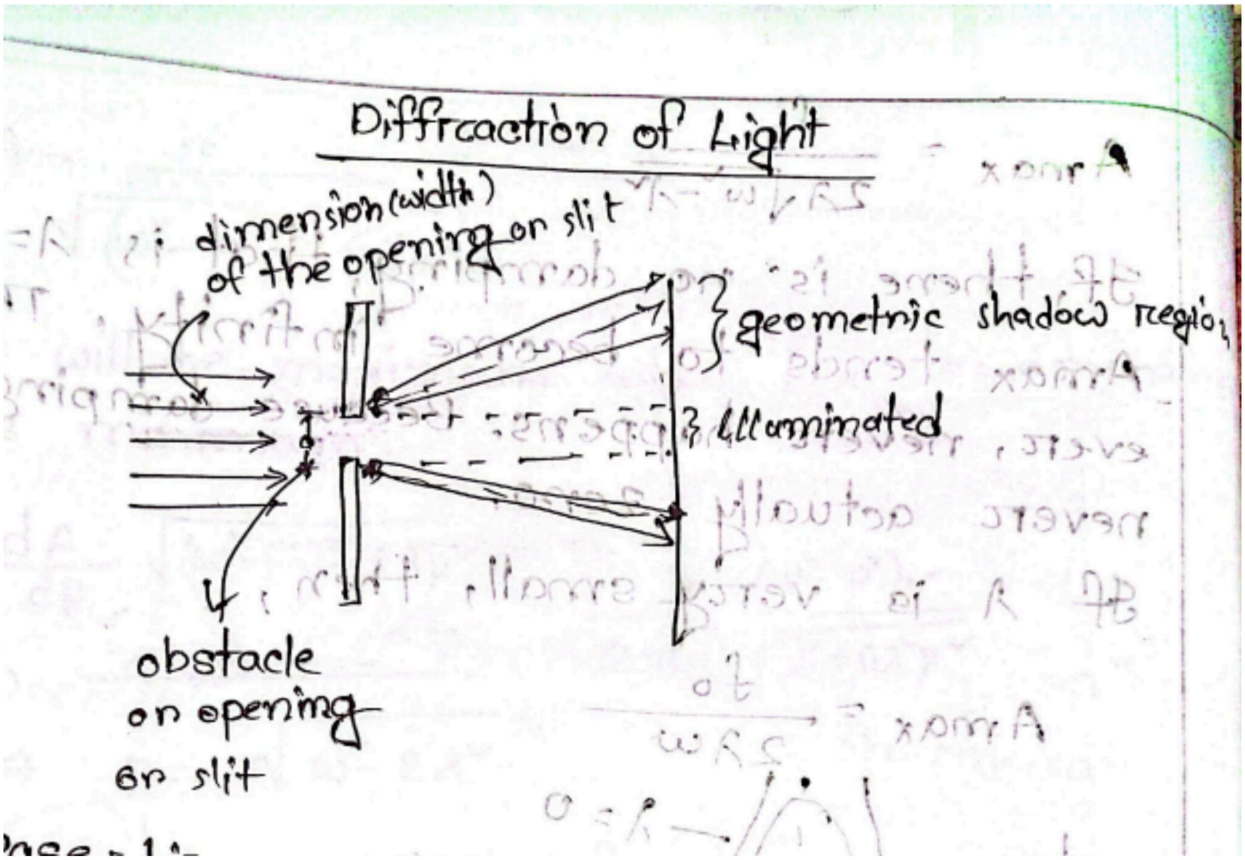


a is the length of the opening of slit

Case-1: $\lambda << a$

Then we will found illuminated region according to the dimension of the slit. (No bending of light at the edges)

Case-2: $\lambda \approx a$, or, $\lambda > a$

It will slightly bend toward the geometric shadow region.

The phenomena of slight bending of light near the edges of the obstacle and entering into the geometric shadow region is called diffraction

There are two types of diffraction

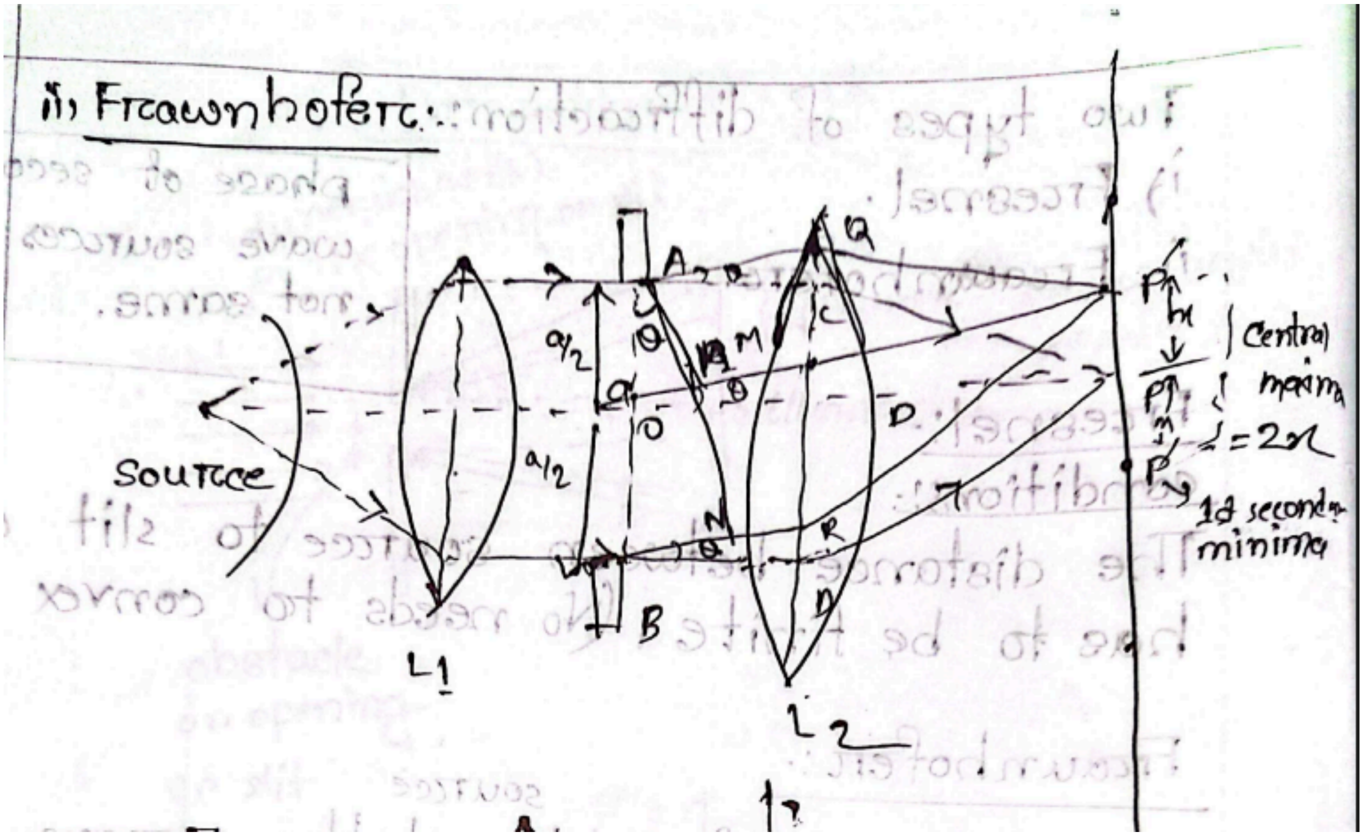
1. Fresnel
2. Fraunhofer

Fresnel

Conditions: The distance between source to slit or screen has to be finite, therefore no convex lens is needed.

Fraunhofer

The distance of light source and the screen should be infinite from the diffracting aperture or obstacle.



$$\sin\theta = \frac{BN}{AB}$$

$$BN = AB\sin\theta$$

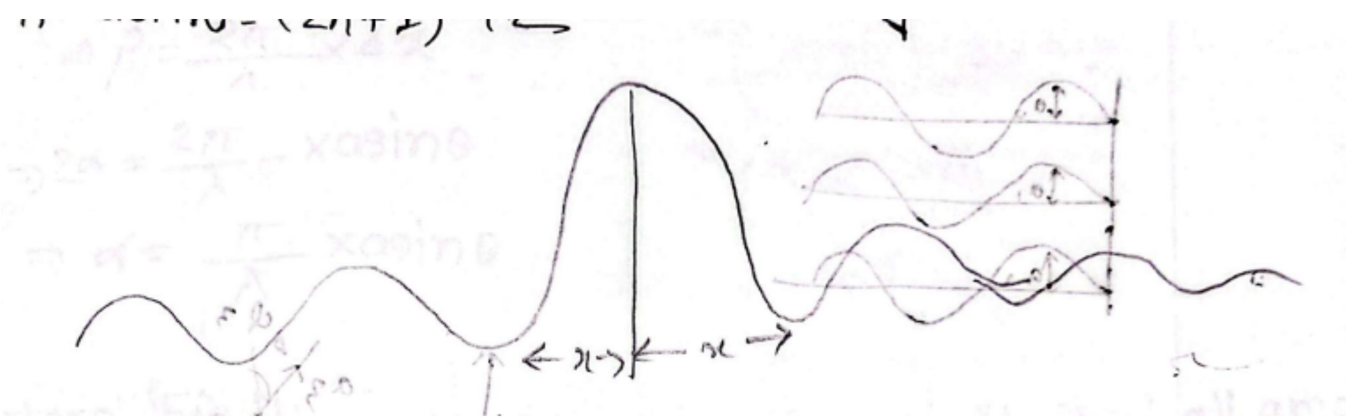
$$\Delta x = a\sin\theta$$

For secondary minima, $\Delta x = n\lambda$

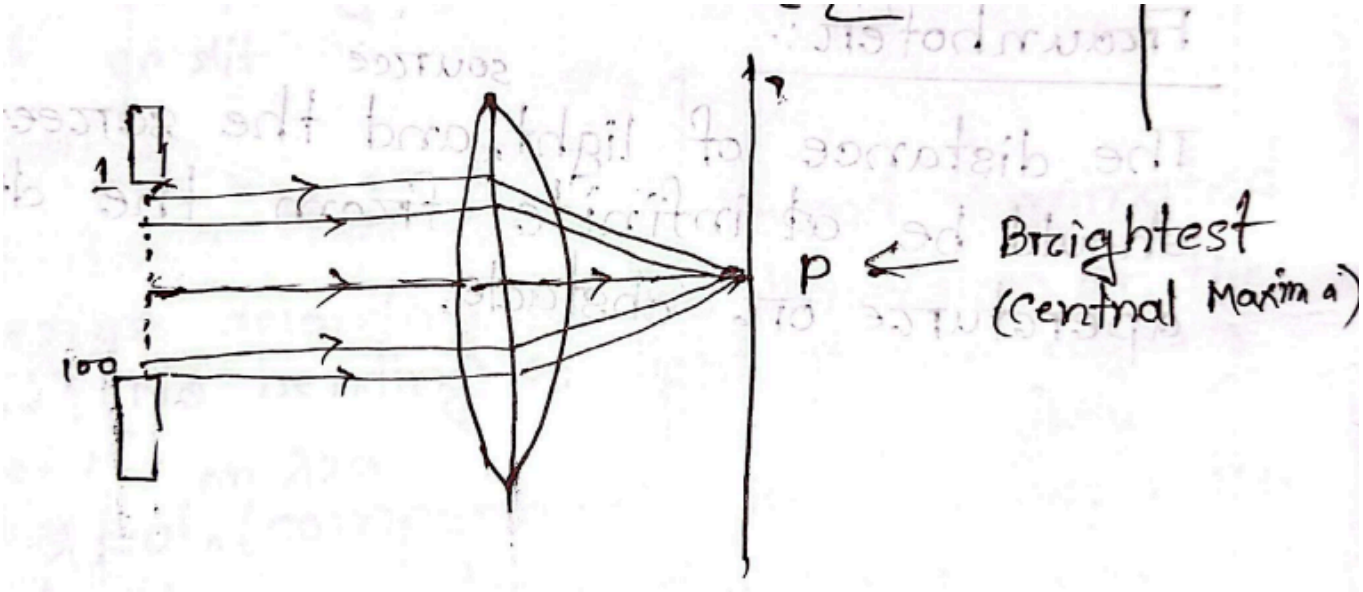
$$\therefore a\sin\theta = n\lambda$$

For secondary maximum, $\Delta x = (2n+1)\frac{\lambda}{2}$

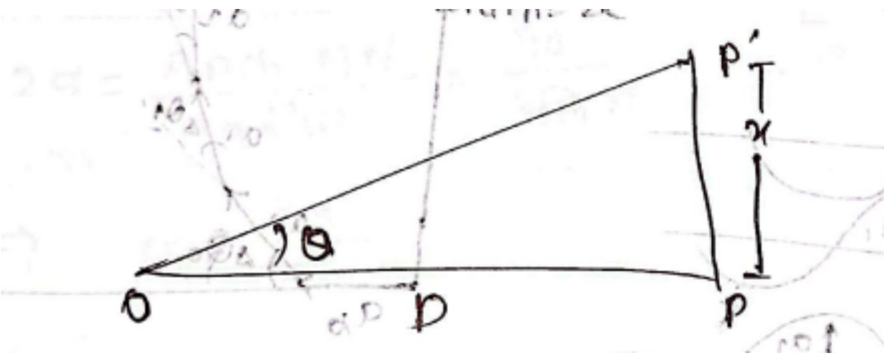
$$\therefore a\sin\theta = (2n+1)\frac{\lambda}{2}$$



The central part is the brightest and is called the central maxima



the width of the central maxima is $2x$, how to calculate it?



If the distance between the slit and lens is very low, then we can say that $D = f$(focus)

$$\sin\theta = \tan\theta = \frac{x}{D}$$

$$\sin\theta = \frac{x}{f}$$

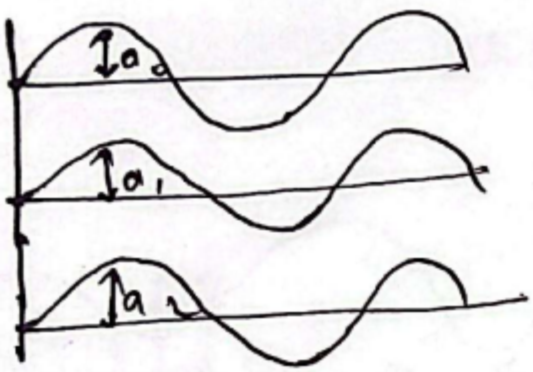
$$\frac{x}{f} = \frac{\lambda}{a}, (n = 1)$$

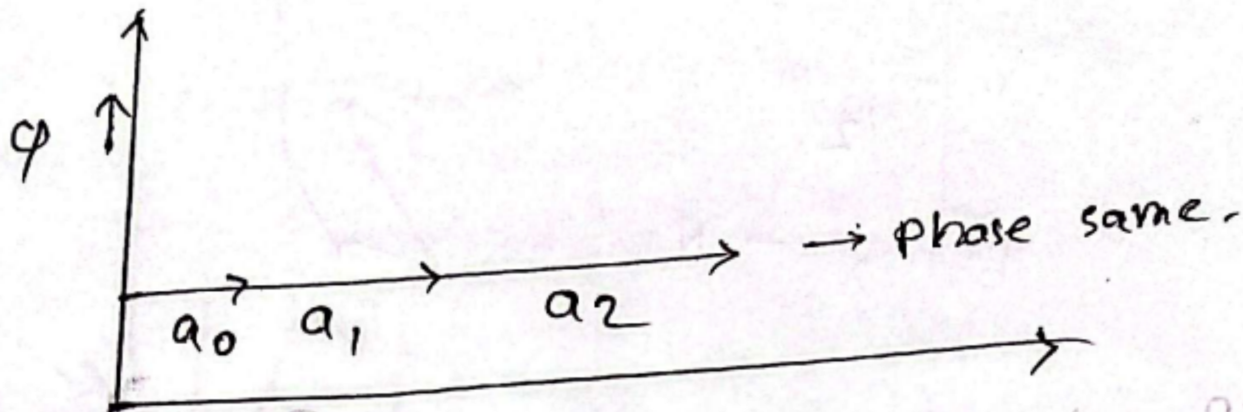
$$x = \frac{f\lambda}{a}$$

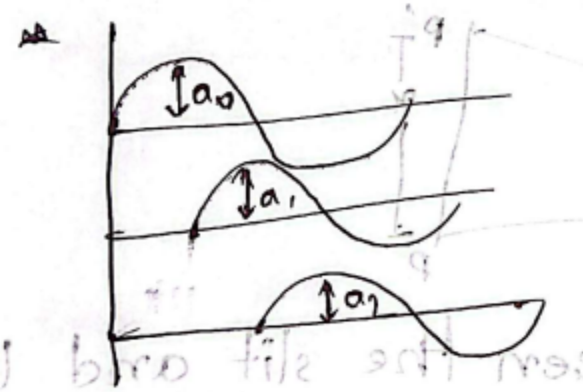
$$2x = \frac{2f\lambda}{a}$$

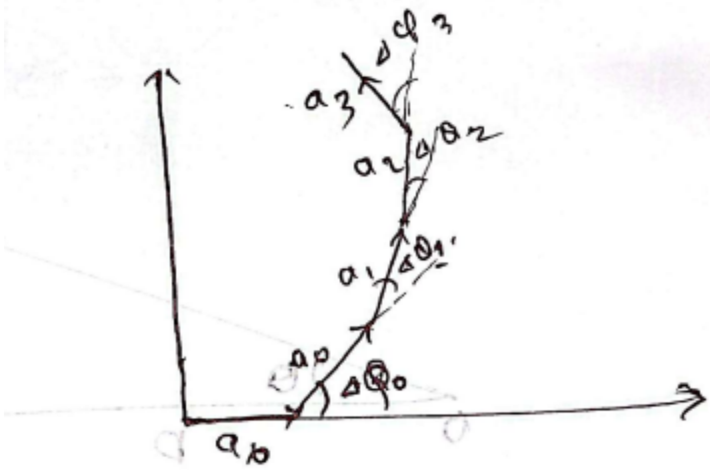
A bit of phasor before moving on

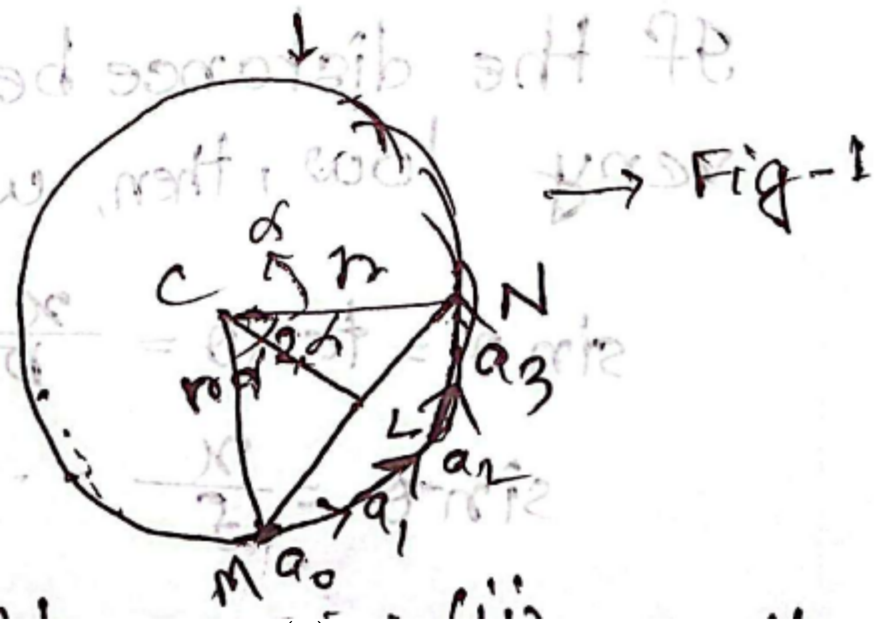
> A person who is always thinking have a thought, then the person is thinking about thought


a_0
a_1
a_2


ϕ
a_0
a_1
a_2
→ phase same.


a_0
a_1
a_2





$MN = MN + NL = 2ML \ldots (ii)$

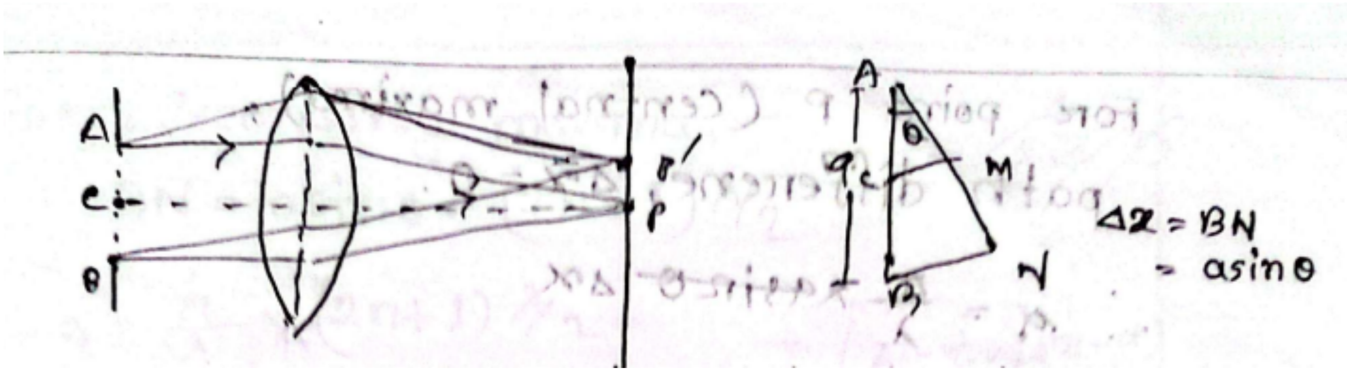
At, ΔCML,

$$\sin\alpha = \frac{ML}{CM}$$

$$\Rightarrow ML = CM\sin\alpha$$

$$\therefore ML = r\sin\alpha$$

$$\therefore MN = 2r\sin\alpha \ldots (iii)$$



Let, the phase difference between the upper and lower point be 2α

$$\Delta P = \frac{2\pi}{\lambda} \times \Delta x$$

$$\Rightarrow 2\alpha = \frac{2\pi}{\lambda} \times a \sin\theta$$

$$\alpha = \frac{\pi}{\lambda} \times a \sin\theta$$

From the figure of circle,

$$2\alpha = \frac{\text{Arch M}}{\text{radius}} = \frac{ka}{r}$$

Considering all amplitudes are equal and there k number of points.

$$\Rightarrow r = \frac{ka}{2\alpha}$$

Let, $MN = A$
$\therefore (iii) \Rightarrow$

$$A = 2 \times \frac{ka}{2\alpha} \times \sin\alpha$$

$$A = ka \times \frac{\sin\alpha}{\alpha}$$

$$A = A_o \frac{\sin\alpha}{\alpha}$$

We know that,

$$I = A^2$$

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

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

$$I_o = A_o^2$$

For point P (central maxima), path difference $\Delta x = 0$

$$\therefore \alpha = \frac{\pi}{\lambda} \times \Delta x = 0$$

When, $\alpha = 0$

$$I = \lim_{\alpha \to 0} I_o \left(\frac{\sin \alpha}{\alpha} \right)^2 = I_o$$

For point P', where the light bends at an angle θ
If, it is a secondary minima then,

$$a \sin \theta = n\lambda = \Delta x$$

$$\alpha = \frac{\pi}{\lambda} \times n\lambda = \pm n\pi$$

$$I = I_o \left(\frac{\sin \alpha}{\alpha} \right)^2 = 0$$

For secondary maxima,

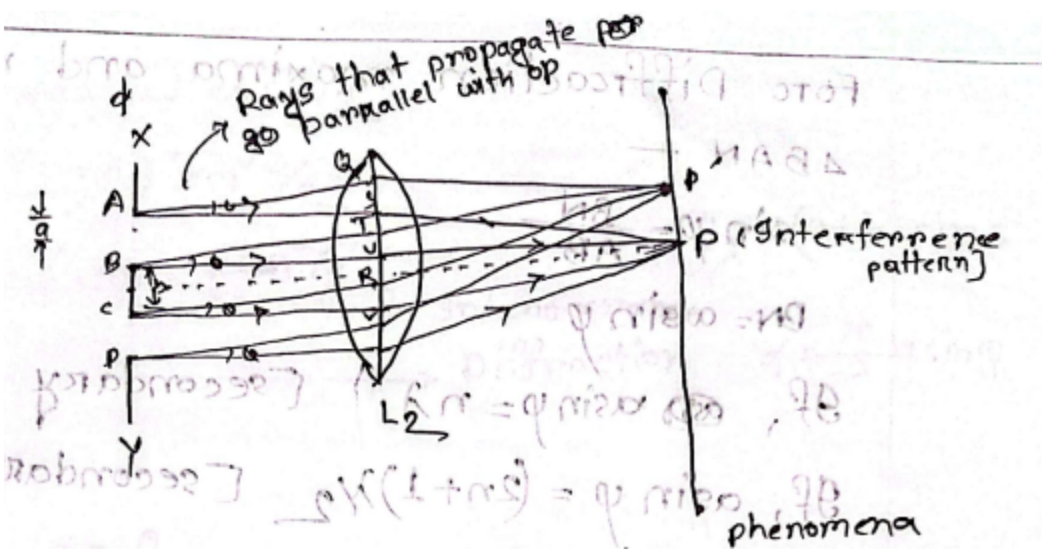
$$\Delta x = (2n+1)\frac{\lambda}{2}$$

$$\therefore \alpha = \frac{\pi}{\lambda} \times (2n+1)\frac{\lambda}{2} = \pm(2n+1)\frac{\pi}{2}$$

If, $n = 1$, then,

$$I = I_o \left(\frac{\sin \frac{3\pi}{2}}{\frac{3\pi}{2}} \right)^2 = I_o \times 0.045$$

Hence a question can be formed of sort, show that the intensity of first secondary maxima is 0.045 times of the intensity of central maxima

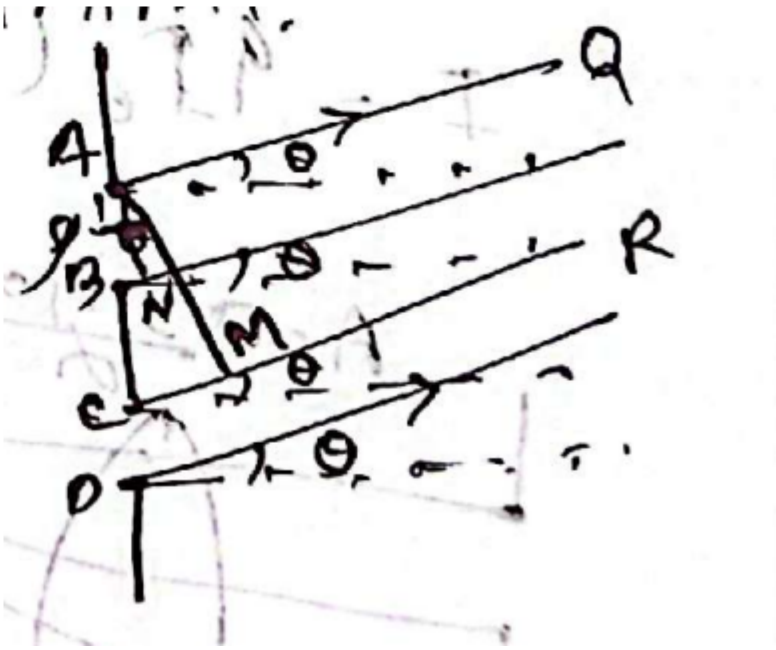


Now let's consider two slits. Both interference and diffraction phenomena occurs here. So, two patterns are found

Interference phenomenon occurs due to secondary waves emitting from corresponding points of two slits.

Diffraction occurs due to the superposition of the secondary waves at the single slits.

For interference maxima and minima



$$AC = AB + BC = a + b$$

at, ΔCAM,

$$\sin\theta = \frac{CM}{AC}$$

$$CM = AC\sin\theta = (a+b)\sin\theta$$

For maxima,

$$(a+b)\sin\theta = n\lambda$$

For minima,

$$(a+b)\sin\theta = (2n+1)\frac{\lambda}{2}$$

For diffraction maxima and minima
ΔBAN

$$\sin\phi = \frac{BN}{AB}$$

$$BN = a\sin\phi$$

Now,
$a\sin\phi = n\lambda$ for secondary minima
$a\sin\phi = (2n+1)\frac{\lambda}{2}$ for secondary maxima

If at a certain point, there is both interference maxima and diffraction minima, then that point is called "a missing order"

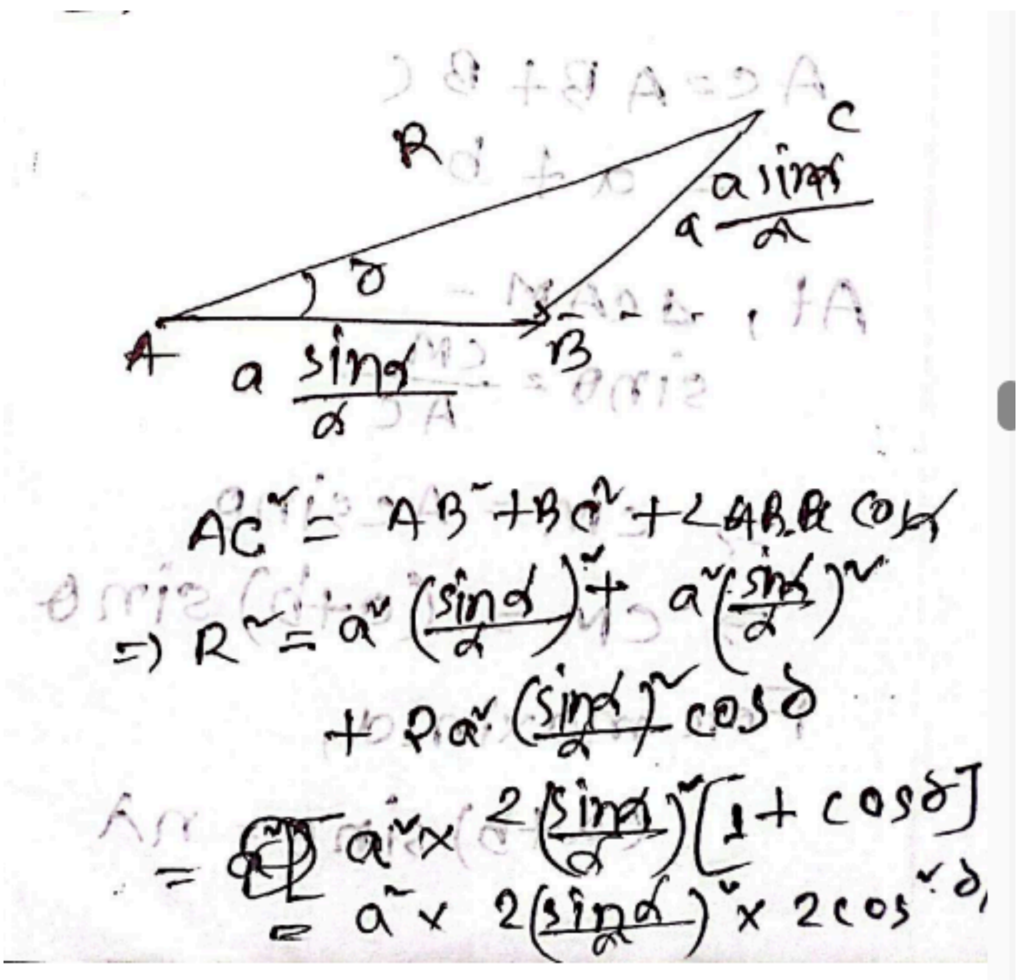
Intensity for diffraction,

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

Intensity for interference,

$$I = 4I_o\cos^2\frac{\delta}{2}$$

$$\therefore I = 4I_o\left(\frac{\sin\alpha}{\alpha}\right)^2\cos^2\frac{\delta}{2}$$

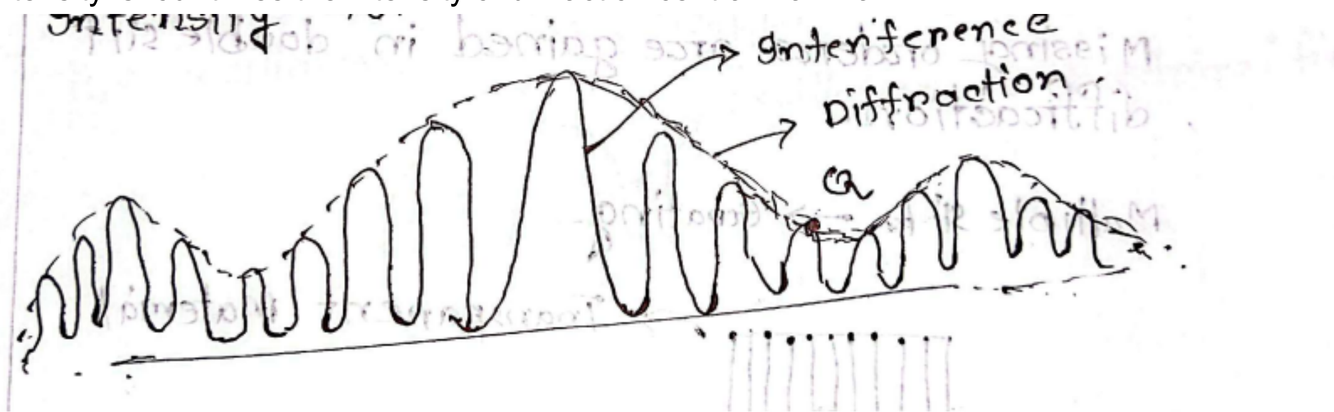


$$I = 4I_o\left(\frac{\sin\alpha}{\alpha}\right)^2\cos^2\beta$$

At P

$\beta = 0$, $\alpha = 0$
$\therefore I = 4I_o$

Intensity is four times the intensity of diffraction central maxima



For interference, $CM = (a+b)\sin\theta$
For diffraction, $BN = a\sin\phi$
For interference maxima, $(a+b)\sin\theta = n\lambda$
For diffraction minima, $a\sin\phi = m\lambda$

At point Q,

$$\theta = \phi$$

$$\frac{a+b}{a} = \frac{n}{m}$$

As, we can say, $a \approx b$
then,

$$2 = \frac{n}{m}$$

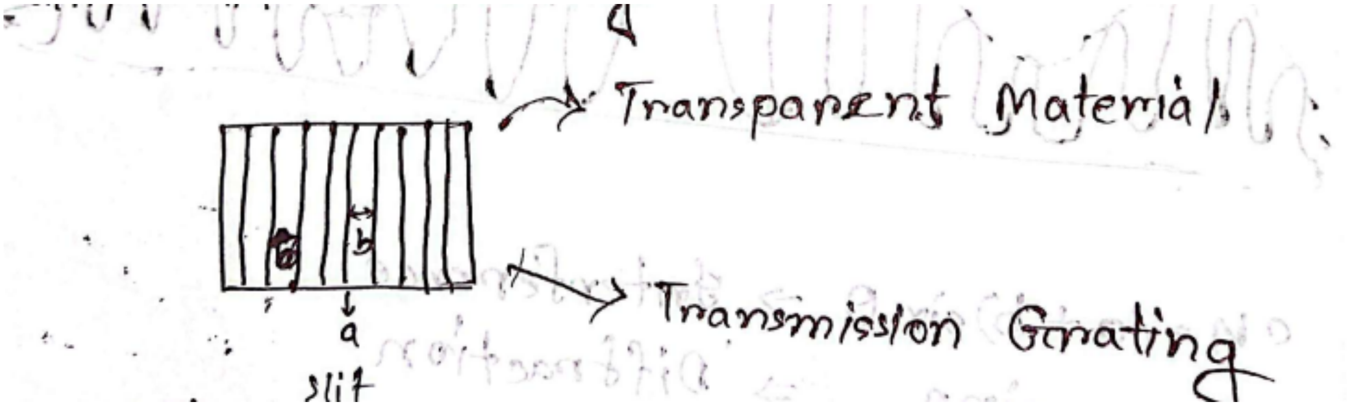
$$\Rightarrow n = 2m$$

where,
m = order of diffraction minima
n = order of interference maxima

$\therefore$ if, $m = 1, 2, 3, 4, \ldots$ and
then, $n = 2, 4, 6, 8, \ldots$ for missing order

Missing orders are gained in double slit diffraction

Multiple slit is called grating



If we create a layer of nS upon transmission slit, we receive a grating, and the grating is called replica grating.

In, multiple slit we represent

$$(a+b) = \frac{1}{N}$$

where, N is the number of lines per unit.