Experiment No. 4

Date:

DETERMINATION OF THE WAVELENGTH OF LASER LIGHT USING DIFFRACTION GRATING.

APPARATUS REQUIRED:

a) Laser light b) Diffraction grating, c) Graph as screen (graph paper),

d) Optical bench, e) Measuring scale.

THEORY:

Laser stands for the 'Light Amplification for the stimulated Emission of Radiation'.It is a highly coherent, unidirectional, monochromatic light. It finds its use in wide areas such as in medical surgery, industries, etc. (Note: 2018 Nobel prize in physic has been awarded to laser field).

Diffraction is the characteristic of the wave. It is the bending of wave (here EM wave i.e. Laser) around the corners of an obstacle.

A transparent glass plate consisting of a large number of ruled lines is called diffraction grating. Each line acts as an obstacle while the spacing between the lines allows LASER to pass through the grating. If the width of the transparency and opacity be 'a' and 'b' respectively, the distance (a+b) is called grating element.

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

Where, N=no. of lines per unit length of grating.

Let a plane wave front of light of wavelength 'λ'be incident normally on the grating surface. Then all the secondary waves travelling in the same direction as that of incident light will come to focus at point 'O' on the screen as shown in figure. Since the path difference between corresponding waves arriving at 'O' is zero, so all the secondary wave reinforce on one another to give central bright maximum at 'O'.

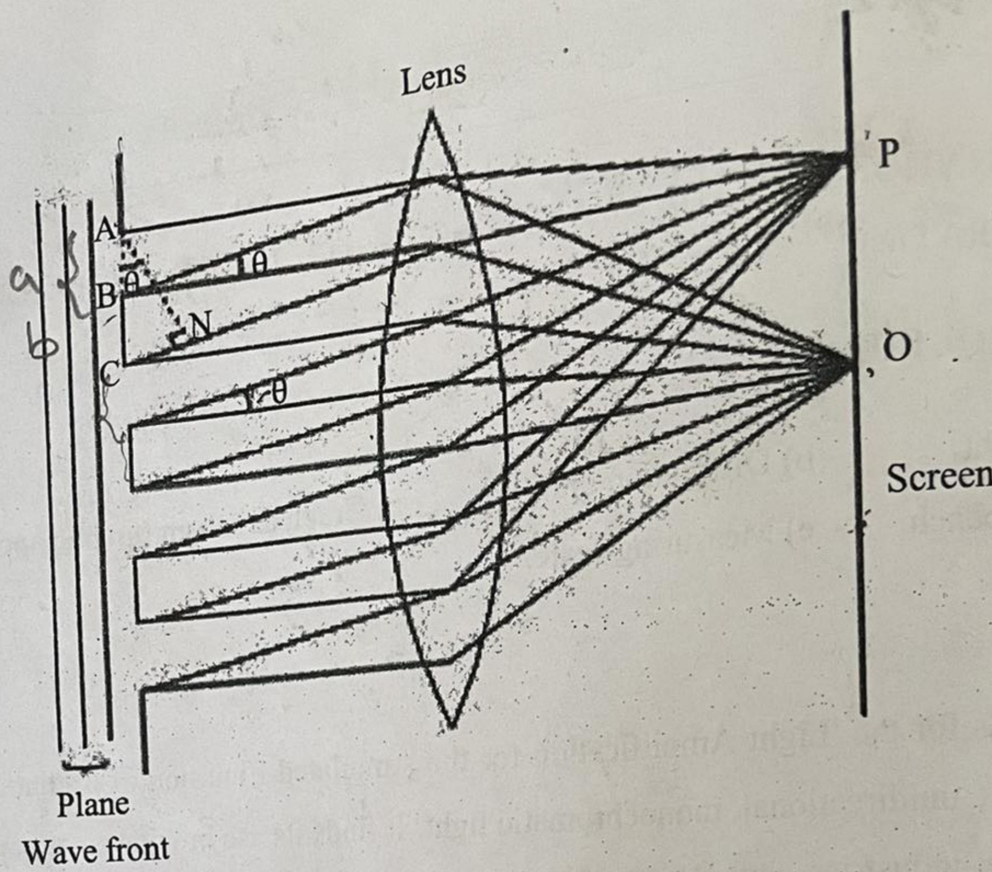

Fig.(a).Diffraction through grating

Consider, secondary waves travelling in a direction inclined at an angle θ with the direction of incident light, which comes to focus at point 'P' on the screen. The intensity at 'P' will depend on the path difference between the secondary waves originating from corresponding points A and C of two neighboring slits.

From figure,

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

or, $$CN = AC\sin\theta = (a+b)\sin\theta$$

$\therefore$Path difference, $CN = (a+b)\sin\theta$

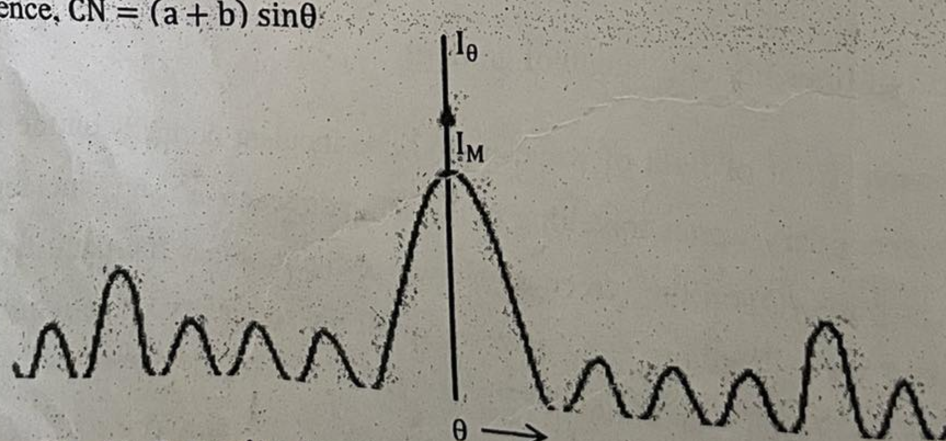

Fig.(b). Intensity distribution for diffraction through grating

The point 'P' will be of maximum intensity if the path difference is equal to integral multiple of 'λ'. i.e. when

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

Where, n = 1,2,3, ...

Eq^n (i) is the required diffraction grating equation.

and the condition of minima is,

$$(a+b)\sin\theta = (2n+1)\lambda/2, \qquad n = 0,1,2,3,....$$

Note : The asterik (*) below is assigned for the extra theoretical feedback for the students & can be omitted.

*Fraunh offer diffraction through single slit :-

Consider a slit of width 'a'. As the plane wave front is incident on the slit AB , each point on it act as source of secondary disturbance. The secondary waves travelling in the direction of incident wave front come to focus at point 'O' on screen and a central bright fringe is observed. Consider secondary waves travelling in the direction inclined at angle θ with horizontal come to focus at point 'P' on the screen. The point 'P' will be of maxima or minima depends upon path difference between secondary waves that originate from corresponding points of the wavefront. From figure, this path difference = BN =$a\sin\theta$

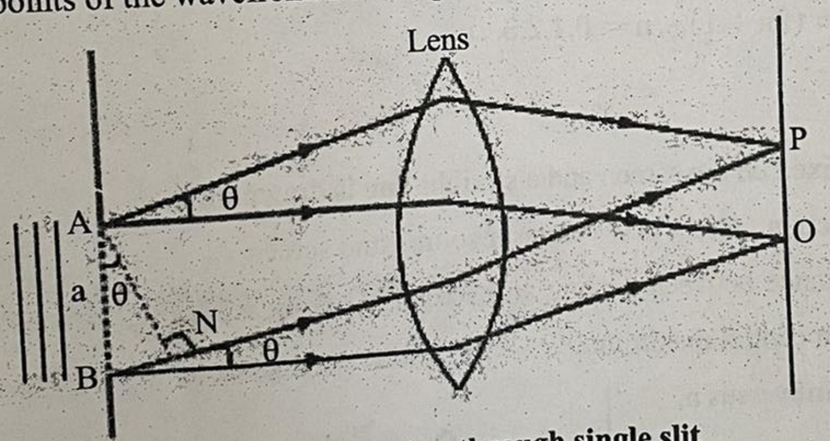

Fig.(c). Diffraction through single slit

If we divide slit into two equal parts. The path difference between the waves originating from extreme of each part is $\lambda/2$ as the ray from bottom of each part travels half wavelength more than rom the top part. This has been proved by Fresnel giving the concept of Fresnel's zones.

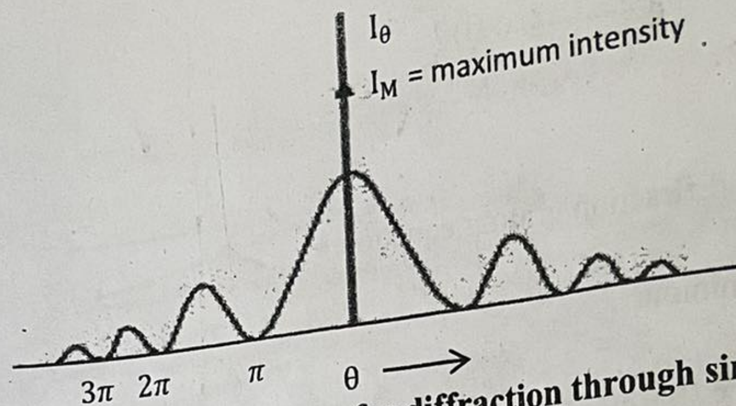

Fig.(d). Intensity distribution for diffraction through single slit

$\therefore$ $\frac{a}{2}\sin\theta = \frac{\lambda}{2} \Rightarrow a\sin\theta = \lambda$..... corresponds to first minimum.

Similarly, if we divide the slit into four equal parts,

$\frac{a}{4}\sin\theta = \frac{\lambda}{2} \Rightarrow a\sin\theta = 2\lambda$.......... corresponds to 2nd minimum

Dividing the slit into 2n equal parts,

$\Rightarrow$ $\frac{a}{2n}\sin\theta = \frac{\lambda}{2} \Rightarrow a\sin\theta = n\lambda$ ....(ii) minimum

Equation (ii) is the condition of minima for diffraction through single slit.

The condition of maxima is

$$a\sin\theta = (2n+1)\frac{\lambda}{2}, n = 0,1,2,3,\ldots\ldots$$

PROCEURE:

1. A mm graph is fixed on the screen and a straight line is drawn on it.
2. Adjust the diffraction grating between laser source and screen.
3. Measure the distance between grating and screen. Also measure the distance between bright spots about central maximum.
4. Plot a graph of sinθversus n.

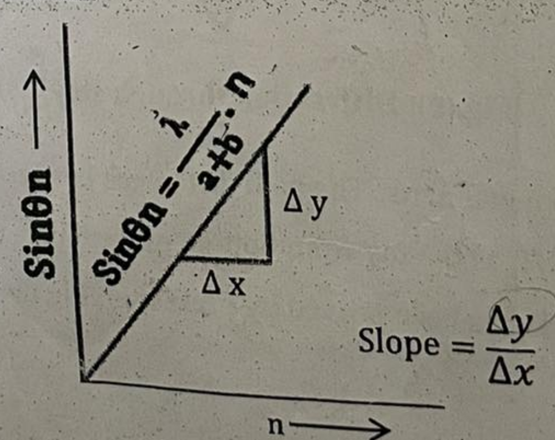

Fig.(e). Plot of $\sin\theta_n \sim n$ for grating

$N =$

The value of grating element $(a + b) = \frac{1}{N} = \frac{1}{2500}$ lines/inch

Table No.1. Determination of wavelength of given light (λ)

(n)	Separation between grating and screen (D)	Distance between bright spot about centre (y)	Distance $x = \frac{y}{2}$	$\tan\theta = \frac{x}{D}$	$\sin\theta$	$\lambda = \frac{(a+b)\sin\theta}{n}$	$\bar{\lambda}$	$(\lambda_i - \bar{\lambda})^2$	σ_λ
1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
3.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
4.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
5.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
6.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				

RESULTS:

The wavelength of given light (λ) =

Standard value of (λ) =

Percentage error =

Wavelength of given light from graph =

CONCULSION :

PRECAUTIONS :

$$\sigma_\lambda = \sqrt{\frac{(\lambda_i - \bar{\lambda})^2}{n(n-1)}}$$