Department of Physics
Karnatak Science College
Dharwad

Lab Manual

BSc III semester

List of the Experiments for NEP III Semester

1. Study of Lissajous Figures.
2. Polarimeter: Determination of specific rotation of sugar solution
3. Newton's rings.
4. Resolving power of grating.
5. Study of elliptically polarized light.
6. Goniometer
7. Determination of wavelength of laser light by diffraction single slit method.
8. Determination of wavelength of monochromatic light using biprism
9. Turn table.
10. Dispersive curve and dispersive power of a prism.

1. USE OF CRO- STUDY OF LISSAJOUS FIGURES

Aim: To determine the frequency of the unknown source using Lissajous Figures.

Formula: Basic formula of lissajous figure: $F_x N_x = F_y N_y$

If unknown Frequency is applied to Y plates of CRO then

$$F_Y = \frac{F_X N_X}{N_Y}$$

If unknown Frequency is applied to X plates of CRO then

$$F_X = \frac{F_Y N_Y}{N_X}$$

N_x - Number of tangential points along x axis

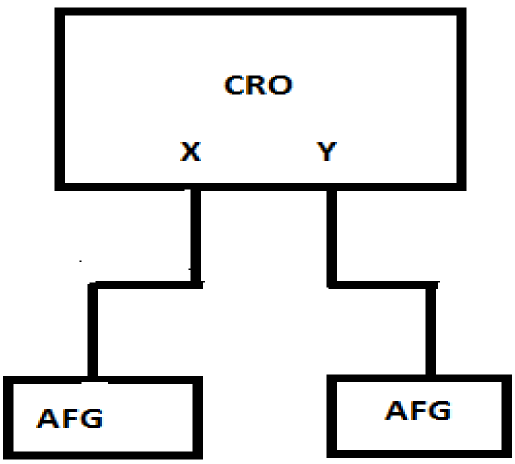
N_y - Number of tangential points along y axis

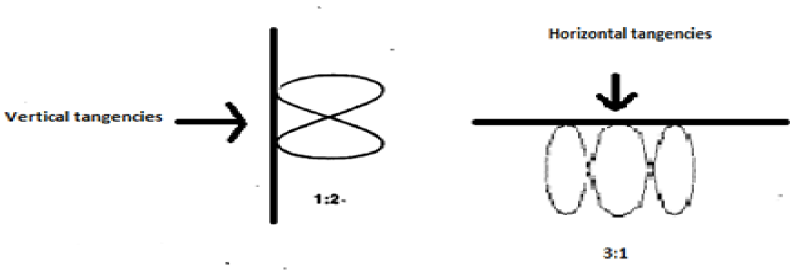
F_X - Frequency of Signal applied to X plates

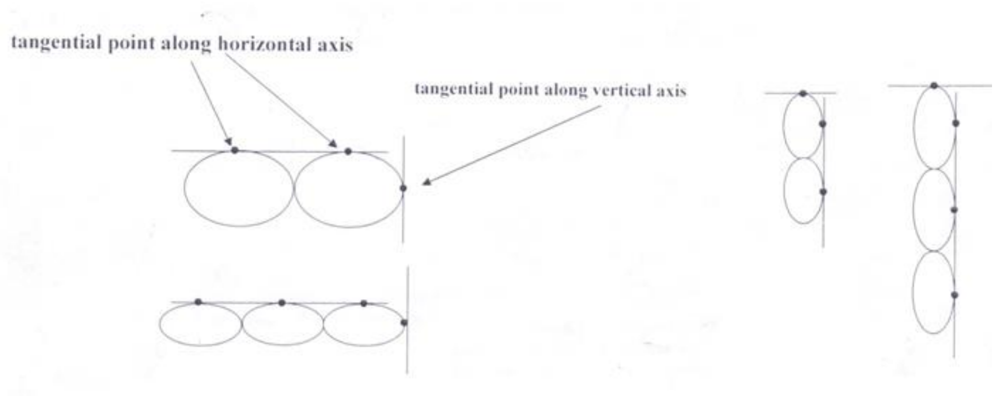
F_Y - Frequency of Signal applied to Y plates

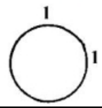
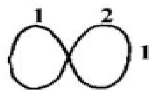
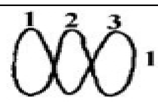
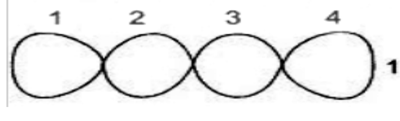
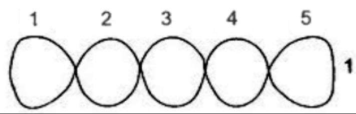
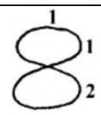
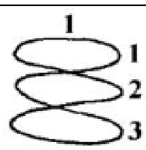
Diagram:

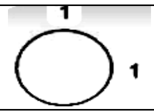
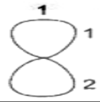
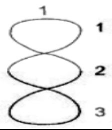
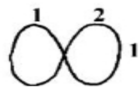
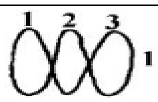
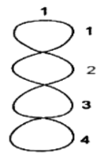
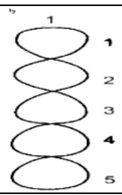
Frequency of unknown source







Frequency of Signal applied to X plates F_X (Hz)	Number of tangential points along x axis (N_x)	Number of tangential points along y axis (N_y)	Unknown Frequency of signal on y axis (Hz) $F_Y = \frac{F_X N_X}{N_Y}$	Lissajous pattern
				
				
				
				
				
				
				

Frequency of Signal applied to Y plates F_Y (Hz)	Number of tangential points along x axis (N_x)	Number of tangential points along y axis (N_y)	Unknown Frequency of signal on x axis $F_X = \frac{F_Y N_Y}{N_X}$	Lissajous pattern
				
				
				
				
				
				
				

Note: i) Unknown signal frequency can be applied to either x plate or y plate and any lissajous pattern can be obtained by controlling the known signal frequency.

ii) While performing this experiment, for each trial, once unknown frequency is fixed you have to tune/vary known frequency only to get required lissajous figure pattern

Result: Unknown frequency was determined using CRO and Lissajous pattern. Frequencies are found to be in agreement with AFG reading.

Lissajous Figures

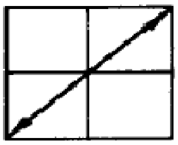
When a particle is vibrating simultaneously under two simple harmonic motions at right angles to each other, the resultant motion of the particle is called Lissajous figure. The nature of the curve traced out by the particle depends upon the amplitude, frequencies, and phase difference of the two component motions.

If two simple harmonic motions with amplitudes a, b having equal periods $\frac{2\pi}{\omega}$ are acting along X and Y axes respectively with phase difference φ then their displacements at any time t are represented by

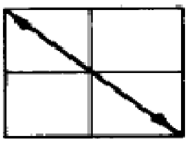
$$x = a\sin(\omega t + \phi)$$
$$y = b\sin(\omega t)$$

The resultant motion is expressed by $\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab}\cos\phi = \sin^2\phi$

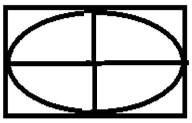
(i) When φ =0, then resultant Lissajous figure represents a pair of coincident straight lines $y = \frac{bx}{a}$ passing through origin and lying in the first and third quadrants.



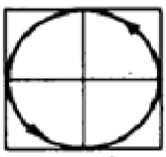
(ii) When φ =π, then resultant Lissajous figure represents a pair of coincident straight lines $y = -\frac{bx}{a}$ passing through origin and lying in the second and fourth quadrants.



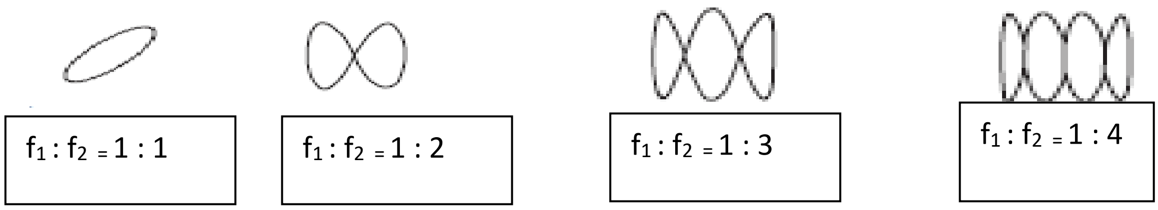
(iii) When φ = π/2, then resultant Lissajous figure represents an ellipse.



(iv) When a=b, φ = π/2 then resultant Lissajous figure represents a circle.



(v) Lissajous figures with different frequency ratios



2. POLARIMETER

AIM: Using the Polarimeter, determine the specific rotation of the given substance (SUGAR) taking at least four different concentrations. Also determine the unknown concentration of the given solution

APPARATUS: Laurent's half shade polarimeter, Sodium lamp, distilled water, sugar, beakers, digital weighing balance, measuring jar etc

FORMULA:

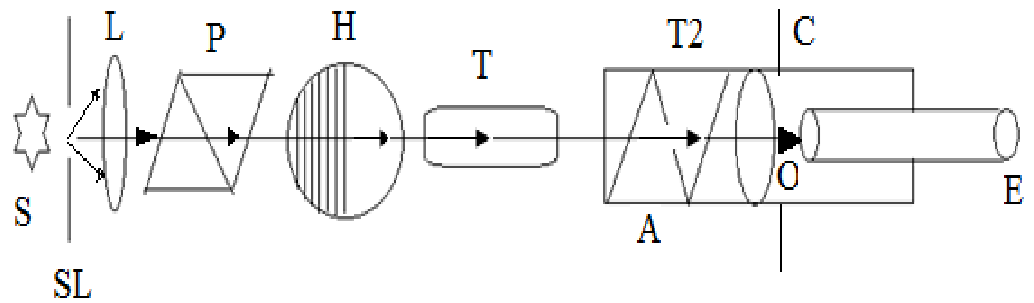
$$\text{Specific rotation} = S = \frac{10 \times \text{Slope}}{L} = \ldots\ldots\ldots \text{degree } dm^{-1}/g\,cc^{-1}$$

Or

$$\text{Specific rotation} = S = \frac{10 \times \text{slope}}{L} \times \frac{\pi}{180} \times 10^{-2} = \ldots\ldots\ldots \text{ rad}m^2Kg^{-1}$$

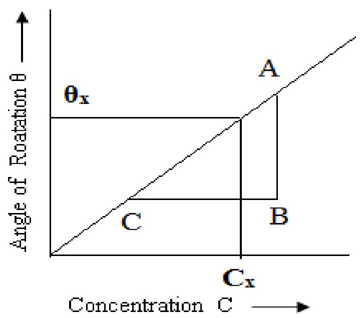
Unknown concentrations of the given solutions $C_x = \ldots\ldots\ldots$ g/cc

RAY DIAGRAM:



S: Sodium Source; SL: Slit; L: Collimating lens; P: Polariser; H: Half shade plate; T: Tube; A: Analyser; O, E: Objective and Eyepiece of observing Telescope; C: Circular Scale.

NATURE OF GRAPH:



Slope = $\frac{AB}{BC}$ = ___________

C_x = ____________

PRINCIPLE: In an ordinary light the vibrations takes place in all directions perpendicular to the direction of propagation. Such light has the same properties in all directions and is known as unpolarised light. When light is passed through crystals, like tourmaline quartz etc., it acquires the properties of one sidedness i.e., the vibrations takes place only in one plane. In such case light is said to be plane polarised. An arrangement for producing polarised light is called polariser. A Nicol prism is generally used for the purpose. When a plane polarized light passes through OPTICALLY ACTIVE substance (such as sugar solution in polarimeter tube), the plane of polarization (vibration) of incident light is rotated through an angle θ, by the time light comes out of substance. This angle θ is measured in this experiment.

OBSERVATIONS:

Least count of Polarimeter = $\frac{Value\ of\ one\ main\ scale\ division}{No.of\ divisions\ on\ vernier\ scale}$

TABULATION

'rial No.	ɔncentration of ıgar solution in gm/cc (%)	larimeter reading with ɔlvent (distilled water) when P and A are crossed R_0			arimeter reading with ugar solution when P and A are crossed R			Angle of rotation θ = R_0-R
		MSR	CVD	TR	MSR	CVD	TR	
1	16							
2	8							
3	4							
4	2							
5	1							
6	Unknown concentration							

RESULT:

Specific rotation = S = _______ degree dm^{-1}/ gm cc^{-1}

Unknown concentration of the solution = _________gm/cc.

VIVA QUESTIONS:

1. What is polarisation of light?
2. Define specific rotation.
3. Explain the construction and action of a half- shade device.

4. What is plane polarised light? How do you obtain the plane polarised light?
5. What is optical activity?
6. What is difference between dextro rotatory and laevo rotatory?
7. Identify nature of given substance as Dextro or Laevo rotatory after completion of experiment on seeing the readings

REFERENCES:

C. L. Arora, B. Sc. Practical Physics, S. Chand and Company LTD

3. NEWTON'S RINGS

AIM: Obtain distinct Newton's rings using monochromatic source and determine the radius of curvature of the given Plano-convex lens by Newton's rings method.

Given: Wavelength of sodium source of light = 589.3 nm

APPARATUS: Sodium lamp, Microscope, Plano convex lens, Thick and thin glass plates, Condensing lens, Hand lamp, Magnifying lens etc.

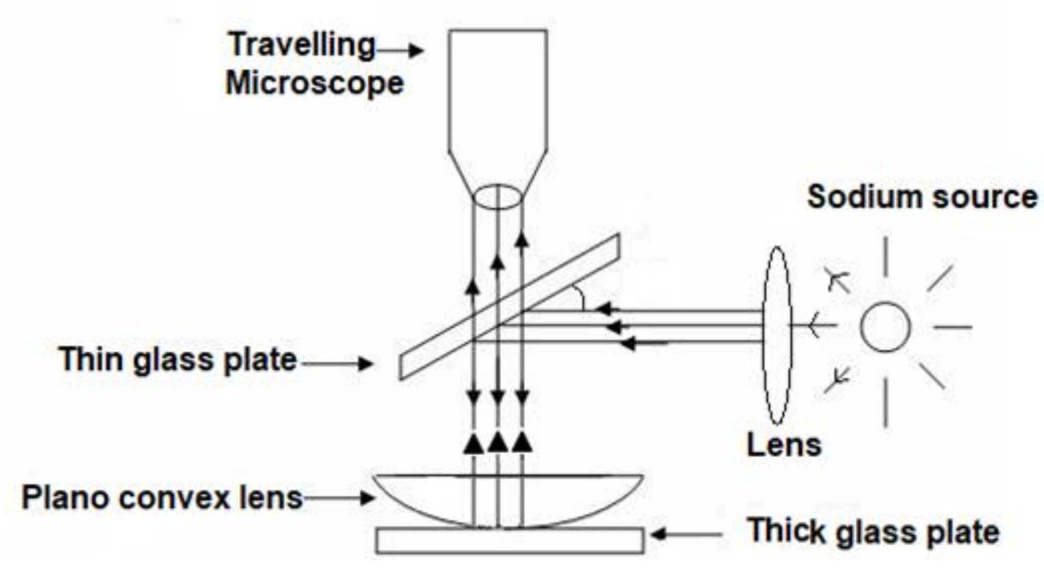
FORMULA:

Radius of curvature of convex lens surface is given by,

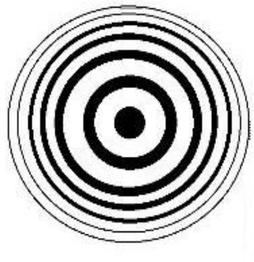
$$R = \frac{{D_N}^2 - {D_M}^2}{4\lambda\,(N-M)}$$

where N and M is some n^{th} and m^{th} ring and, D_N and D_M there corresponding diameter. λ is the wavelength of sodium source

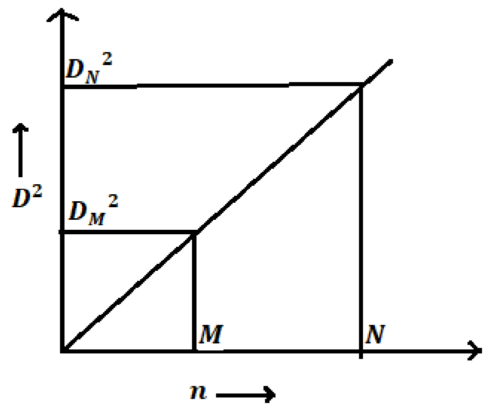
RAY DIAGRAM:



NATURE OF THE RINGS:



NATURE OF GRAPH:



$N =$........ $M =$........ $D_N^{\ 2} =$........ $D_M^{\ 2} =$.........

PRINCIPLE: The experiment is based on circular interference fringes produced by enclosing a thin air film of varying thickness between the surface of a convex lens of large radius of curvature and a plane glass plate. The thickness of air film is zero at the point of contact and increases as we go outwards.

If monochromatic light is incident on such an air film normally from above, it undergoes partial reflection from its two faces. The two systems of reflected beams are in a position to interfere, whenever the effective path difference between them is an odd multiple of $\lambda/2$. We obtain a number of concentric rings which are alternately bright and dark.

OBSERVATIONS:

1. Mean wavelength of the monochromatic light used= λ= 5893 Å
2. Least count of travelling microscope scale= LC = ………… cm

TABULAR COLUMN:

Number of Ring 'n'	Microscope reading to measure diameter						Diameter of the ring (cm) D= a~b	D^2 (cm^2)
	Left 'a'			Right 'b'				
	PSR	HSR	TR	PSR	HSR	TR		
20								
18								
16								
14								
12								
10								
8								
6								

RESULT:
Radius of curvature of convex lens surface R =........ cm

VIVA QUESTIONS:
1. What is interference of light?
2. How are Newton's rings formed?
3. Why is central ring dark?
4. What do you understand by coherent sources?
5. Why do the rings get closer as we move away from the center?
6. What is the function of glass plate inclined at 45^0 ?
7. What happens if glass plate at the bottom is replaced by a plane mirror?
8. What if sodium light is replaced with white light?
9. What happens if few drops of liquid is introduced between the lens and the lens and the glass?
10. Why plano convex lens of larger aperture is used in this experiment?

REFERENCES:

1. F. Jenkins and H. White, Fundamentals of Optics, TATA-McGrawHill.
2. A. Ghatak, Optics, TATA-McGraw Hill.
3. R.K. Shukla and A. Srivatsava, Practical Physics, New Age International Ltd.

4. RESOLVING POWER OF THE GRATING

AIM : To determine the resolving power of the grating and to compare the theoretical resolving power with practical resolving power.

APPARATUS: Sodium source, Spectrometer, Grating, Prism , Auxilary slit , Travelling microscope, Hand lamp , Sprit level , etc

FORMULA:

1. Theoretically Resolving power of grating, RP = nN

where, n – order of the spectrum

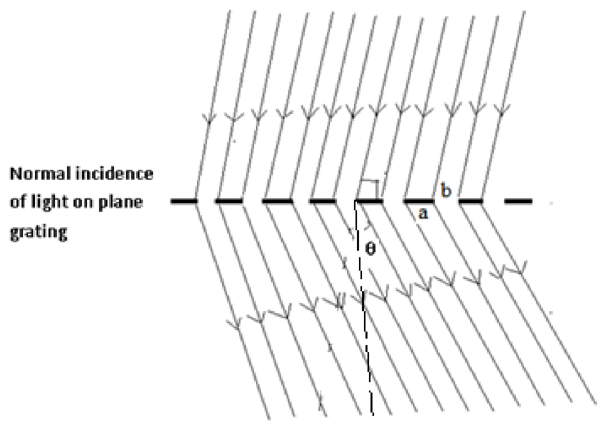
N – number of lines per unit length of the grating – 15000 lines/inch

2. Practically Resolving power of grating, RP = $\frac{\lambda}{\Delta\lambda} \times \frac{\cos\theta_n}{w}$

   where λ is Mean Wavelength $= \frac{\lambda_1 + \lambda_2}{2}$
   $\Delta\lambda$ is difference in wavelengths = $\lambda_1 - \lambda_2$
   w - Mean width of auxiliary slit
   θ_n – mean angle of diffraction where n = 1, 2

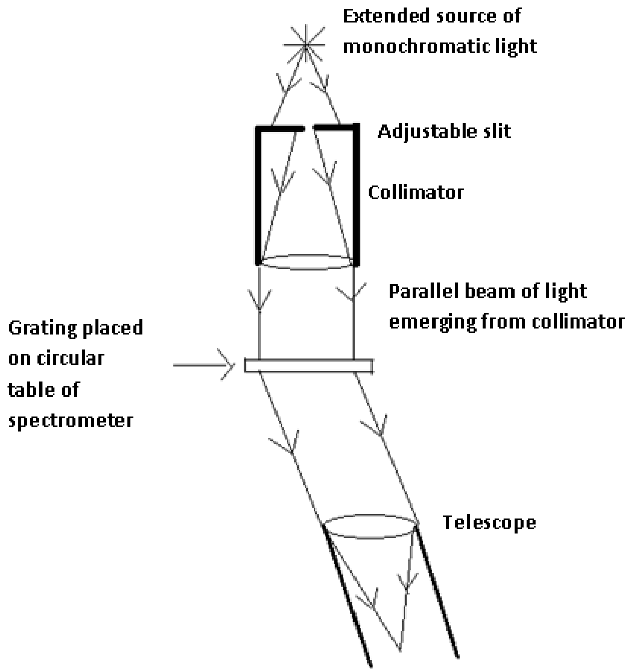
RAY DIAGRAM 1

PARALLEL RAYS OF LIGHT FROM COLLIMATOR

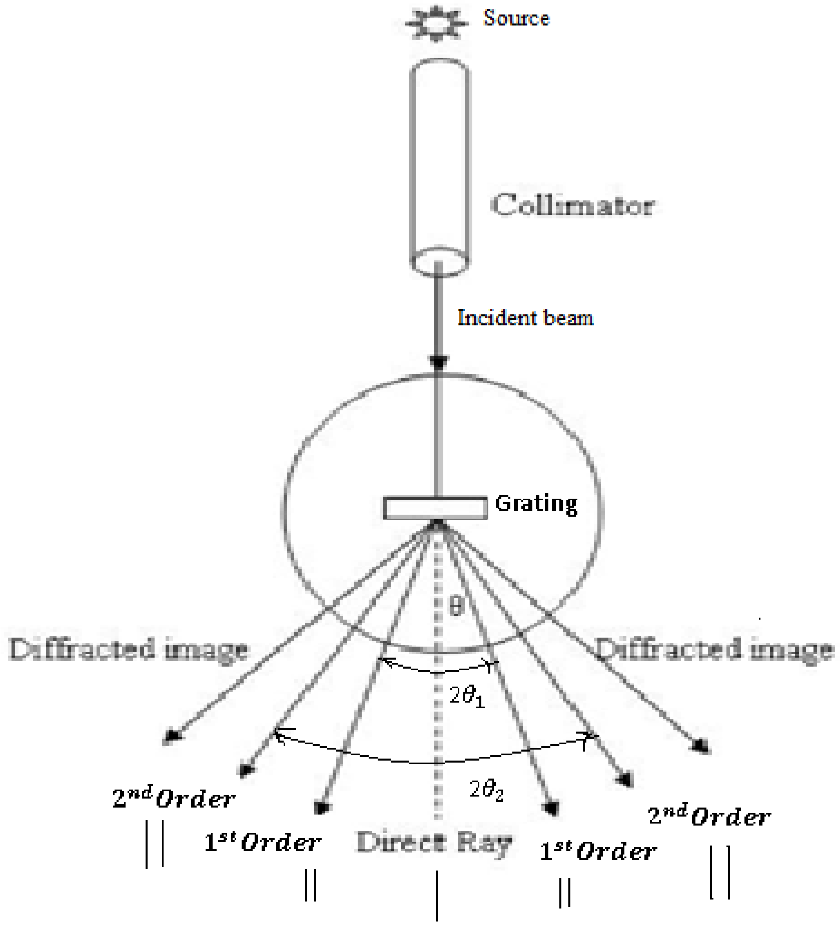


a+b = width of the grating element
for normal incidence $(a + b)sin\theta = n\lambda$
θ – angle of diffraction
λ – wavelength of incident light
n – order of spectrum

RAY DIAGRAM 2



RAY DIAGRAM 3



NOTE: resolving power for first order diffraction is less than that of second order diffraction. However the first order spectra is sharper than the second order spectra. The sharpest line is for the direct beam, since most of the light travels straight.

PRINCIPLE :

The experiment is based on the principle of limit of resolution of two closely spaced lines. The limit of resolution is the minimum distance of separation between the two point objects at which they are just resolved and the reciprocal of limit of resolution is termed as the resolving power of optical instrument. The resolving power of an instrument is its ability to resolve two closely lying point objects. The phenomenon is based on diffraction of light.

OBSERVATIONS AND TABULAR COLUMN .

1. Source of light used = Sodium
2. Wavelength of first yellow line = $\lambda_1 = 5896\ A^o$
3. Wavelength of second yellow line $\lambda_2 = 5890\ A^o$
4. Mean wavelength $\lambda = \frac{\lambda_1 + \lambda_2}{2} = 5893\ A^o$
5. Difference between λ_1 *and* $\lambda_2 = \Delta\boldsymbol{\lambda} = \mathbf{6}\ A^o$
6. Number of lines per cm on grating = N = _________
7. Least count of the spectrometer scale = _______min

TO DETERMINE ANGLE OF DIFFRACTION

Telescope to the	**First order spectrum n = 1**		**Second order spectrum n = 2**	
	Vernier A Reading	**Vernier B Reading.**	**Vernier A Reading**	**Vernier B Reading**
Left	X = _______	Y = _______	X = ______	Y = ______
Right	X_1 = ______	Y_1 = ______	X_1 = ______	Y_1 = ______
$2\theta_n$	$\lvert X - X_1 \rvert$ = ______	$\lvert Y - Y_1 \rvert$= ______	$\lvert X - X_1 \rvert$ = ______	$\lvert Y - Y_1 \rvert$ = ______
θ_n	$\frac{\lvert X - X_1 \rvert}{2}$ = ________	$\frac{\lvert Y - Y_1 \rvert}{2}$ = ________	$\frac{\lvert X - X_1 \rvert}{2}$ = _______	$\frac{\lvert Y - Y_1 \rvert}{2}$ = ________
Mean $\boldsymbol{\theta}$				

TO DETERMINE THE WIDTH OF SLIT

1. Value of smallest division on pitch scale **S** = _________cm
2. Total number of divisions on the head scale **N** = ________div
3. Least count of auxiliary slit LC = **S/N** .... cm

Order of the spectrum	**Micrometer reading of the slit when separation between two Yellow lines**		**Mean width** $w = \frac{w_1 + w_2}{2}$
	Just Disappear w_1	**Just Reappear** w_2	
1			
2			

TO DETERMINE THE RESOLVING POWER

Order of spectrum N	**Theoretical R.P.** R.P. = nN	**Practical R.P.** $R.P. = \frac{\lambda}{\Delta\lambda} \times \frac{\cos\theta_n}{w}$
1		
2		

RESULTS :

Theoretically Resolving power of the grating for

1st order = _________

2nd order = __________

Practically Resolving power of the grating for

1st order = _________

2nd order = __________

VIVA QUESTIONS.

1. What is the resolving power of grating?
2. What is grating and grating element?
3. What is diffraction?
4. What is plane transmission grating?
5. How does a grating work?
6. What are the uses of a diffraction grating?
7. What is the effect of increasing the number lines per cm of the grating on the diffraction pattern?
8. Does the separation of spectral lines remain the same in different orders of the spectra?

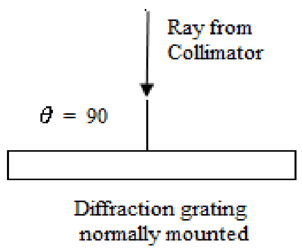
REFERENCE:

1. C. L. Arora, B. Sc. Practical Physics, S. Chand and Company LTD.
2. Practical Physics by Geeta Sanon.

PRELIMININARY ADJUSTMENTS

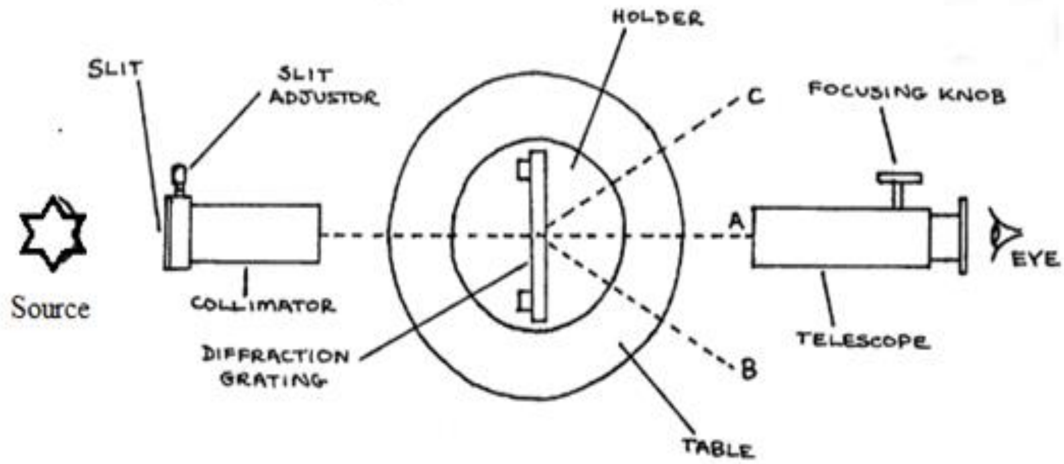
Adjust the collimator and telescope for parallel rays (focussing) using prism; SCHUSTER'S METHOD.

For normal mounting we should follow certain steps at the end of which angle of incidence i = 0 and glancing angle θ = 90^{o} as shown below



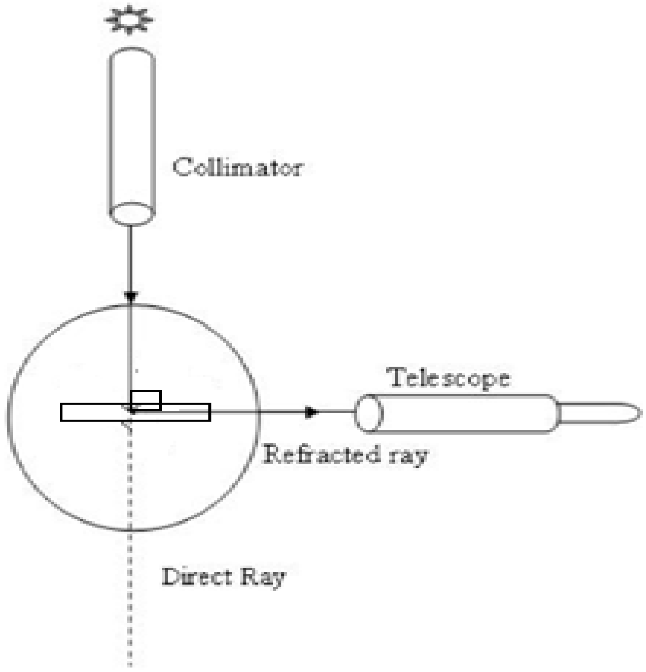
The steps followed for normal mounting of grating are listed below:

1. Keep grating on the grating table, approximately normal to the incident rays from collimator. Lock the grating table and unlock the telescope. Now place the telescope in line with the collimator so that the vertical cross wire falls exactly in the centre of the image of the slit. Note the scale reading as shown in figure below.

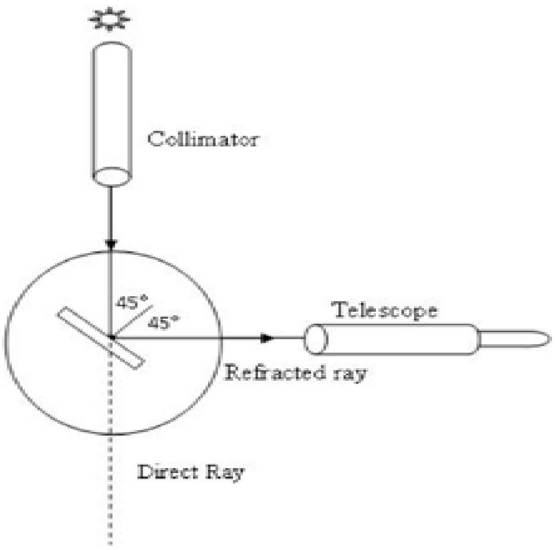


Take direct reading R_1 (Vernier A) - ___________

2. Calculate $R_2 = R_1 + 90^o$ and rotate telescope anticlockwise and place it to get the reading R_2. Now the axis of the telescope is perpendicular to the axis of the collimator and the field of view of eyepiece will be dark. Lock the telescope while taking reading R_2

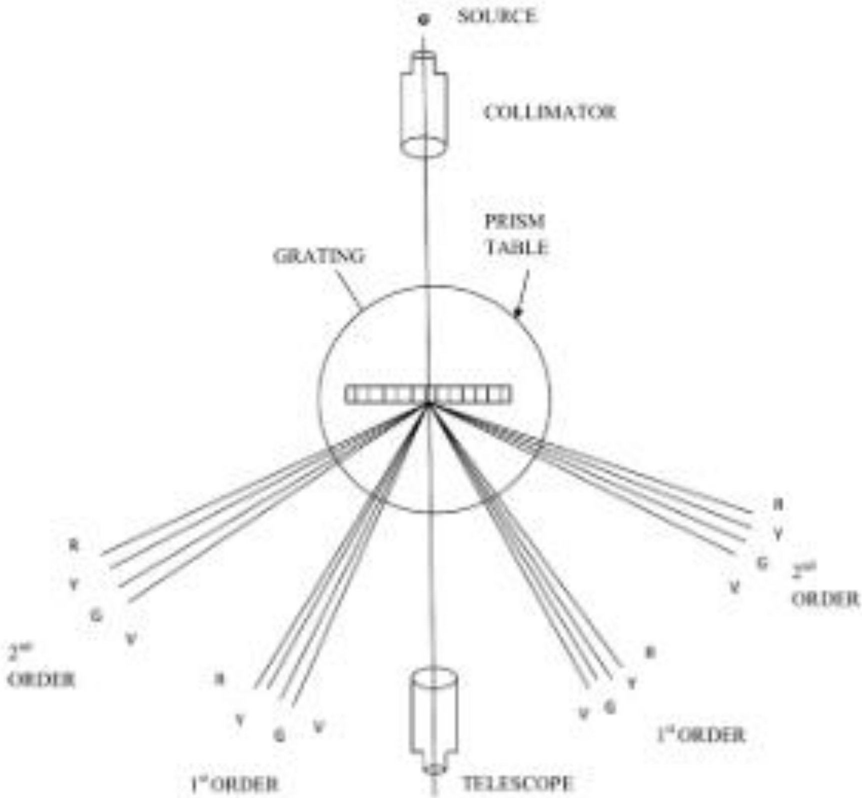


3. Rotate grating table after unlocking it in clockwise direction, such that after reflection from the grating surface, the image of the slit is observed in the field of view of eyepiece of the telescope. In this position the plane of the grating is inclined at an angle of 45^o to the incident light as illustrated in the figure below. Note down the reading $R_3 = R_2 + 45^o$



4. Calculate $R_4 = R_3 - 45^{o}$ continue to rotate grating table in the anticlockwise direction so as to get the reading R_4. Now $i = 0$ and $\theta = 90^{o}$ i.e. normal mounting of the grating is completed. Lock the grating table in this position till the end of the experiment.

5. Unlock the telescope and turn it either towards left or right to receive the first ordered diffraction spectrum.



Note: Take readings from second order spectrum on left side upto second order spectrum on right side in an order.

5.STUDY OF ELLIPTICALLY POLARISED LIGHT

Aim: To produce elliptically polarized light using Quarter Wave plate and sodium light source and study the same using polarizer and analyzer. Plot graph of

(a) Light Intensity (I) vs Angle of rotation of analyser (θ)

(b) Intensity (I) vs $\cos^2\theta$ and find Slope 'a' and intercept 'b'

(c) Plot graph of bsin(θ) versus acos(θ)

Apparatus: Nicol prism, Quarter wave plate Detector(LUX METER) ,source.

Formula: From graph I v/s $\cos^2\theta$

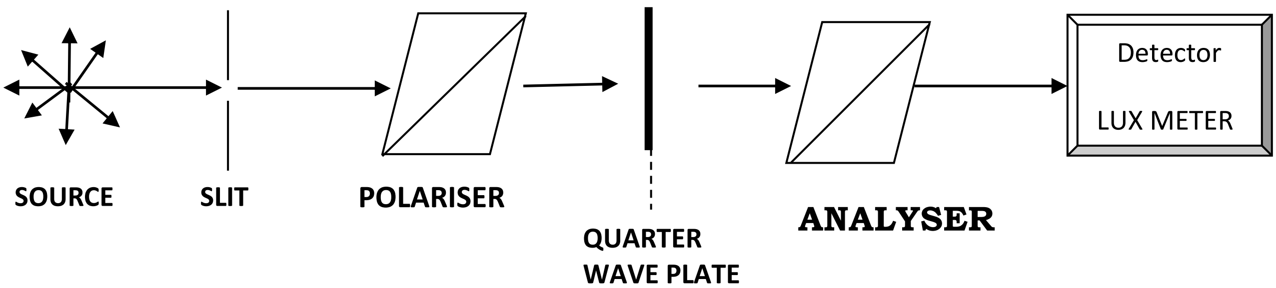
Slope = a^2-b^2

where b^2 = y Intercept

a^2 =

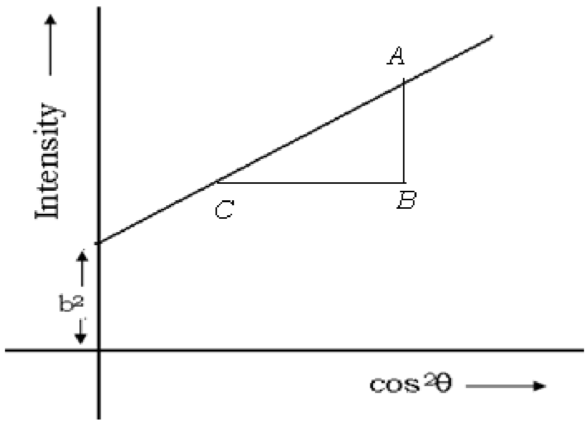
∴ a = b =

Experimental setup

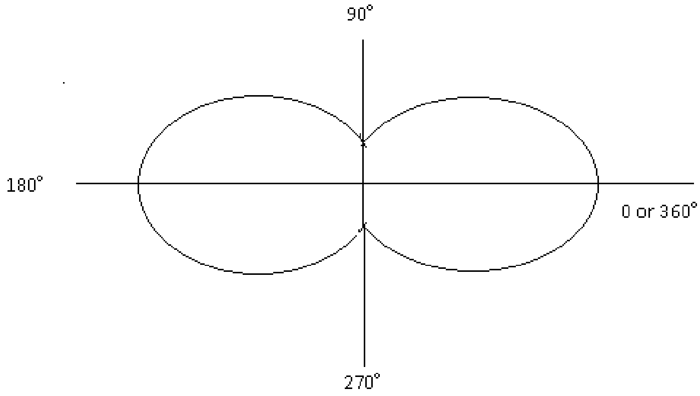


Nature of graph

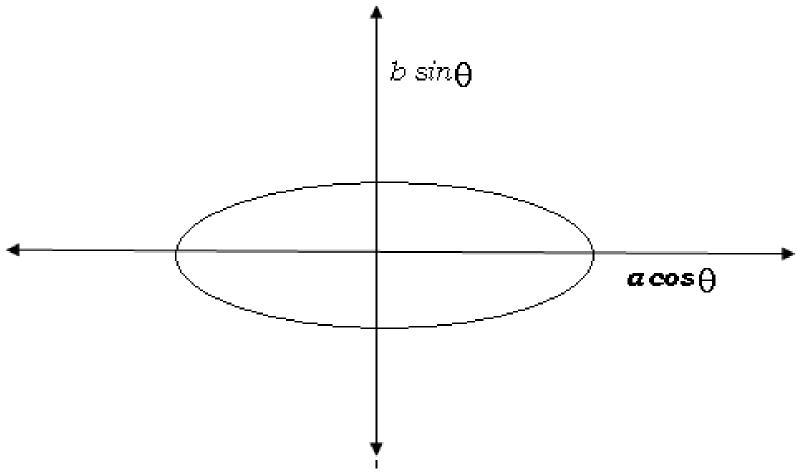
Intensity v/s $\cos^2\theta$



Intensity v/s θ (Angle of rotation)



bsinθ v/s acosθ



Tabular column

Angle of rotation	**Intensity I in (LUMEN)**	**cosθ**	**sinθ**	**$\cos^2\theta$**	**acosθ**	**bsinθ**
0^0						
10^o						
20^o						
360^0						

Calculation from the graph

I v/s $\cos^2\theta$

Slope = $a^2 - b^2$ =

b^2 = y intercept =

a^2 = slope + b^2

a = $\sqrt{\text{slope} + b^2}$

b =

Result: studied the production and detection of elliptically polarized light using polarizer and analyser

Theory:

Polarization is the phenomenon in which waves of light or other radiation are restricted in direction of vibration or vibrations are said to occur in a single plane. The process of transforming unpolarized light into polarized light is known as **Polarization.**

Types of Polarized Light

1. **Unpolarized light**:- It consists of sequence of wave trains, all oriented at random. It is considered as the resultant of two optical vectors. Components, which are incoherent.

2. **Linearly polarized light**: It can be regarded as a resultant of two coherent linearly polarized waves.

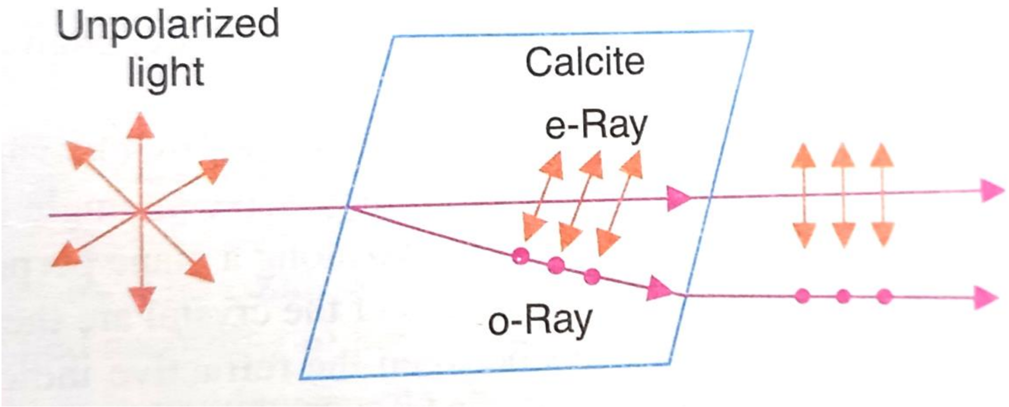
3. **Partially polarized light**: It is a mixture of linearly polarized light and unpolarized light.

4. **Elliptically polarized light**: It is the resultant of two coherent waves having different amplitudes and a constant phase difference. In elliptically polarized light, the magnitude of electric vector E rotates about the direction of propagation. If light is coming towards us, we would observe that tip of the E vector traces an ellipse.

Elliptically polarized light consists of two light waves that are linearly polarized, but unlike circularly polarized light, they have unequal amplitudes but the same frequency. This results in a light wave with electric vectors that both rotates and changes its magnitude. An elliptical shape can be traced out by the tip of the electric field vector, and therefore it is referred to as elliptical polarization. This is a special case of circular polarization.

Polariser /Analyser: A Nichol prism is an optical device used for producing and analysing polarised light. It is made up of calcite crystal which is transparent to visible and uvlight, rhombohedral in shape and each of the six faces of the crystal form a parallelogram having angles of 78° and 120° approximately.

When a Nichol prism is used for polarisation case, it is known as a polariser otherwise it can be used as an analyser for analysing the transmission of light. There is one axis known as the optic axis through the crystal where no double refraction takes place and a ray passing through the optic axis does not break into O- and E- rays.



Quarter wave plate: A doubly refracting uniaxial crystal plate having refracting faces parallel to the direction of the optic axis, having a thickness 't' such that it creates a path difference of $\lambda/4$ or a phase difference of $\pi/2$ between the O-ray and the E-ray is called Quarter wave plate.

For quarter wave plate : Path difference, $\Delta = \lambda/4$ where λ is the wavelength of the incident light.

Uses of quarter wave plate:

If linearly polarized light is incident on a quarter-wave plate at 45° to the optic axis, then the light is divided into two equal electric field components. One of these is retarded by a quarter wavelength. This produces circularly polarized light.

If circularly polarized light is incident on quarter wave plate at 45° to the optic axis then it produces linearly polarized light. If linearly polarized light is incident on quarter wave plate other than 45° to the optic axis then it produces elliptical polarized light.

Applications of Polarization of Light

1. In the production of glare-reducing sunglasses.
2. In many industries, polaroid filters are used for stress analysis tests on transparent plastics.
3. In the entertainment industry, to telecast or to show a 3D film, the phenomenon of polarization of light is used.
4. To differentiate between a longitudinal and a transverse wave.
5. To cut the refractions, Fishermen, Skiers, motorists, sportsmen need special sunglasses. In the production of these special sunglasses polarization of light is used.

6. Many photographers use polarizers to capture the perfect scene.

7. Polarization microscopes are used in geological studies to identify minerals.

8. In infrared spectroscopy.

9. To check the chirality of organic compounds

10. To study the physics of the early universe, the effect of polarization is used.

11. To know the source of radiation and scattering.

12. To characterize the stress-strain distribution in the prototypes, polarization is used.

13. To identify thermally tempered lenses.

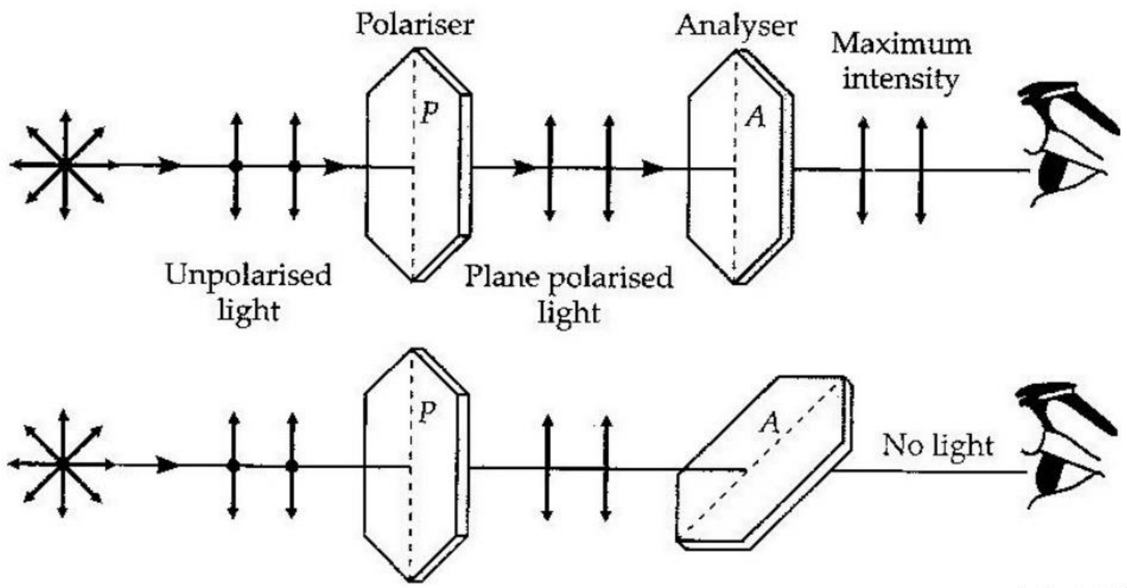
14. In ophthalmic instruments, to eliminate strong reflection from a patient's cornea, the phenomenon polarization of light is used.

15. As light passes through the atmosphere polarization of light is observed

16. The scattered light is known to give rise to various colors in the sky

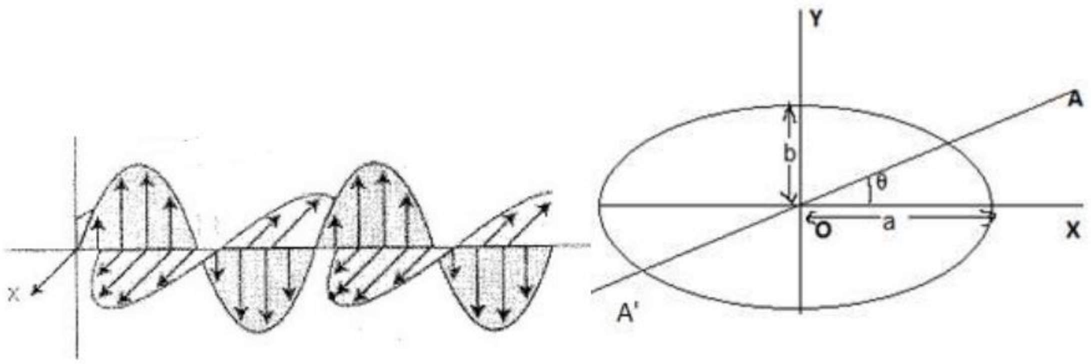
17. It is used in seismology to study earthquakes.

18. To identify surface defects or other otherwise hidden structures.



Producing & Analysing an elliptically polarized light:

When a beam of plane polarized light is sent through a thin doubly refracting plate, it breaks up into two coherent plane polarized components vibrating at right angles to each other with a certain phase difference. The emergent light is the resultant of these two components and is in general elliptically polarized. The constant of the elliptical polarization i.e. The phase difference between the two component and the ratio of the ellipse, depends upon the thickness and optical properties of the doubly refracting plate used, and upon the angle which the plane of vibration of the incident light make with the principal plane of the plate. The angle should be different from 0, $\pi/4$ and $\pi/2$, because angles 0 and π/2 cause the emergent light plane polarized, while the angle π/4 cause it circularly-polarized. When the given elliptically- polarized light is passed through an analyzer rotating about the direction of light as axis, a variation in intensity is observed but the minimum intensity is not zero. The intensity is a maximum when the principal section of the analyzer is parallel to the major axis of the elliptic vibration and minimum when parallel to the minor axis. This light is then transmitted through the rotating analyzer and is allowed to fall on Light Detector or Luxmeter (Photo devices) where the light intensity is measured for the various orientations of the analyzer.



INITIAL ADJUSTMENT OF THE EXPERIMENTAL SET-UP

1. Put all the upright on the optical bench and mount polarizer, analyzer, quarter wave plate and detector in suitable upright on the optical bench as shown in above Fig. All the above items like polarizer, analyzer and quarter wave plate can be rotated in their own planes about the axis of the light beam and the positions of polarizer and analyzer can be read on the circular scales provided with them.
2. Put the monochromatic light at one end of the optical bench as shown in the above Fig. Align the source with polarizer, analyzer, quarter wave plate and detector such that the light from the source is allowed to fall on the polarizer and then on quarter wave plate to make it elliptically polarized. It is then transmitted through the analyzer A, the intensity of transmission being different for different orientation of the analyser A. The transmitted light is received by the detector or the lux meter.

METHOD:

3. Adjust the polarizer P and quarter wave plate Q in relative such that by the rotation of analyzer A about the axis of light the intensity of the light varies between the maximum and minimum but is never zero. This ensures that the light emerging from quarter wave plate is elliptically polarized. In this position the adjustment of P and quarter wave plate is not disturbed for one set of observations.

4. When the light is going through polarizer, analyser and then into a detector make sure polarizer and analyser transmission axes are parallel. To do this, keep the polarizer fixed and rotate the analyser until you observe a maximum intensity. At this point the axes of polarizer and analyser are parallel.

5. Rotate the analyzer A in steps of 10° and note the corresponding current in Lux meter. This is done until Analyser is given a full rotation of 360°. Make table as shown below.

6. Plot the graph for intensity of light (I) vs (θ) orientation of the analyzer on a polar graph. The maximum value of the radius vector defines θ =0° (or 180°) and the minimum value defines θ = 90° (or 270°). The shape of the curve obtained resembles the figure of eight.

Result: On rotating the analyzer with respect to polarizer it is observed that the intensity of light varies between the maximum and minimum, hence it confirms the light emerging from quarter wave plate is elliptically polarized light.

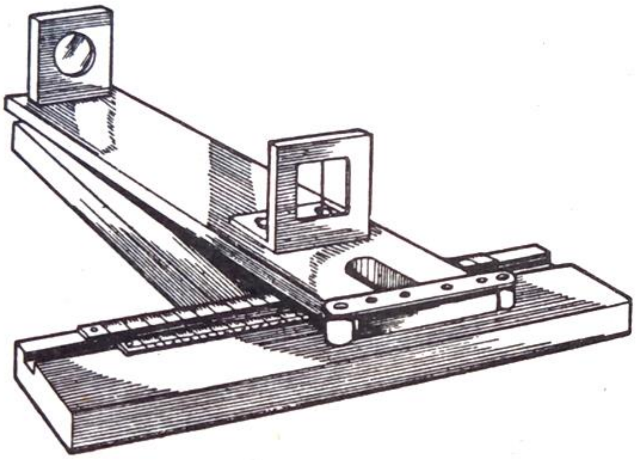
6. GONIOMETER

Aim: Find the equivalent focal length and cardinal points of the given optical system.

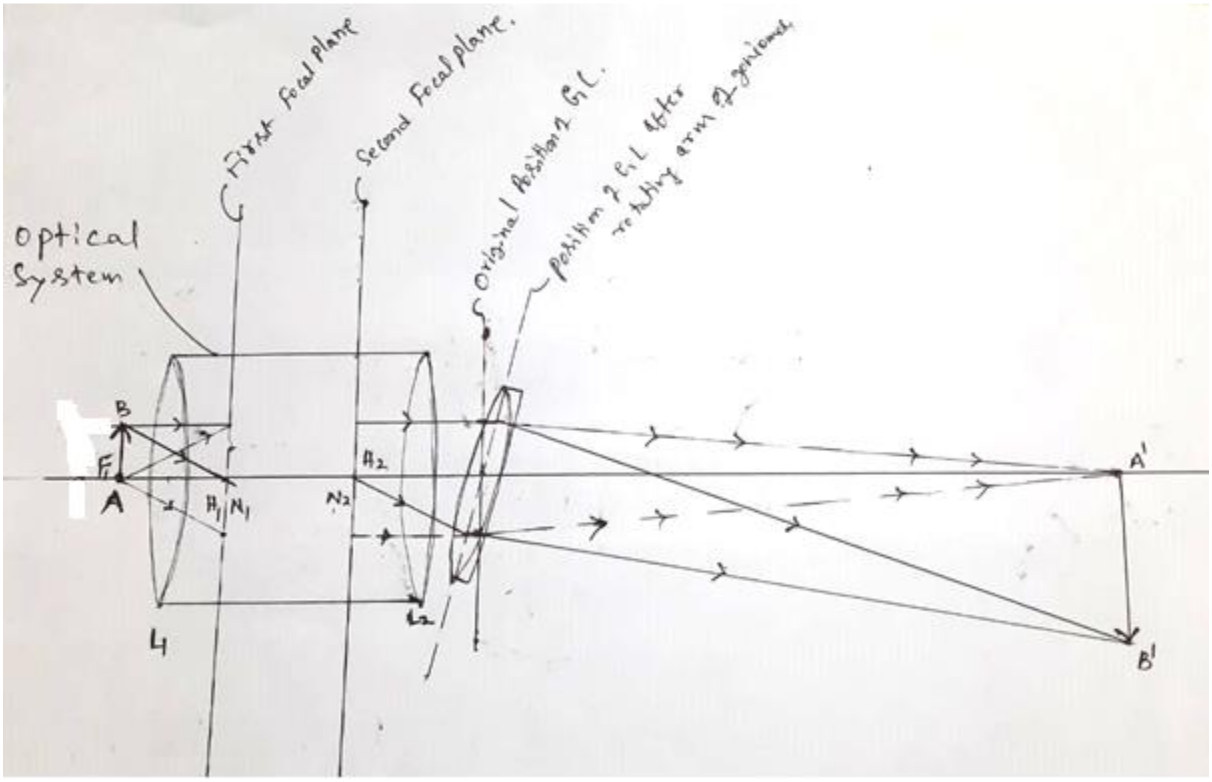
Apparatus: Goniometer, Optical systems or two lens combinations, scale plane mirror vertical wire etc.

Figure:

Experimental Set up of the Optical system:



Ray Diagram



Theoretical Formula :

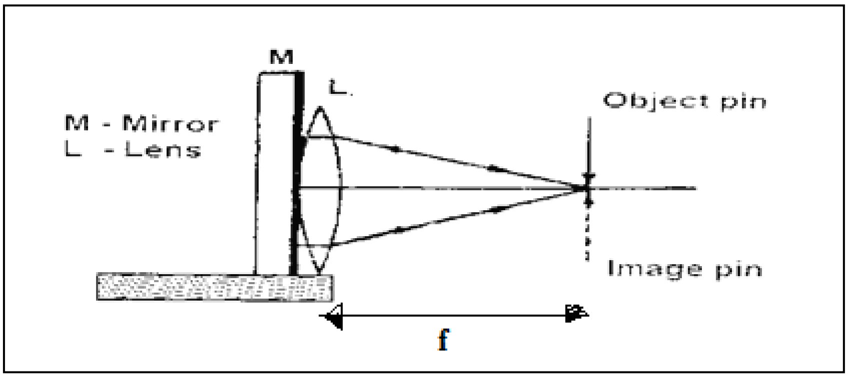
$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1 f_2}$$

where F = Focal length of the system

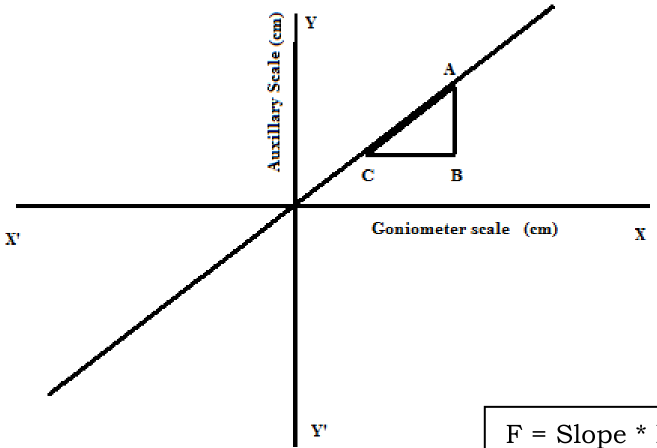
f_1, f_2 Focal lengths of individual lenses L_1 and L_2 ,

d = Separation between two lenses L_1 and L_2

Ray diagram to find the focal length of individual lens



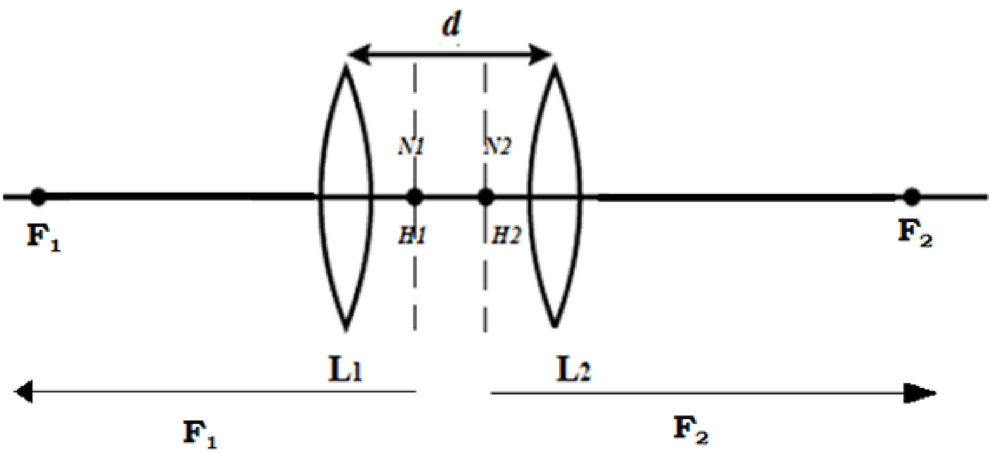
Nature of Graph:



F = Slope * L

where L is Goniometer arm length

Representation of Cardinal Points



L_1L_2 = d = Distance between two lenses

N_1 and N_2 = Nodal Points

H_1 and H_2 = Principal Points

F_1 and F_2 = Focal Points

L_1F_1 = Distance between auxillary scale and lens L_1

L_2F_2 = Distance between auxillary scale and lens L_2

Observations:

1) Length of the Goniometer arm L =____cm.
2) Focal length of the lens L_1, f_1 =_____cm.
3) Focal length of the lens L_1, f_2= _____cm.
4) Distance between the system of two lens d = ______cm.

Calculation:

1. Verify the relation:

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1-f_2} \quad \textbf{Or} \quad F=\frac{f_1 f_2}{f_1+f_2-d}= \_\_\_\_ cm$$

2. From Graph:

$$F=\frac{F_1+F_2}{2}= \_\_\_\_ cm$$

To determine the equivalent focal length and the cardinal points of the given optical system:

When auxillary scale is in the first focal plane of the system **Distance L_1F_1 = ________ cm**				When auxillary scale is in the Second focal plane of the system **Distance L_2F_2 = ________ cm**			
Side	**Readings on**			**Side**	**Readings on**		
	Auxillary Scale (in mm)	**Goniomete r Scale (in cm)**	**Shift on Goniometer Scale (in mm)**		**Auxillar y Scale (in mm)**	**Goniomete r Scale (in cm)**	**Shift on Goniomete r Scale (in mm)**
Left		a_0 = 0	a_0-a_0= 0	**Left**		a_0 = 0	a_0-a_0= 0
	-1	a_1 =	a_1-a_0=		**-1**	a_1 =	a_1-a_0=
	-2	a_2 =	a_2-a_0=		**-2**	a_2 =	a_2-a_0=
	-3	a_3 =	a_3-a_0=		**-3**	a_3 =	a_3-a_0=
	-4	a_4 =	a_4-a_0=		**-4**	a_4 =	a_4-a_0=
	-5	a_5 =	a_5-a_0=		**-5**	a_5 =	a_5-a_0=
Right		a_0 =	a_0-a_0= 0	**Right**		a_0 =	a_0-a_0= 0
	1	a_1 =	a_1-a_0=		**1**	a_1 =	a_1-a_0=
	2	a_2 =	a_2-a_0=		**2**	a_2 =	a_2-a_0=
	3	a_3 =	a_3-a_0=		**3**	a_3 =	a_3-a_0=
	4	a_4 =	a_4-a_0=		**4**	a_4 =	a_4-a_0=
	5	a_5 =	a_5-a_0=		**5**	a_5 =	a_5-a_0=

Result: Equivalent focal length of the system of lenses

1. Experimentally Obtained = ______cm
2. Graphically Obtained = ______cm

7.DIFFRACTION AT A SINGLE SLIT USING LASER SOURCE

AIM : Determine the wavelength of a given laser source using single slit diffraction pattern. Take atleast two different distances.

APPARATUS : Laser Source, Single Slit, Screen, Travelling Microscope, etc

FORMULA:

A general condition for a dark fringe of the diffraction pattern is

a $\sin\theta_m$ = mλ where m = ±1 , ±2 , ±3……….(dark fringe)

a = width of the slit.

θ_m = Distance between position of dark fringe of m[th] order and central bright fringe.

For small angle , we replace $\sin\theta_m$ by

$$\text{Sin } \theta_m = \frac{d_m}{2L} , \quad m = 1, 2, 3, \ldots..$$

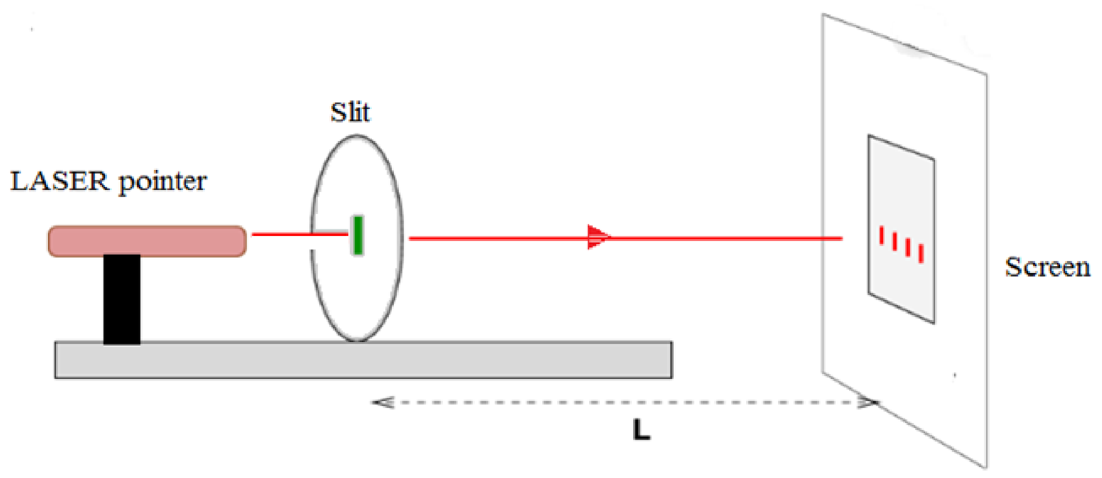
where d_m is the distance between two symmetrical dark fringes of the same order m and L is the distance between the slit and screen.

Substituting we get

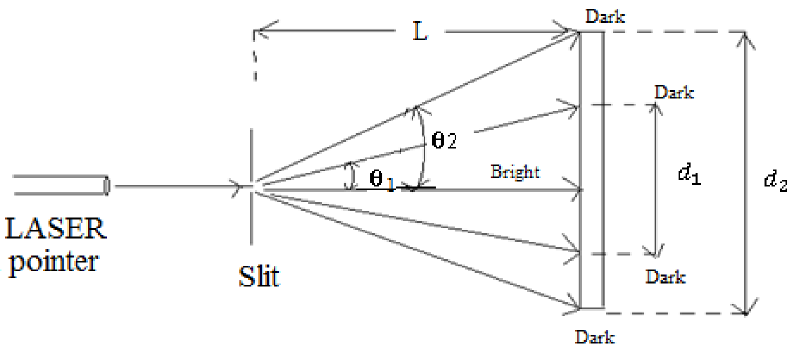
$$\frac{ad_m}{2L} = m\lambda$$

$$\lambda = \frac{ad_m}{2mL} \qquad m = 1,2,3,\ldots\ldots\ldots$$

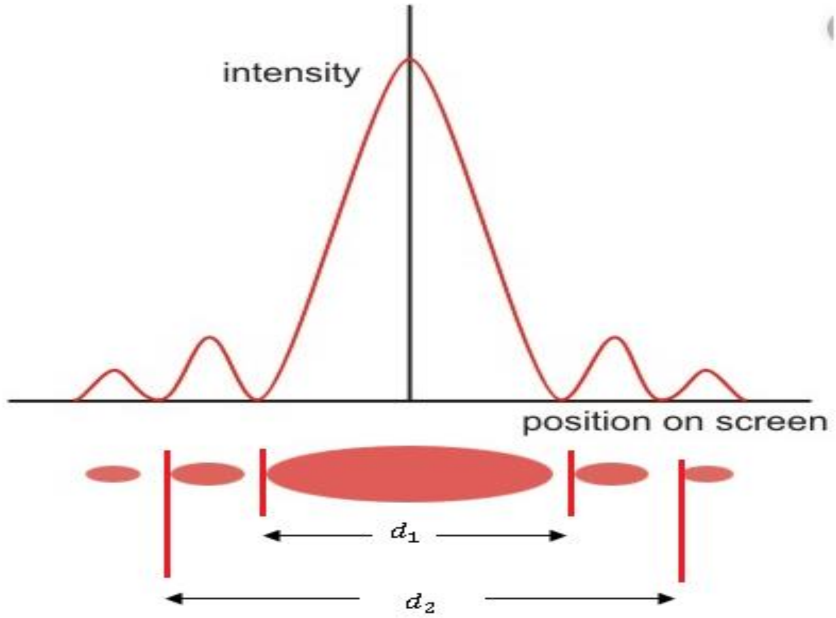
EXPERIMENTAL SETUP



RAY DIAGRAM .1



FRINGE PATTERN



PRINCIPLE : In the Fresnel type diffraction the source of light and screen are at finite distances from the obstacle or aperture at which diffraction takes place. Such diffraction takes place when light suffers diffraction at a straight edge, narrow slit, a thin wire etc.

OBSERVATIONS AND TABULAR COLUMN

I. To estimate the slit width (a)

1. Value of smallest division on main scale 's' = _________cm
2. Total number of divisions on the vernier scale 'N' = ________div
3. Least count of travelling microscope LC = s/N = _________cm

Obs. No,	Left edge A (cm)	Right edge B (cm)	Slit width a = A – B (cm)	Mean slit width a (cm)

Slit width, a = ………….

II. Distance between slit and screen, L = ...cms

Order m	**Distance between two symmetrical dark fringes d_m (cm)**	**Wavelength $\lambda = \frac{ad_m}{2mL}$ (nm)**
1	d_1=	
2	d_2=	
3	d_3=	
4	d_4=	
5	d_5=	
6	d_6=	

Mean λ = _________nm

RESULT : Wavelength of given laser source is **λ** = ___________nm

VIVA QUESTIONS.

1. What is Diffraction of light?

2. What is difference between Diffraction and Interference ?

3. What is the full form of LASER?

4. What are the main properties of LASER beam?

5. Differentiate between Laser beam and ordinary beam light?

6. Object of what size is needed to diffract a light wave?

REFERENCE :

3. C. L. Arora, B. Sc. Practical Physics, S. Chand and Company LTD.
4. Practical Physics by Geeta Sanon.

8. BIPRISM

AIM: Using the given Frenel's Biprism obtain distinct interference fringes and determine the wavelength of the given monochromatic source.

APPARATUS: Optical bench, Sodium lamp, Biprism, Hand lamp, Magnifying lens, Convex lens, etc

FORMULA:

Wavelength of the sodium source = $\lambda = \frac{(S_2 - S_1)d}{(D_1 - D_2)}$ = ________ Å

where

d = $\sqrt{d_1 d_2}$ = Distance between virtual sources

d_1= distance between two magnified images

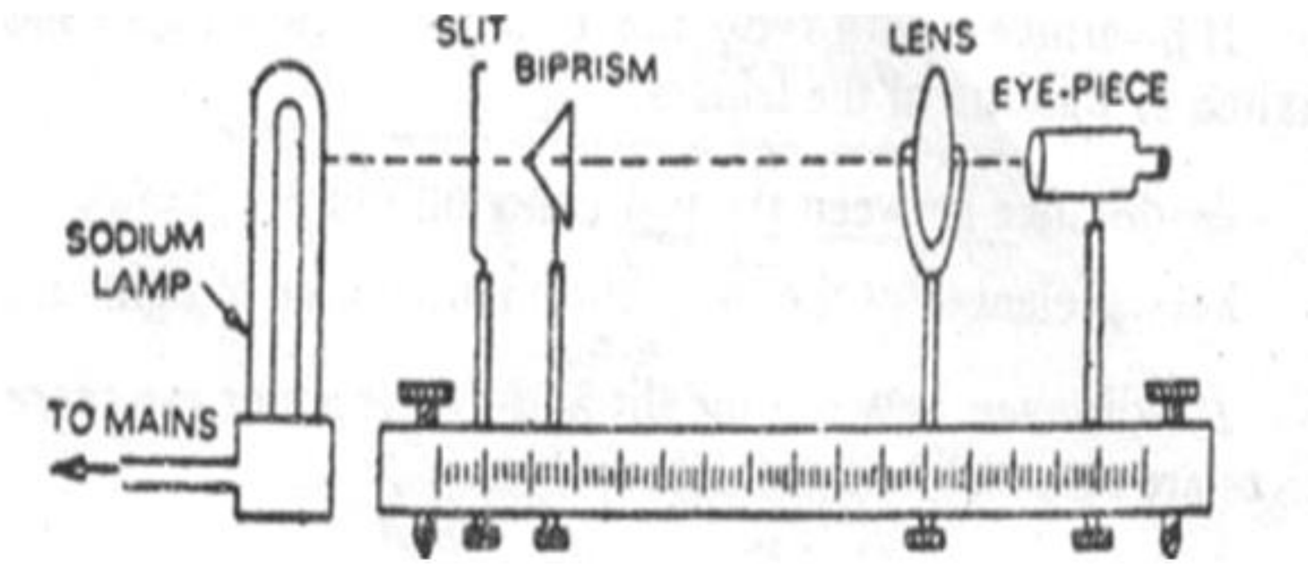
d_2 = distance between two diminished images

S_1 = Width of a fringe when distance is D_1

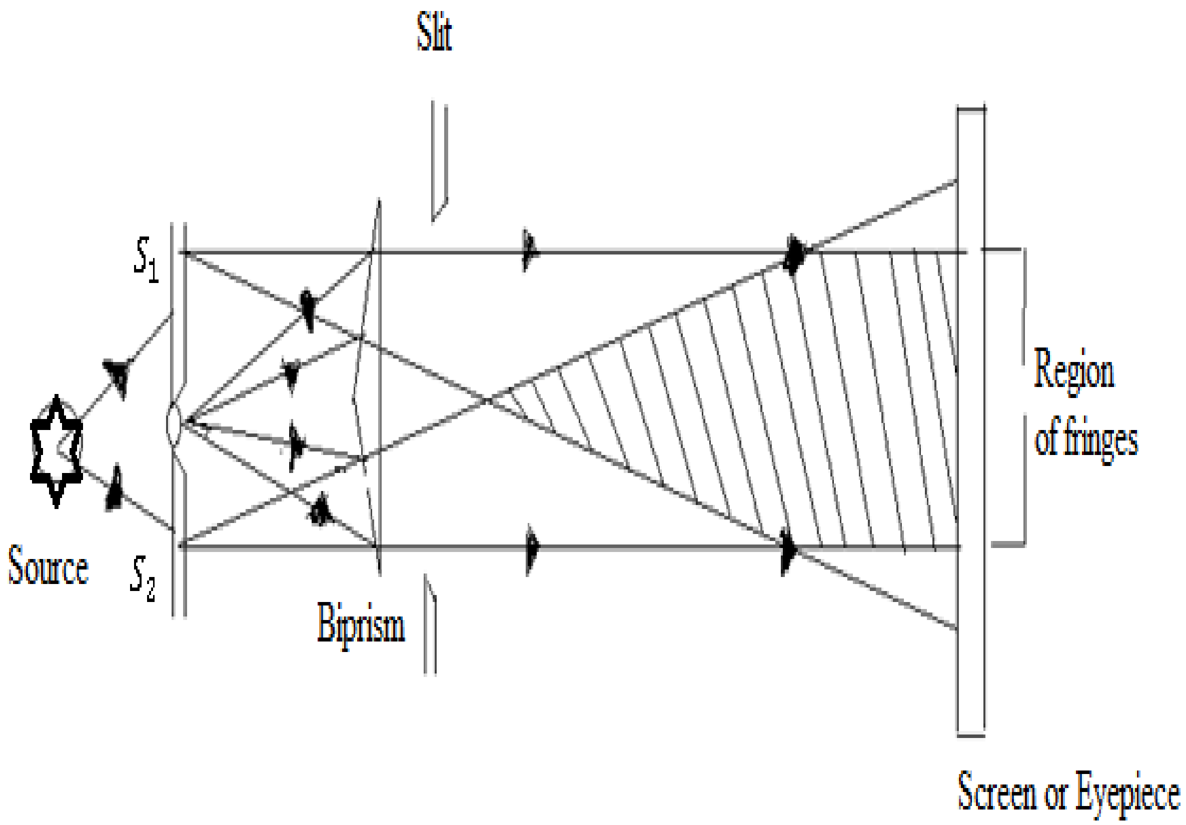
S_2= Width of a fringe when distance is D_2

D_1 AND D_2=Distance between slit and eye piece.

EXPERIMENTAL SETUP

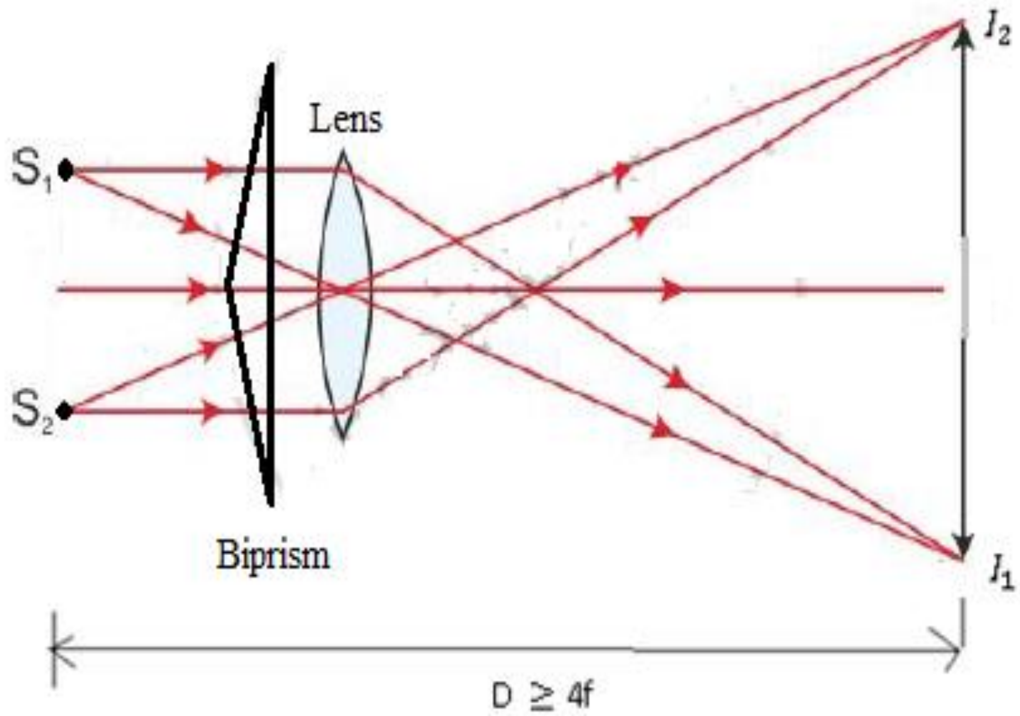


RAY DIAGRAM

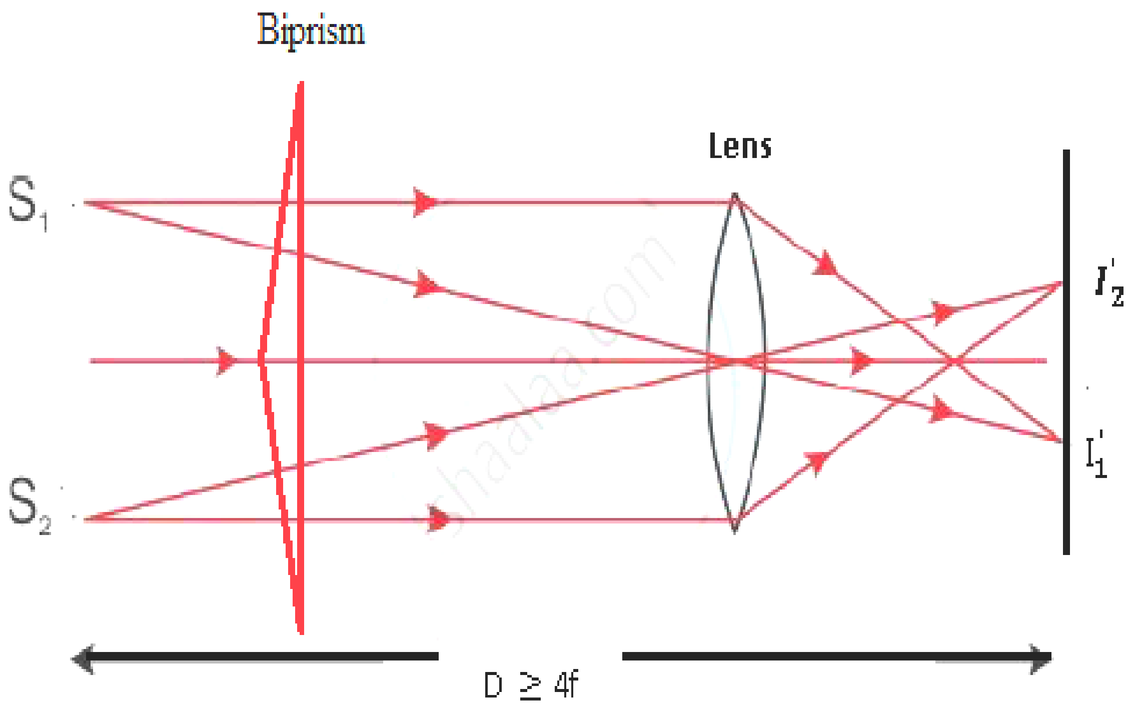


S_1 *and* S_2: Virtual images of' Source acting as two coherent sources.

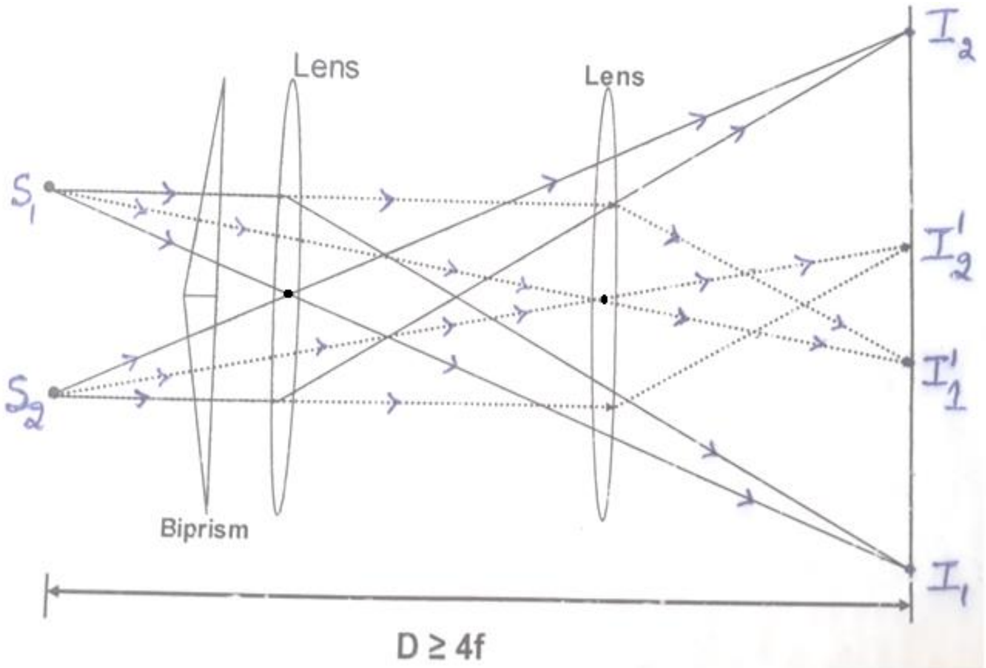
1. **RAY DIAGRAM FOR THE MAGNIFIED IMAGES OF VIRTUAL SOURCES**



2. RAY DIAGRAM FOR THE DIMINISHED IMAGES OF VIRTUAL SOURCE



3. RAY DIAGRAM FOR THEMAGNIFIED AND DIMINISHED IMAGES OF VIRTUAL SOURCE



Note: When ray diagram 1 is superposed on ray diagram 2, ray diagram 3 is produced.

PRINCIPLE: The experiment is based on interference pattern produced due to two coherent sources from a single source with the help of Bi-prism.

Basically a Biprism is regarded as made up of two prism of very small refracting angles placed base to base with an obtuse angle of 179^0 and remaining angles of 30' each.

OBSERVATIONS AND TABULAR COLUMN:

Least count of the micrometer eye piece scale = L.C. = __________cm

1. To determine fringe width.

Distance between slit and eyepiece.	No. of fringes	Micrometer reading **a** (cm)			No. of fringes	Micrometer reading **b** (cm)			Width of five fringes **(a-b)** (cm)	Mean width of five fringes (cm)	Width of a fringe (cm)
		PSR	HSR	TR		PSR	HSR	TR			
D_1 =	1				6					X =	$S_1 = \frac{X}{5}$
	2				7						
	3				8						
	4				9						
	5				10						
D_2=	1				6					Y =	$S_2 = \frac{Y}{5}$
	2				7						
	3				8						
	4				9						
	5				10						

2. To determine distance between diminished and magnified images.

Nature of the image.	**Micrometer reading for** **Image 1** **a** (cm)			**Image 2** **b** (cm)			**Distance between two images (a-b)**
	PSR	HSR	TR	PSR	HSR	TR	
Magnified							d_1=
Diminished							d_2 =

CALCULATIONS.

1. d = $\sqrt{d_1 d_2}$

2. Wavelength of the sodium source = $\lambda = \frac{[(S_2 - S_1)d]}{(D_1 - D_2)}$ = ______________A^o

RESULT : Wavelength of sodium source = ___________A^o

VIVA QUESTIONS

1. What is Biprism?
2. What is meant by the virtual source in Fresnels Biprism experiment?
3. Explain how the fringes are produced with biprism?
4. Why monochromatic light is used in interference?
5. What are the types of interference?
6. What are coherent sources?
7. What is lateral shift in biprism experiment and what is the reason for the lateral shift to appear?

REFERENCE :

1. C. L. Arora, B. Sc. Practical Physics

2. Practical Physics by Geeta Sanon.

9.TURN TABLE

Aim: Find the equivalent focal length and cardinal points of the given optical system. Locate cardinal points on the graph sheet, and verify the relation $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$

Apparatus: Turn table capable of rotating about vertical axis, Optical system, scale, plane mirror, vertical pins etc.

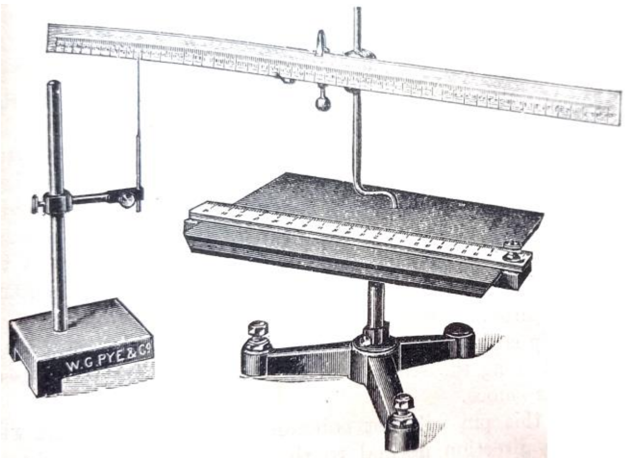
Theoretical Formula :

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

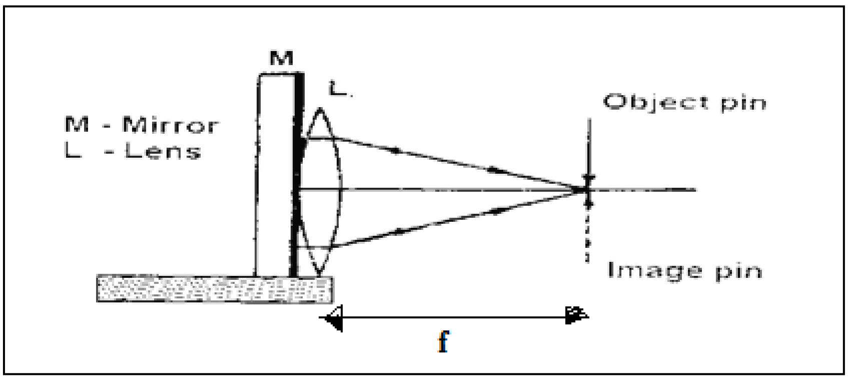
where F = Focal length of the system

f_1, f_2 Focal lengths of individual lenses L_1 and L_2 ,

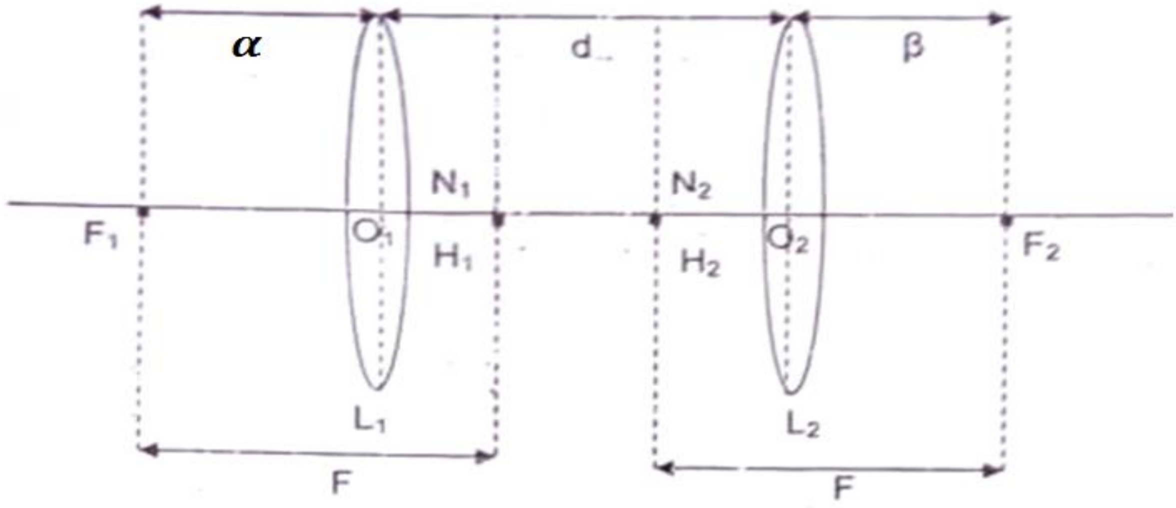
d = Separation between two lenses L_1 and L_2



Ray diagram to find the focal length of individual lens



Representation of Cardinal Points



L_1 and L_2 = system of two convex lenses

L_1L_2 = d = Distance between two lenses

N_1 and N_2 = Nodal Points

H_1 and H_2 = Principal Points

F_1 and F_2 = Focal Points

$F_1 N_1 = F_1 H_1 = F$

$F_2 N_2 = F_2 H_2 = F$

$F_1 O_1 = \alpha$

$F_2 O_2 = \beta$

Note : To locate the Cardinal points use the experimental value of focal length

Observations:

1) Focal length of the lens L_1, f_1 =_____cm.

2) Focal length of the lens L_1, f_2 = _____cm.

3) Perpendicular distance between two pins for the adjustment of the axis of the system, x = _______ cm.

4) Distance through which the lens system is to be shifted so that two axis will intersect, $x/2$ = ________cm.

TABULAR COLUMN

Distance between L_1 and L_2 d (cm)	Lens L_1 facing the object				Lens L_2 facing the object				Mean focal length of the system F (cm)
	Distance between L_1 and pin α (cm)	Scale reading for the position of the pin 'a' (cm)	Scale reading for the position of the pin after reversing 'b' (cm)	Focal length of the system $F_1 = \frac{\|a-b\|}{2}$ (cm)	Distance between L_2 and pin α (cm)	Scale reading for the position of the pin 'a' (cm)	Scale reading for the position of the pin after reversing 'b' (cm)	Focal length of the system $F_2 = \frac{\|a-b\|}{2}$ (cm)	

Result:

Trial No.	Distance between L_1 and L_2 d (cm)	Theoretical value of focal length $F = \frac{f_1 f_2}{f_1 + f_2 - d}$ (cm)	Experimental value of focal length determined using turn table F (cm)

KARNATAK SCIENCE COLLEGE, DHARWAD.
Department of Physics
B.Sc III Semester

DISPERSION CURVE AND DISPERSIVE POWER

Aim: To obtain the dispersion curve for the given prism & to determine the Dispersive power of the material of the prism with respect to the following wave lengths.

λ_1 = ________ AU
λ_2 = ________ AU

Apparatus: Spectrometer, Prism, Mercury source, Spirit level, Magnifying lens, Hand lamp, etc.,

Formulae:

1) Refractive index of the material of the prism for light of different wave lengths is given by

$$\mu_\lambda = [\sin((A + \delta_\lambda)/2) / \sin(A/2)]$$

Where, μ_λ – Refractive Index for corresponding wave length λ
$\bar{\delta}_\lambda$ – Mean angle of deviation for corresponding wave length λ
A – Mean angle of the prism

2) Dispersive power of the material of prism with respect to λ_1 & λ_2 wavelength is given by

$$\omega = \frac{(\mu_{\lambda 1} - \mu_{\lambda 2})}{(\mu - 1)}$$

Where, $\mu_{\lambda 1} = \mu_1$ = Refractive index of material of prism for λ_1 light = ...
$\mu_{\lambda 2} = \mu_2$ = Refractive index of material of prism for λ_2 light = ...

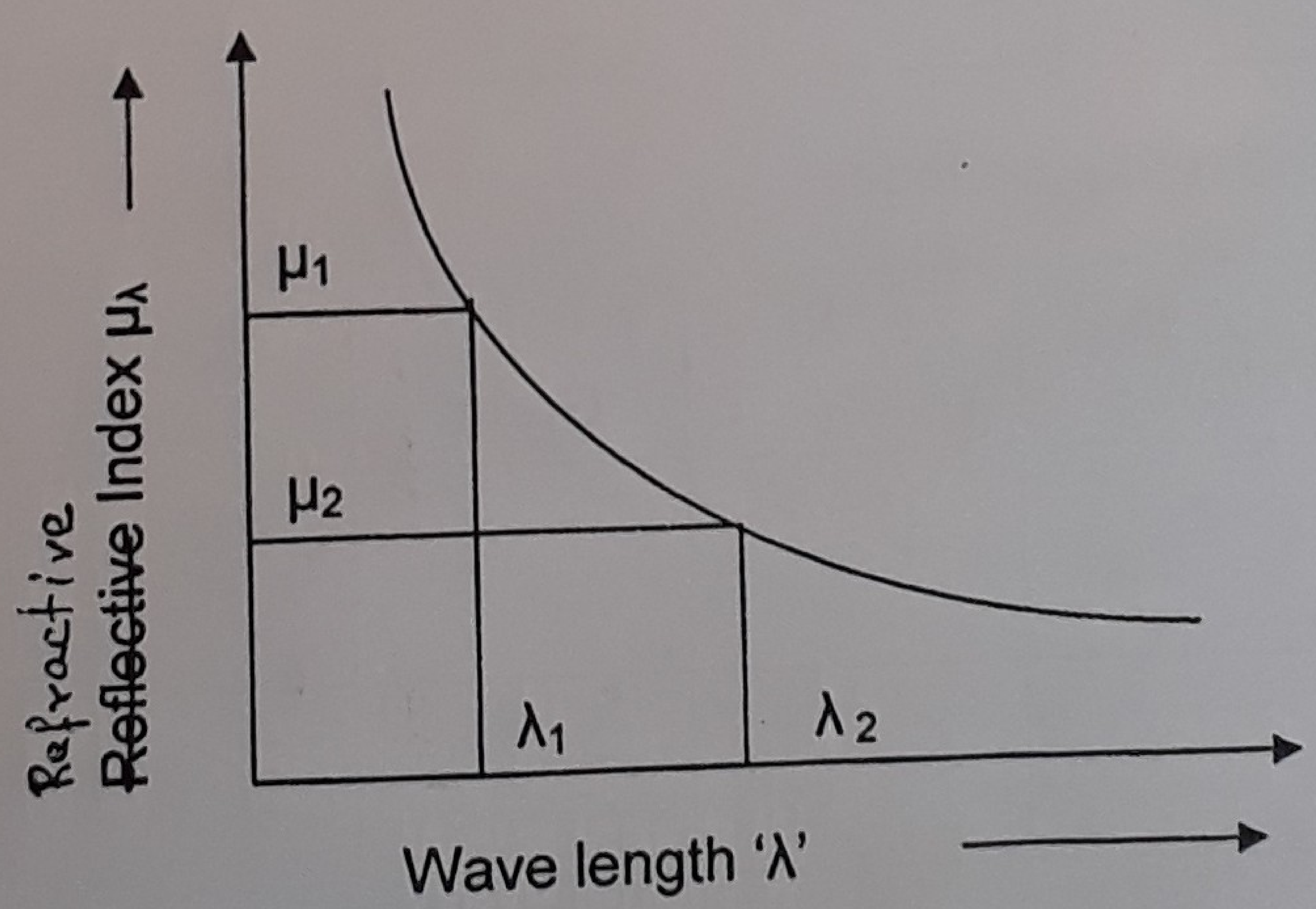
Where, $\mu = \frac{(\mu_{\lambda 1} + \mu_{\lambda 2})}{2}$

Observations:

1) Least count of the Spectrometer, L.C = ________ minute

Nature of the Graph:

DISPERSIVE CURVE



Tabular Column:

1. To determine the angle of the prism.

Scale reading when Telescope is focused on	Vernier A	Vernier B
One surface	X =	Y =
Another Surface	X_1 =	Y_1 =
Angle of the prism	$A_1 = \frac{(X \sim X_1)}{2}$	$A_2 = \frac{(Y \sim Y_1)}{2}$
Mean angle of the prism	$A = \frac{(A_1 + A_2)}{2}$	

2. To determine the angle of minimum deviation.

Wavelength & Colour of the Spectral line (in AU)	Spectrometer reading for minimum deviation.		Angle of minimum deviation		Mean angle of minimum deviation $\delta = \frac{\delta_1+\delta_2}{2}$
	Vernier A X_1	Vernier B Y_1	$\delta_1 = X \sim X_1$	$\delta_2 = Y \sim Y_1$	
5791 Yellow – 1					
5770 Yellow – 2					
5461 Green					
4358 Blue					
4078 Violet – 1					
4047 Violet – 2					
Direct rays reading	X =	Y =	-	-	-

3. To determine the refractive index

Wavelength (in AU)	5791 Yellow – 1	5770 Yellow – 2	5461 Green	4358 Blue	4078 Violet – 1	4047 Violet – 2
Angle of minimum deviation 'δ'						
Refractive index 'μ'						

Calculation of Refractive Index (RI):

Refractive index of the material of the prism for light of different wave lengths is given by

$\mu_\lambda = [\sin((A + \delta_\lambda)/2) / \sin(A/2)]$

Calculations of Dispersive power:

1) Refractive index of material of prism for λ_1 light = $\mu_1 = \mu_{\lambda 1}$ = ………………
2) Refractive index of material of prism for λ_2 light = $\mu_2 = \mu_{\lambda 2}$ = ………………
3) Dispersive power of the material of prism with respect to λ_1 & λ_2 wavelength is given by

$$\omega = \frac{(\mu_{\lambda 1} - \mu_{\lambda 2})}{(\mu - 1)}$$

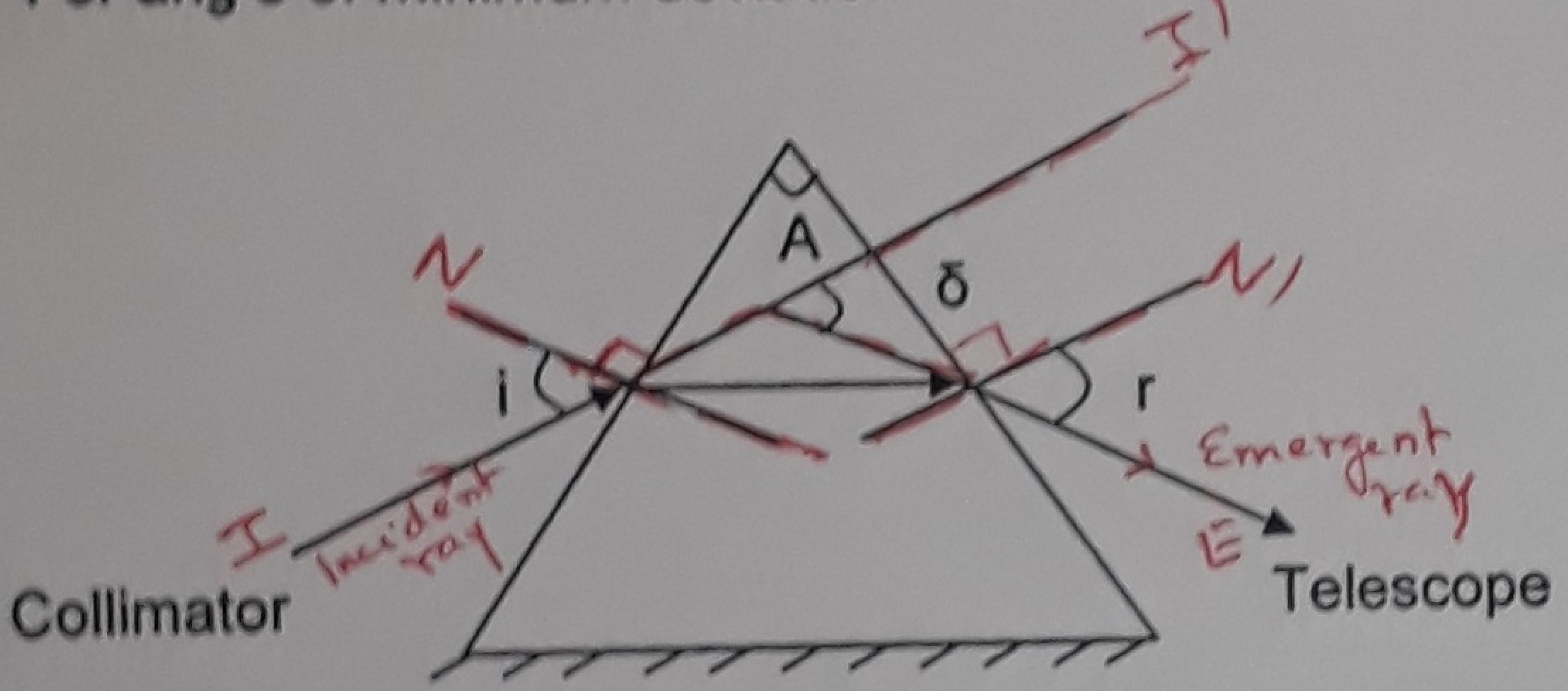
Where, $$\mu = \frac{(\mu_{\lambda 1} + \mu_{\lambda 2})}{2}$$

Result:

Dispersive power, ω = ………………

Ray Diagram:

1. For angle of minimum deviation



2. For angle of prism