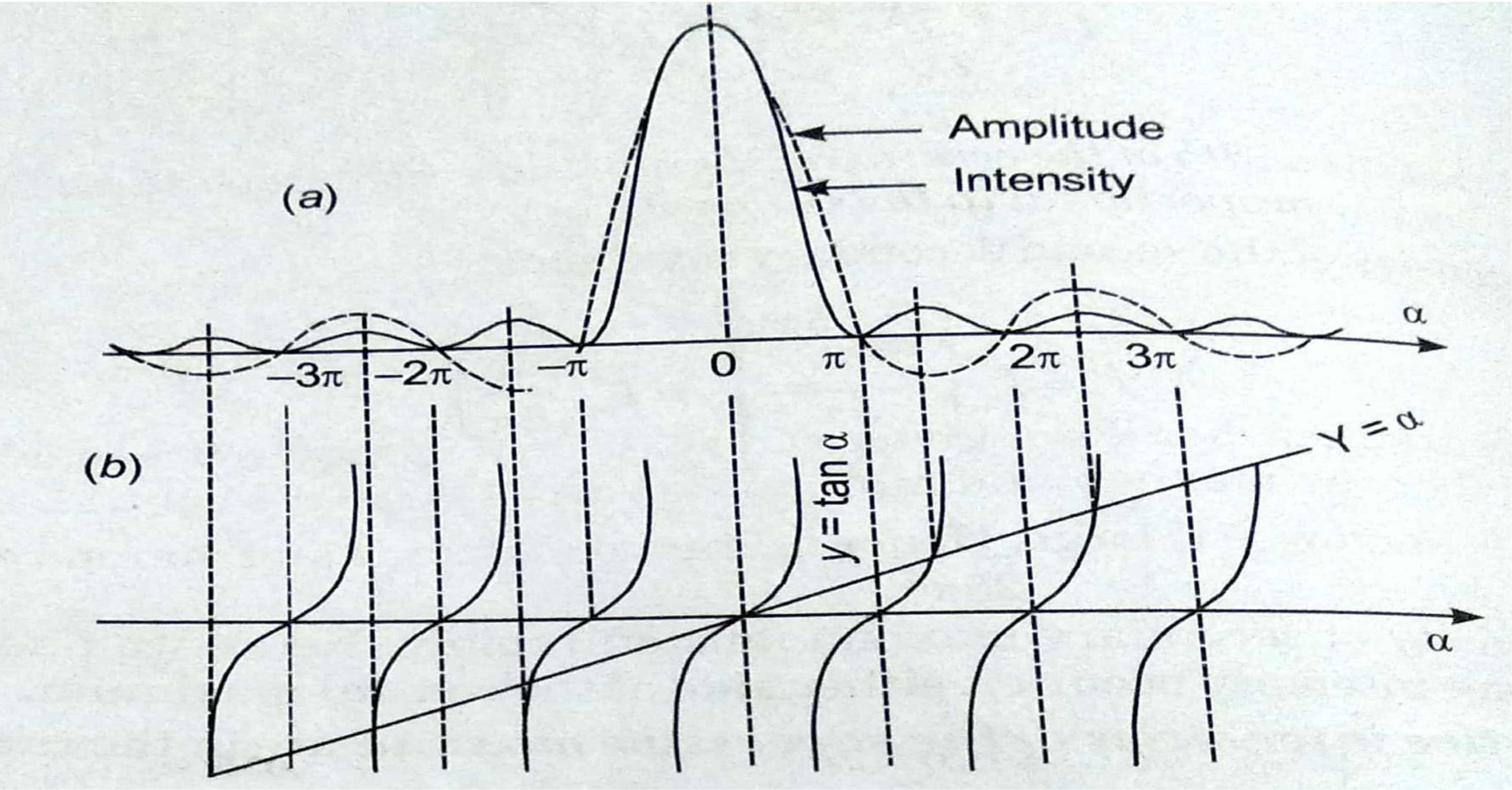
$$\alpha = \frac{\pi e \sin\theta}{\lambda} = \pm\frac{\pi}{\lambda}\left(m + \frac{1}{2}\right)\lambda = \pm\left(m + \frac{1}{2}\right)$$

For various values of m = 1,2,3,4,-------- we get

$$\alpha = \pm\frac{3\pi}{2}, \pm\frac{5\pi}{2}, \pm\frac{7\pi}{2} ------$$

Single Slit Diffraction

Intensity Distribution Curve of Fraunhofer Diffraction in Single Slit



Thank you