GARVIT SHAH
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- **Aim:** To determine the no. of lines per millimeter of the grating using the green line of the mercury spectrum.
To calculate the wavelength of the other prominent lines of Hg by normal incident method.

- **Apparatus:** Spectrometer, Diffraction grating element & Hg vapor lamp.

- **Theory:**
When a wave train strikes as obstacle, the light ray will bend at the corners and edges of it, which causes the spreading of light waves into the geometrical shadow of the obstacle. The 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. Huygens considered each point along a wave front, to be the source of a secondary disturbance that forms a semicircular wavelet. Diffraction is due to the superposition of such secondary wavelets. The secondary wavelets spread out & overlap each other interfering with each other to form a pattern of maximum & minimum intensity. The pattern formed on a screen consists of a broad

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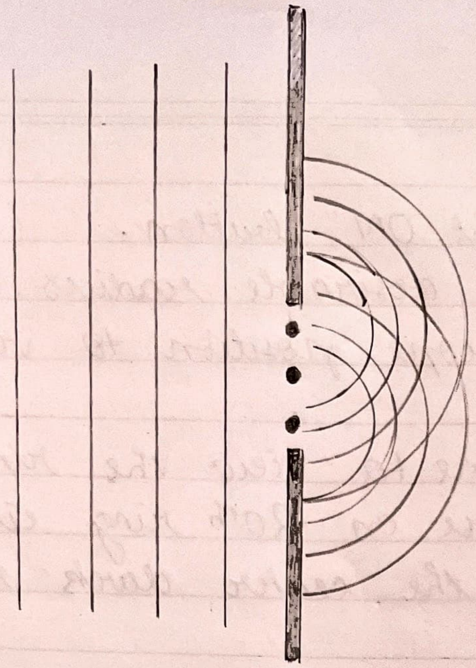
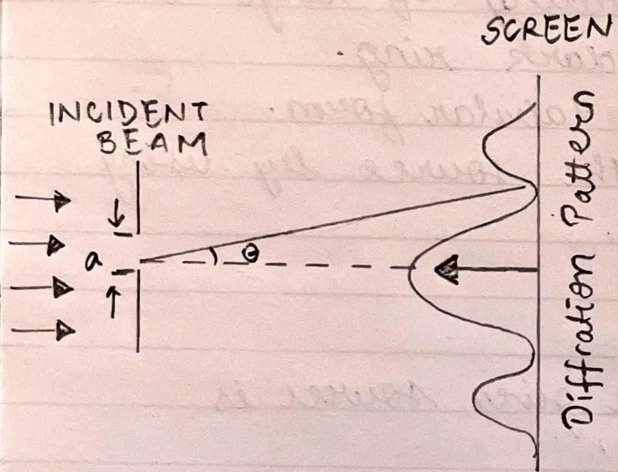
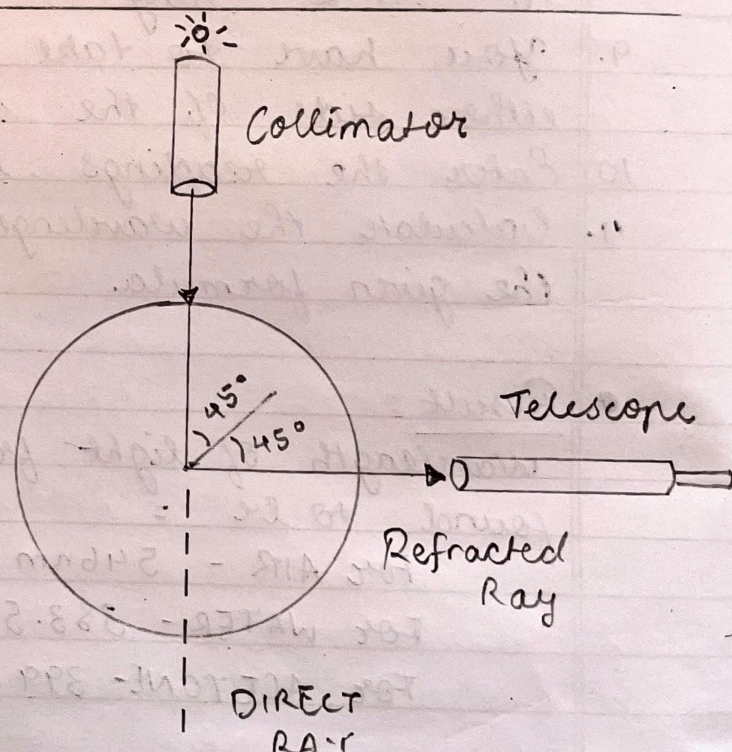


Wavefronts add / cancel out each other





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central band of light with dark bands on either side. The dark bands are called when the light from the top half of the slit destructively interfere with the light from the bottom half.

Consider a slit of width 'a'. Let at an angle 'θ', the path difference between the top & bottom of the slit is the wavelength. This causes destructive interference to occur because the path difference between the top & the middle of the slit is half of the wavelength. At this slit will get cancelled with the light from the bottom half to produce a dark band.

$$\therefore \Delta S = a \sin\theta \quad - \text{①}$$

Intensity minima will occur if this path length difference is an integer no. of wavelengths.

$$\therefore a \sin\theta = n\lambda \quad - \text{②}$$

a → distance between slits

θ → angle at which destructive interference occurs

λ → wavelength

n → order of each minima

~~Inz~~ Intensity is given by -

$$I = \frac{I_0 \sin^2\left(\frac{N\delta}{2}\right)}{\left(\frac{\delta}{2}\right)^2} \quad - \text{③}$$

I_0 - Max. Intensity

δ - total phase angle

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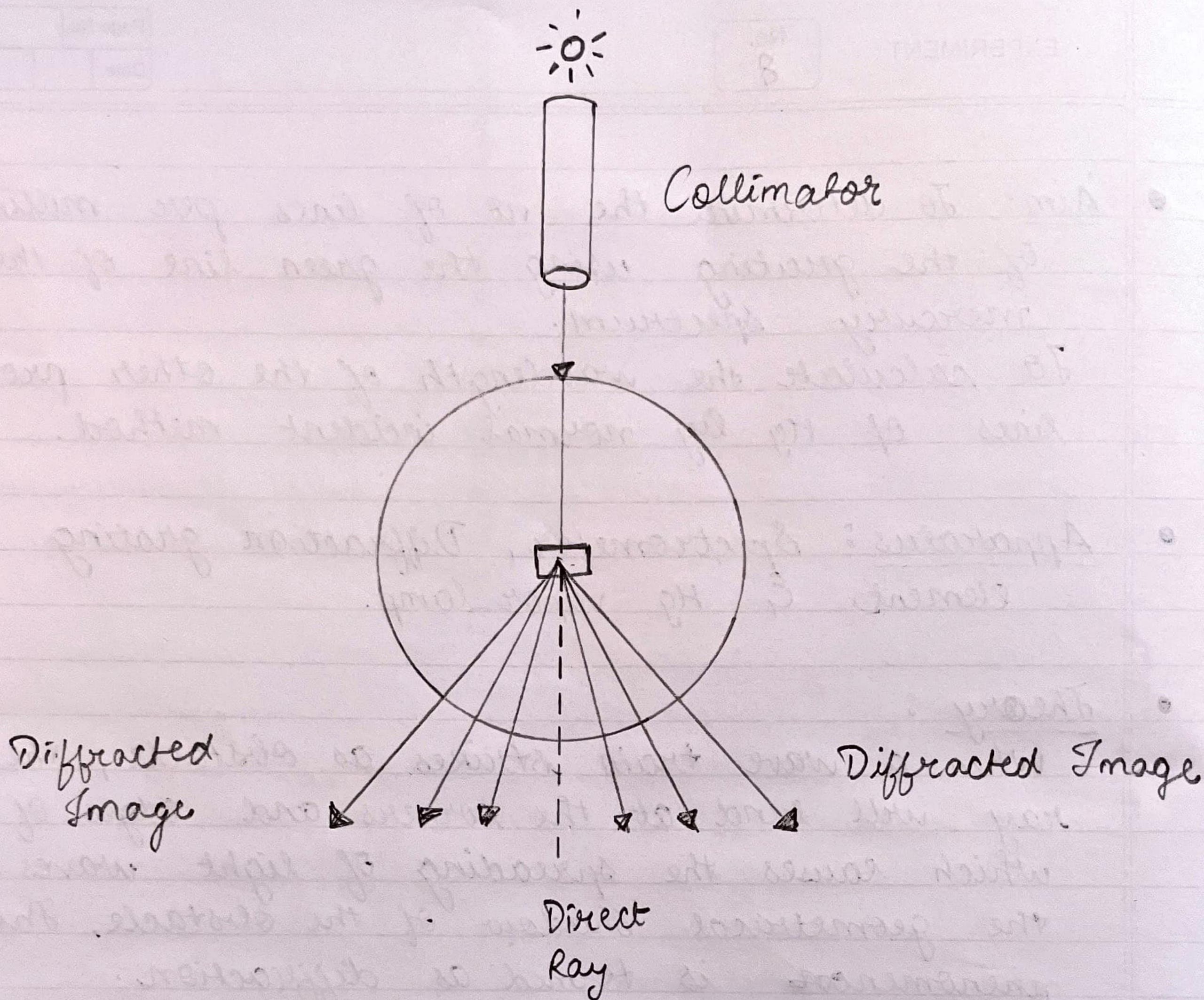
Collimator
Diffracted Image
Diffracted Image
Direct Ray

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$$\delta = \frac{2\pi a \sin\theta}{\lambda} \quad - \quad (4)$$

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

At normal incidence,

$$\sin\theta = N n \lambda \quad - \quad (5)$$

N - no. of lines per unit length of the grating
n - order of the spectrum
λ - wavelength of light.
θ - diffracting angle.

- Procedure -

REAL LAB

1. The preliminary adjustments of the spectrometer are made. The grating is set for normal incidence.
2. The slit is illuminated by mercury vapor lamp.
3. The telescope is brought in a line with the collimator and the direct image of the slit is made to coincide with the vertical cross wire.
4. The readings of one ~~version~~ vernier are noted.
5. Now, the telescope is rotated exactly through 90°. The grating is mounted vertically on the prism

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table with its ruled surface facing the collimator.

6. The vernier table is released & is slowly rotated till the reflected image coincides with the vertical cross wire.

7. The levelling screws are adjusted so that the image is at the centre of the field of the view of the ~~landscape~~ telescope.

8. The prism table is fixed & after ~~meeting~~ making fine adjustments with the tangential screws, the readings of the vernier are noted.

9. Now the angle of incidence is 45°. The vernier table is then released & rotated exactly through 45° in the proper direction so that the surface of the gratings become normal to the incidence light. The vernier Scale / table is firmly clamped in the position.

10. The telescope is then released and is bought to observe the direct image. On the either side of the direct image, the diffraction spectra are seen.

11. The telescope is turned slowly towards the left so that the vertical cross wire coincides with the violet lines of the first order.

12. The vertical cross wire is then made to coincide with the other lines on the left & the vernier readings are taken in each case.

13. The telescope is then moved to the right & the readings of different lines is similarly taken.

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14. The difference between the readings on the left & right on the same vernier is determined for each line.
15. The mean value of this difference gives 2θ - twice the angle of diffraction. The wavelength of the green light is 546.1×10^{-9} m
16. The no. of lines per metre (N) of the grating is calculated.
17. Using this value of N, the wavelengths of the other prominent lines in this spectrum are calculated.

SIMULATOR

To standardise the grating:

1. Turn the telescope to obtain the image of the slit.
2. Turn the telescope to both sides to obtain green lines. Note the reading of both the verniers.
3. Calculate the difference in the reading to obtain the diffracting angle. Then from the equations, no. of lines per unit length of the grating can be calculated.

To calculate the wavelength of different lines

1. Obtain the direct image.
2. Telescope is moved to make the cross-wire coincide with each line of the spectrum.
3. Note the readings on the versions & calculate the diffracting angle.

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Observations -

I Standardisation of Equipment -

Green λ (nm)	LEFT		RIGHT		Diff Reading		Mean θ	$N = \frac{\sin\theta}{n\lambda}$
	Ver I	Ver II	Ver I	Ver II	Ver I	Ver II		
546.1	26°22'	115°10'	64°58'	153°54'	38°36'	38°39'	19°19'	546.1'

For green light,

$$\lambda = 546.1 \text{ nm}$$

$$\therefore N = \frac{\sin(19°19')}{1 \times 546.1 \times 10^{-9}} = 0.6 \times 10^{6} \text{ lines/m}$$

II Determination of wavelength of prominent lines :

Colour	LEFT		RIGHT		Diff Reading		Mean θ	$\lambda = \frac{\sin\theta}{nN}$
	Ver I	Ver II	Ver I	Ver II	Ver I	Ver II		
Yellow	25°20'	114°27'	65°28'	154°84'	40°8'	40°27'	20°8'	568.1 nm
Blue	28°9'	115°10'	62°24'	151°50'	34°15'	34°42'	17°13'	488.5 nm
Indigo	30°25'	117°10'	60°50'	149°35'	30°25'	29°55'	15°5'	429.5 nm
Violet	31°8'	120°45'	59°6'	148°45'	28°8'	28°9'	14°4'	398.8 nm

Calculations -

	Yellow	Blue	Indigo	Violet
Vernier I ($2\theta_1$) :	$65°28' - 25°20'$ $= 40°8'$	$62°24' - 28°9'$ $= 34°15'$	$60°50' - 30°25'$ $= 30°25'$	$59°6' - 31°8'$ $= 28°8'$
Vernier II ($2\theta_1$) :	$40°27'$	$34°42'$	$29°55'$	$28°$
∴ Mean θ :	$20°8'$	$17°13'$	$15°5'$	$14°4'$

λ (yellow) $= \dfrac{\sin(20°8')}{0.6 \times 10^6 \times 1} = \underline{568.1 \text{ nm}}$

λ (Blue) $= \dfrac{\sin(17°13')}{0.6 \times 10^6 \times 1} = \underline{488.5 \text{ nm}}$

λ (Indigo) $= \dfrac{\sin(15°5')}{0.6 \times 10^6 \times 1} = \underline{429.5 \text{ nm}}$

λ (Violet) $= \dfrac{\sin(14°4')}{0.6 \times 10^6 \times 1} = \underline{398.8 \text{ nm}}$

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4. Then calculate the wavelength of each colour.

- Results -

1. Wavelength of Yellow is 568.1 nm
2. Wavelength of Blue is 488.5 nm
3. ~~Indigo~~ Wavelength of Indigo is 429.5 nm
4. Wavelength of Violet is 398.8 nm

- Conclusions -

- The no. of lines per millimeter of the grating using the green line of mercury spectrum is successfully obtained.
- The wavelengths obtained by normal line incidence method concur with actual wavelengths.

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