WAVELENGTH OF WHITE LIGHT
SPECTROMETER

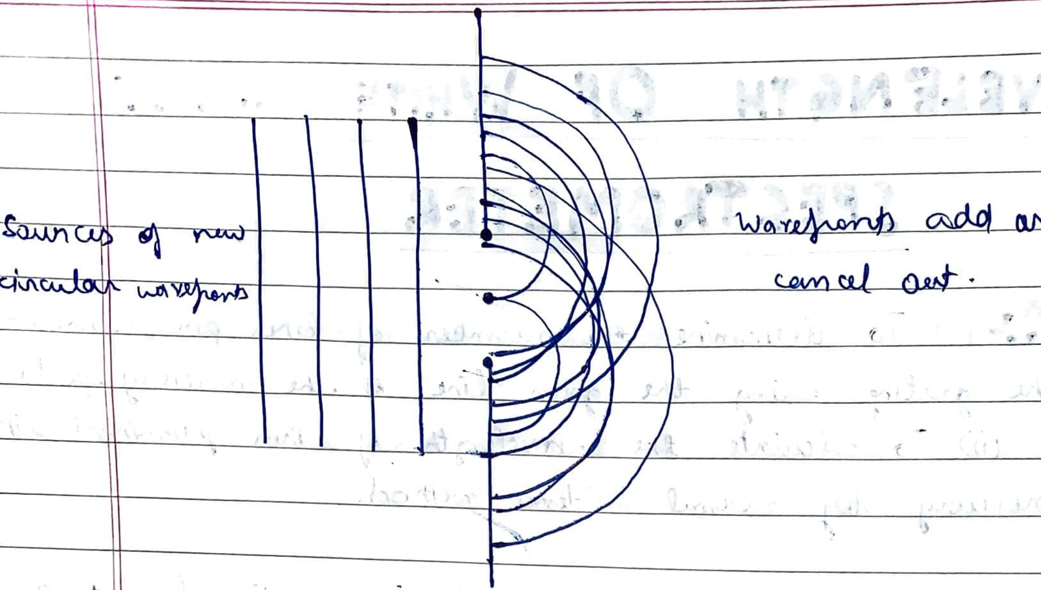
AIM:- (i) To determine the number of lines per milimeter of the grating using the green line of the mercury spectrum.
(ii) To calculate the wavelength of other prominent lines of mercury by normal incidence method.

APPARATUS:- Spectrometer, diffraction grating element and mercury vapour lamp.

THEORY:- When a wave train strikes on an obstacle, the ~~ra~~ light ray will bend at the corners and edges of it, which causes the spreading of light waves into the geometrical shadow of a obstacle. This phenomenon is termed as diffraction.

Single slit Diffraction :-

When waves pass through a gap, which is about as wide as the wavelength they spread out into the region beyond the gap. Hygen's considered each point along a wave front to be of a secondary disturbance that forms a semi-circular wavelet. Diffraction is due to the superposition of such secondary wavelets. This secondary wavelets spread out and overlap each other interfering with each other to form a pattern of maximum and minimum intensity. The pattern formed on a screen consists of a broad central band of light with dark boards on either side. The darks bands are caused when the light from the top part of the slit destructively interferes with the bottom half.



Consider a slit of width 'a'. Let at an angle θ, the path difference between the top and bottom of the slit is a wavelength. This causes destructive interference to occur to because the path difference between the two halves is $\frac{\lambda}{2}$. At this angle from top is getting cancelled by bottom ray.

$$\Delta S = a \sin\theta$$

Intensity minima ~~ac~~ will occur if this path length difference is an integral number of wavelength,

$$a^* \sin\theta = n\lambda$$

$n \rightarrow$ order of each minima
$\lambda \rightarrow$ wave length
$a \rightarrow$ distance b/w slits
$\theta \rightarrow$ angle at which destructive interference occurs

Intensity is given by :-

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

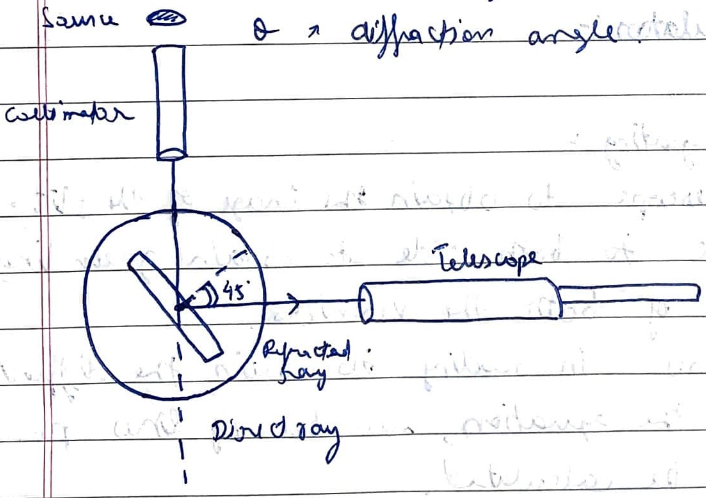
$\delta \rightarrow$ total phase angle.

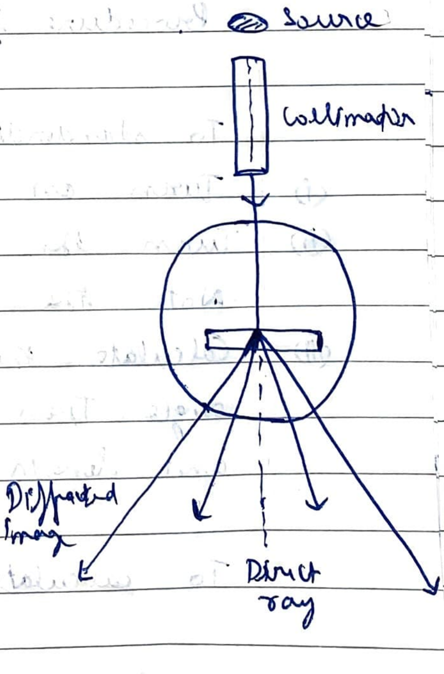
$$\delta = \frac{2\pi a^* \sin(\theta)}{\lambda}$$

$I \Rightarrow$ maximum intensity.
$\lambda \Rightarrow$ wavelength
$a \Rightarrow$ slit width

Diffraction grating is an optical component having a periodic structure which can split and diffract light several beams travelling in different directions. This depends on the spacing of the grating and the wavelength of incident light.

At normal incidence,
$$\sin\theta = N\lambda n$$
$N \Rightarrow$ number of lines per unit length of grating
$n \Rightarrow$ order of spectrum
$\lambda \Rightarrow$ wavelength
$\theta \Rightarrow$ diffraction angle





PROCEDURE:-

Components of the simulator:-

(i) Telescope Caliberate slider:- helps user to change focus of telescope.
(ii) Start Button
(iii) Light toggle button: helps user to switch ON or OFF lamp
(iv) Grating toggle button: helps user to place or remove the grating
(v) Telescope angle slider: used to change telescope angle
(vi) Vernier angle slider: used to change angles of Vernier scale
(vii) Caliberating Telescope button: helps to recaliberate the telescope if needed.

Procedure for simulator:-

To standardise the grating:-

(i) Turn on the telescope to obtain the image of the slit.
(ii) Turn the telescope to both side to obtain green lines. Note the reading of both the verniers.
(iii) Calculate the difference in reading to obtain the diffraction angle. Then from the equation, number of lines per unit length can be calculated.

To calculate the wavelength of different lines:-

- Obtain the direct image
- Telescope is moved to make the cross wire coincide with each line of the spectrum
- Note the reading & calculate diffraction angle

- Then calculate the wavelength of each colours.

TABULATION :-

$N = 5917.15976$ lines per unit length on grating

$n = 1$ (order)

Color of light	Window	Towards right of the central image (a)			Towards left of the central image (b)			$\theta = \frac{(a-b)}{2}$	Mean
		M.S	V.S	Total	M.S	V.S	Total		
Violet	V_1	119	0/60	119	147	0/60	147	14	13.9625
	V_2	299	9/60	299.15	327	0/60	327	13.925	
Green	V_1	114	27/60	114.45	152	0/60	152	18.775	18.9375
	V_2	293.5	20/60	293.83	332	2/60	332.03	19.10	
Yellow	V_1	112.5	7/60	112.61	153	10/60	153.16	20.275	20.2
	V_2	292.5	23/60	292.88	333	8/60	333.13	20.125	

λ for violet colour $\rightarrow$ $\frac{\sin\theta}{nN} = \frac{\sin(13.9625)}{1 \times 5917.15976}$

$= 4077\,Å$

λ for green colour $\rightarrow$ $\frac{\sin(18.9375)}{1 \times 5917.15976} = 5484\,Å$

λ for yellow colour $\rightarrow$ $\frac{\sin(20.2)}{1 \times 5917.15976} = 5838\,Å$

RESULT :-

λ for violet ⇒ 407.7 nm
λ for green ⇒ 548.4 nm
λ for yellow ⇒ 583.8 nm

SELF EVALUATION :-

1. The wavelength of green light in mercury spectrum is ?
— 546.1 nm

2. When the path difference b/w two light waves is integral multiples of wavelength, then the waves are said to be ?
— In phase

3. Diffraction arises as a result of ?
— Superposition of secondary wavefronts from slits

4. What is diffraction pattern?
— A pattern of intensity variation consisting of unequal width of maxima and minima

5. A point source produces
— Spherical wavefront