Manonmaniam Sundaranar University,

Directorate of Distance & Continuing Education,

Tirunelveli - 627 012 Tamilnadu, India

OPEN AND DISTANCE LEARNING (ODL) PROGRAMMES

(FOR THOSE WHO JOINED THE PROGRAMMES FROM THE ACADEMIC YEAR 2023–2024)

II YEAR

B.Sc. Physics

Course Material

Core Practical

Prepared
By

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COURSE	**FOURTH SEMESTER - CORE PRACTICAL 4**
COURSETITLE	**PHYSICS PRACTICAL IV**
CREDITS	3
COURSE OBJECTIVES	Demonstrate various optical phenomena principles, working, apply with various materials and interpret the results. Also, construct circuits to learn about the concept of electricity and magnetism.

Minimum of Six Experiments from the list:

1. Determination of refractive index of prism using spectrometer.
2. Determination of refractive index of liquid using hollow prism and spectrometer
3. Determination of dispersive power of a prism.
4. Determination of radius of curvature of lens by forming Newton‘s rings.
5. Determination of thickness of a wire using air wedge.
6. Determination of Cauchy‘s Constants.
7. Determination of resolving power of grating
8. Determination of refractive index of a given liquid by forming liquid lens
9. Determination of refractive index - by forming Newton‘s rings
10. Spectrometer - grating – oblique incidence - dispersive power
11. Tangent Galvanometer – Horizontal earth‘s magnetic induction
12. Spectrometer - grating – oblique incidence -Wave length of Mercury spectral lines
13. Ballistic Galvanometer – Absolute capacity of a condenser
14. Ballistic Galvanometer – Comparison of Capacitances (C1 / C2)
15. Determination of refractive index using Laser.

Note : Use of digital balance, digital screw gauge, digital calipers are permitted

1. DETERMINATION OF REFRACTIVE INDEX OF PRISM USING SPECTROMETER

AIM:

To determine the refractive index of a prism by using a spectrometer.

APPARATUS REQUIRED:

Spectrometer, prism, mercury vapour lamp, spirit level and reading lens.

FORMULA USED:

The refractive index μ of the prism is given by the following formula:

$$\mu = \frac{sin\left(\frac{A+D}{2}\right)}{Sin\left(\frac{A}{2}\right)}$$

Where A = angle of the prism, D = angle of minimum deviation.

PROCEDURE:

The following initial adjustments of the spectrometer are made first.

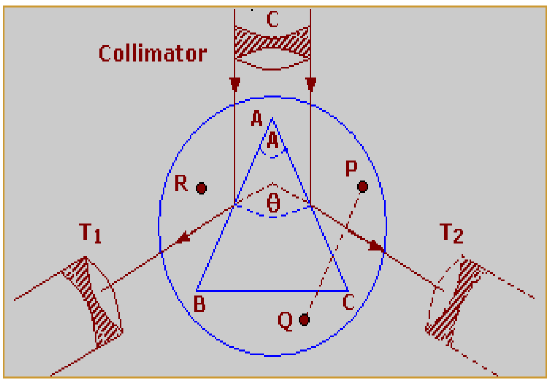
- The spectrometer and the prism table are arranged in horizontal position by using the leveling screws.
- The telescope is turned towards a distant object to receive a clear and sharp image.
- The slit is illuminated by a mercury vapour lamp and the slit and the collimator are suitably adjusted to receive a narrow, vertical image of the slit.
- The telescope is turned to receive the direct ray, so that the vertical slit coincides with the vertical crosswire.
- Determine the least count of the spectrometer.
- Place the prism on the prism table with its refracting angle A towards the collimator and with its refracting edge A at the centre. In this case some of the light falling on each face will be reflected and can be received with the help of the telescope.
- The telescope is moved to one side to receive the light reflected from the face AB and the cross wires are focused on the image of the slit. The readings of the two verniers are taken.
- The telescope is moved in other side to receive the light reflected from the face AC and again the cross wires are focused on the image of the slit. The readings of the two verniers are taken.

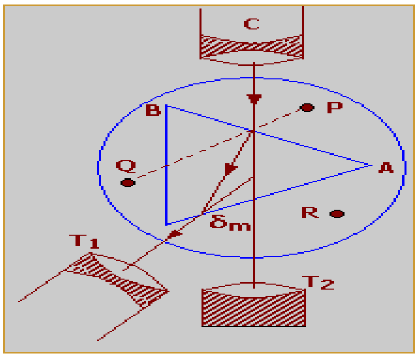
• The angle through which the telescope is moved; or the difference in the two positions gives twice of the refracting angle *A* of the prism. Therefore, half of this angle gives the refracting angle of the prism.

(A) Measurement of the angle of minimum deviations:

- Place the prism so that its center coincides with the center of the prism table and light falls on one of the polished faces and emerges out of the other polished face, after refraction. In this position the spectrum of light is obtained.
- The spectrum is seen through the telescope and the telescope is adjusted for minimum deviation position for a particular colour (wavelength) in the following way: Set up telescope at a particular colour and rotate the prism table in one direction, of course the telescope should be moved in such a way to keep the spectral line in view. By doing so a position will come where a spectral line recedes in opposite direction although the rotation of the table is continued in the same direction. The particular position where the spectral line begins to recede in opposite direction is the minimum deviation position for that colour. Note the readings of two verniers.
- Remove the prism table and bring the telescope in the line of the collimator. See the slit directly through telescope and coincide the image of slit with vertical crosswire. Note the readings of the two verniers.
- The difference in minimum deviation position and direct position gives the angle of minimum deviation for that colour.
- The same procedure is repeated to obtain the angles of minimum deviation for the other colours.

Figure: Left: Arrangement to determine the angle of prim.





Right: Arrangement to determine the angle of minimum deviation.

Observations:

(i) Value of the one division of the main scale = ……… degrees

(ii) Total number of vernier divisions = ……….

Least count of the vernier = ………. degrees = ……… second

Table for the angle (A) of the prism.

S.No	Vernier	Telescope reading for reflection						Difference $\theta = a - b = 2A$	Mean value of 2A	A	Mean A degrees
		from first face			from second face						
		MSR	VSR	TR (a)	MSR	VSR	TR (b)				
1	V_1										
	V_2										
2	V_1										
	V_2										
3	V_1										
	V_2										

MSR = Main Scale Reading, VSR = Vernier Scale Reading, TR = MSR+VSR = Total Reading.

Table for the angle of minimum deviation (D).

S.No	Colour	Vernier	Telescope reading for minimum deviation			Telescope reading for direct image			Difference $D = a - b$	Mean value of D
			MSR	VSR	TR (a)	MSR	VSR	TR (b)		
1	Violet	V_1								
		V_2								
2	Yellow	V_1								
		V_2								
3	Red	V_1								
		V_2								

MSR = Main Scale Reading, VSR = Vernier Scale Reading, TR = MSR+VSR = Total Reading.

Calculations:

Angle of the prism = ………

Angle of minimum deviation for violet = ………..

Refractive index for violet = …………..

Angle of minimum deviation for blue = …………..

Refractive index for yellow = ………….

Angle of minimum deviation for red = ………..

Refractive index for red = …………..

S.No	Colour	Calculated refractive index	Standard refractive index	% Error

Result: Refractive index for the material of the prism = __________

2. DETERMINATION OF REFRACTIVE INDEX OF LIQUID USING HOLLOW PRISM AND SPECTROMETER

AIM:

To determine the refractive index of a transparent liquid using hollow prism and spectrometer.

APPARATUS:

Spectrometer, sodium vapour lamp, reading lamp, reading lens, spirit level, hollow glass prism, and the given liquid.

THEORY:

Refractive index μ of the liquid is given by

$$\mu = \frac{sin\left(\frac{A+D}{2}\right)}{Sin\left(\frac{A}{2}\right)}$$

where A is the angle of the prism and

D is the angle of minimum deviation.

PROCEDURE:

Preliminary adjustments of the spectrometer are done and the least count of spectrometer is noted as described earlier (see experiment no. 3). Now spectrometer is ready for use. Here the experiment is done in two steps; first we find the angle of the prism and secondly we find the angle of minimum deviation Clean the hollow glass prism and fill it with the given transparent liquid v refractive index is to be found out. Wipe it dry from outside and see that there air bubbles inside. After this find the angle of the prism.

To find the angle of the prism

First of all, make the base of the prism table horizontal by using spirit level this adjust the levelling screws (3 in number) of the prism table.

To determine the angle of the prism (A) mount the prism on the prism table to its base towards the clamp. The prism table is rotated such that light for collimator falls symmetrically on the faces AB and AC of the prism (see below). The vernier table is clamped. The telescope is adjusted to get the image the slit reflected from the face AB. The telescope is then clamped and adjusted the image of the slit reflected from the face AC without disturbing the arrangement. If the arrangement of the prism is disturbed, we have to again go back to face AB and see whether we get the reflected image after the correction. If not, the process has to be repeated till we get the images from both faces for the position of the prism.

Now the telescope is brought to the face AB to view the brightest image of the slit and clamp the telescope. Then by working the tangential screw the cross wire of the telescope is made to coincide with the image. If the slit is narrow, the point of intersection of the cross wires is kept at the centre of the image. If the slit is not narrow the point of intersection of the cross wire is made to coincide with the fixed edge of the slit. The readings of the circular scale and coinciding vernier divisions on both verniers are noted (this being a circular scale reading will differ by 180°). Then the total reading = main scale reading + verniers scale coincidence division × least count.

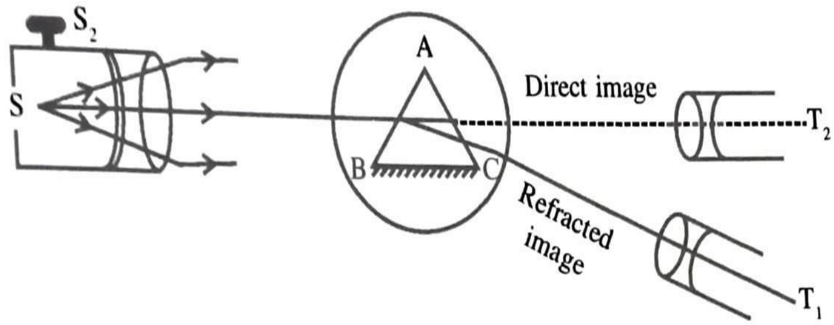
The telescope Is then unclamped and brought to the other face AC to view the image of the slit. After getting the image the telescope is clamped and the crosswire is adjusted to coincide with the image by working the tangential screw. The corresponding reading of both verniers are noted. Then the total readings of each vernier are calculated as before.

The difference in readings of vernier on both faces (AB and AC) gives twice the angle of the prism, from which the angle of the prism A can be found. The mean value of A is found.

To find the minimum deviation

First of all, we have to set the prism in the minimum deviation position. To set the prism in minimum deviation position, place the prism ABC on prism table, such that light coming from collimator falls on the face AC at an acute angle. Look for the spectrum through the face AB. Rotate the prism table gradually. The spectral line also turns. This is because in rotating the prism table angle of incidence changes. Therefore, angle of deviation changes. For a particular position of the prism, the spectral line becomes stationary. If we rotate the prism further in the same direction the spectral line is seen to move in the opposite direction. Fix the prism table, where the spectral line appears stationary. This is the minimum deviation position.

After setting the prism in the minimum deviation position, turn the telescope to the position T, (see figure below), so that its cross wire coincides with the image of the slit. This can be done by fixing the telescope. For fine adjustments make use of the tangential screw. Then take the main scale readings and vernier scale coincidence divisions of both the verniers and calculate the total reading for each vernier as before.



Now the prism is removed. The telescope is brought in line with the collimator to view the direct image of the slit. Fix the telescope and by working the tangential screw the cross wire is made to coincide with the image of the slit. The readings of the main scale and vernier scales are noted then calculate the total reading for each vernier as before. The difference in readings of the corresponding verniers gives the angle of minimum deviation. The mean angle of deviation is found out.

Knowing A and D, the refractive index of the material of the given liquid u can be calculated by using the formula.

$$\mu = \frac{sin\left(\frac{A+D}{2}\right)}{Sin\left(\frac{A}{2}\right)}$$

Observations and tabulations

Value of one main scale division = ---------degree = -----------minute

Number of division on the vernier n = -------------------

Least count = $\frac{Value\ of\ 1\ MSD}{n} = ---------\ minute$

Tabular Column to find angle of the prism (A)

∴ Mean 2A =……..

∴ A = …….

	Vernier I			**Vernier II**		
	M.S.R	**V.S.R**	**Total Reading**	**M.S.R**	**V.S.R**	**Total Reading**
Reading of image reflected from face AB(X_1)						
Reading of image reflected from face AC(X_2)						
Difference between X_1 and X_2 (2A)				Difference between X_1 and X_2 (2A)		

Tabular column to find minimum deviation (D)

	Vernier I			**Vernier II**		
	M.S.R	**V.S.R**	**Total Reading**	**M.S.R**	**V.S.R**	**Total Reading**
Reading of image reflected from face AB(X_1)						
Reading of image reflected from face AC(X_2)						
Difference between X_1 and X_2 (2A)				Difference between X_1 and X_2 (2A)		

Mean D =

Angle of the Prism, A = ………………………..

Angle of Minimum deviation, D = ………………

Refractive index of the given transparent liquid

$$\mu = \frac{sin\left(\frac{A+D}{2}\right)}{Sin\left(\frac{A}{2}\right)} =$$

Result

The refractive index of the given transparent liquid μ = ……….

3. DETERMINATION OF DISPERSIVE POWER OF A PRISM

AIM:

To determine the dispersive power of a material of prism using Spectrometer

APPARATUS:

Spectrometer, Prism, Mercury Vapor Lamp etc.

FORMULA:

The dispersive power of the prism is given by

$$w = \frac{\mu_b - \mu_g}{\mu_{av} - 1}$$

Where,

$$\mu_{av} = \frac{\mu_b + \mu_g}{2}$$

$$\mu_b = \frac{\sin\left(\frac{A + D_B}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\mu_G = \frac{\sin\left(\frac{A + D_g}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

A = angle of the prism

D_g = angle of minimum deviation for green colour

D_b = angle of minimum deviation for blue colour

THEORY:

A spectrometer is used to measure the necessary angles. The spectrometer consists of three units: (1) collimator, (2) telescope, and (3) prism table. The prism table, its base and telescope can be independently moved around their common vertical axis. A circular angular scale enables one to read angular displacements (together with two verniers located diametrically opposite to each other).

In the experiment, we need to produce a parallel beam of rays to be incident on the prism. This is done with the help of a collimator. The collimator has an adjustable rectangular slit at one end and a convex lens at the other end. When the illuminated slit is located at the focus of the lens, a parallel beam of rays emerges from the collimator. We can test this point, with the help of a telescope adjusted to receive parallel rays. We first prepare the telescope towards this purpose as follows:

Setting the eyepiece:

Focus the eyepiece of the telescope on its cross wires (for viewing the cross wires against a white background such as a wall) such that a distinct image of the crosswire is seen by you. In this context, remember that the human eye has an average "least distance of distinct vision" of about 25 cm. When you have completed the above eyepiece adjustment, you have apparently got the image of the crosswire located at a distance comfortable for your eyes. Henceforth do not disturb the eyepiece.

Setting the Telescope:

Focus the telescope onto a distant (infinity!) object. Focusing is done by changing the separation between the objective and the eyepiece of the telescope. Test for the absence of a parallax between the image of the distant object and the vertical crosswire. Parallax effect (i.e. separation of two things when you move your head across horizontally) exits, if the cross-wire and the image of the distant object are not at the same distance from your eyes. Now the telescope is adjusted for receiving parallel rays. Henceforth do not disturb the telescope focusing adjustment.

Setting the Collimator:

Use the telescope for viewing the illuminated slit through the collimator and adjust the collimator (changing the separation between its lens and slit) till the image of the slit is brought to the plane of cross wires as judged by the absence of parallax between the image of the slit and cross wires.

Optical leveling of the Prism:

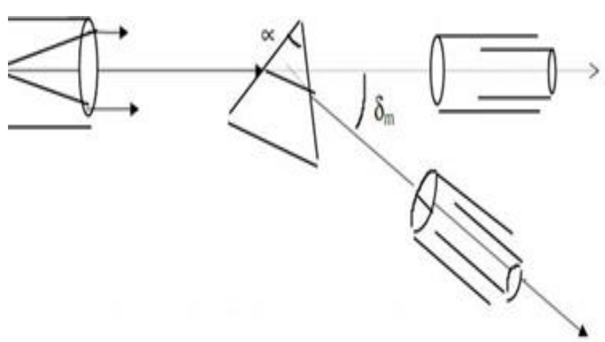
The prism table would have been nearly leveled before uses have started the experiment. However, for your experiment, you need to do a bit of leveling using reflected rays. For this purpose, place the table with one apex at the center and facing the collimator, with the ground (non-transparent) face perpendicular to the collimator axis and away from collimator. Slightly adjust the prism so that the beam of light from the collimator falls on the two reflecting faces symmetrically when you have achieved this lock the prism table in this position. Turn the telescope to one side so as to receive the reflected image of the slit centrally into the field of view. This may be achieved by using one of the leveling screws. The image must be central whichever face is used as the reflecting face. Similarly, repeat this procedure for the other side.

Finding angle of minimum deviation (D_m)

Unlock the prism table for the measurement of the angle of minimum deviation (D_m). Locate the image of the slit after refraction through the prism. Keeping the image always in the field of view, rotate the prism table till the position where the deviation of the image of the slit is smallest.

At this position, the image will go backward, even when you keep rotating the prism table in the same direction. Lock both the telescope and the prism table and to use the fine adjustment screw for finer settings. Note the angular position of the prism.

In this position the prism is set for minimum deviation. Without disturbing the prism table, remove the prism and turn the telescope (now unlock it) towards the direct rays from the collimator. Note the scale reading of this position. The angle of the minimum angular deviation, viz, D_m is the difference between the readings for these last two settings.



OBSERVATION TABLES:

For angle of the prism $2A=120^0$

$A=60^0$

For angle of minimum deviation:

Colour of the spectrum	**Vernier A**			**Vernier B**			**Avg D**
	Direct Reading (R)	**Minimum Deviation(D)**	**D_m = (R-D)**	**Direct Reading(R)**	**Minimum Deviation (D)**	**D_m = $(R-D)_m$**	

RESULT: - The dispersive power of a material of prism using spectrometer is w= …………

4. DETERMINATION OF RADIUS OF CURVATURE OF LENS BY FORMING NEWTON 'S RINGS

AIM:

To observe Newton rings formed by the interface of produced by a thin air film and to determine the radius of curvature of a Plano-convex lens.

APPARATUS:

Traveling microscope, sodium vapour lamp, Plano-convex lens, plane glass plate, magnifying lens.

FORMULA:

The radius of curvature of a convex lens is given by

$R= (D^2_{m-p} - D^2_m) / 4p\lambda$

Where,

D = diameter of the fringe in m

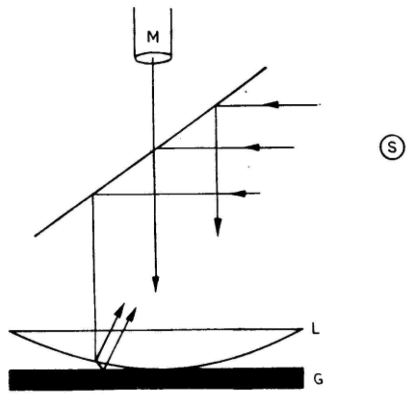
λ = wavelength of a given monochromatic light m & p = order of the fringe

THEORY:

The phenomenon of Newton's rings is an illustration of the interference of light waves reflected from the opposite surfaces of a thin film of variable thickness. The two interfering beams, derived from a monochromatic source satisfy the coherence condition for interference. Ring shaped fringes are produced by the air film existing between a convex surface of a long focus Plano-convex lens and a plane of glass plate.

When a Plano-convex lens (L) of long focal length is placed on a plane glass plate (G), a thin film of air I enclosed between the lower surface of the lens and upper surface of the glass plate. (see fig 1). The thickness of the air film is very small at the point of contact and gradually increases from the center outwards. The fringes produced are concentric circles. With monochromatic light, bright and dark circular fringes are produced in the air film. When viewed with the white light, the fringes are coloured.

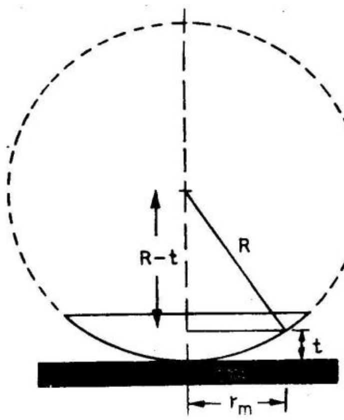
A horizontal beam of light falls on the glass plate B at an angle of 450. The plate B reflects a part of incident light towards the air film enclosed by the lens L and plate G. The reflected beam from the air film is viewed with a microscope. Interference takes place and dark and bright circular fringes are produced. This is due to the interference between the light reflected at the lower surface of the lens and the upper surface of the plate G.



For the normal incidence the optical path difference Between\ the two waves is nearly 2μt, where μ is the refractive index of the film and t is the thickness of the air film. Here an extra phase difference π occurs for the ray which got reflected from upper surface of the plate G because the incident beam in this reflection goes from a rarer medium to a denser medium. Thus, the conditions for constructive and destructive interference are (using μ = 1 for air)

$2t = n\lambda$ for minima n=0,1,2,3……. ……… (1)

And $2t = \left(n + \frac{1}{2}\right)\lambda$ for maxima n=0,1,2,3……. ……… (2)



Then the air film enclosed between the spherical surfaces Of R and a plane surface glass plate, gives circular rings Such that (see fig 2)

$$r_n^2=(2R-t)$$

where r_n is the radius of the n^{th} order dark ring.

(Note: The dark ring is the n^{th} dark ring excluding the central dark spot).

Now R is the order of 100 cm and t is at most 1 cm. Therefore R>>t. Hence (neglecting the t^2 term), giving

$$2t \approx \frac{r_n^2}{R}$$

Putting the value of "2 t" in eq (1) gives

$$2\lambda \approx \frac{r_n^2}{R}$$

With the help of a traveling microscope, we can measure the diameter of the m^{th} ring order dark ring = D_n Then

$$r_n = \frac{D_m}{2}$$

And hence

$$R = \frac{D_n^2}{n}\frac{1}{4\lambda}$$

For diameter of the m+ p th ring

$$R = \frac{D_{(m+p)}^2}{4(m+p)\lambda}$$

Thus,

$R= (D^2{}_{m-p} - D^2{}_m) / 4p\lambda$

So if we know the wave length λ , we can calculate R (radius of curvature of the lens).

PROCEDURE:

1. Clean the plate G and lens L thoroughly and put the lens over the plate with the curved surface below B making angle with G.

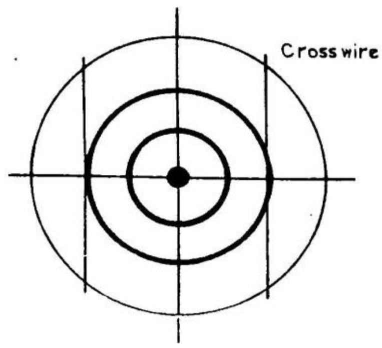
2. Switch in the monochromatic light source. This sends a parallel beam of light. This beam of light gets reflected by plate B falls on lens L.

3. Look down vertically from above the lens and see whether the center is well illuminated. On looking through the microscope, a spot with rings around it can be seen on properly focusing the microscope.

4. Once good rings are in focus, rotate the eyepiece such that out of the two perpendicular cross wires, one has its length parallel to the direction of travel of the microscope. Let this cross wire also passes through the center of the ring system.

5. Now move the microscope to focus on a ring (say, the 20th order dark ring). On one side of the center. Set the crosswire tangential to one ring as shown in fig 3. Note down the microscope reading.

6. Move the microscope to make the crosswire tangential to the next ring nearer to the center and note the reading. Continue with this purpose till you pass through the center. Take readings for an equal number of rings on the both sides of the center.



OBSERVATION:

1. Least count of vernier of traveling microscope = ________________________m
2. Wave length of light = _____________________________m

Table 1: Measurement of diameter of the ring

S.No	Order of the ring (n)	Microscope reading						Diameter		$(D^2_{m-p} - D^2_m)$
		Left side			Right side					
		MS	VS	Net(m)	MS	VS	Net(m)	D(m)	D^2 (m^2)	
1	20									
2	18									
3	16									
4	14									
5	12									
6	10									
7	8									
8	6									
9	4									
10	2									

RESULT:

The radius of curvature of a given planoconvex lens is = m

5. DETERMINATION OF THICKNESS OF A THIN WIRE

(AIR WEDGE METHOD)

AIM:

To determine the thickness of the thin wire by forming the interference fringes using the air wedge set up.

APPARATUS:

Traveling microscope, Sodium vapor lamp, optically plane rectangular glass plates thin wire, reading lens, Condensing lens with stand, Rubber band, wooden box with glass plate inclined at 45^0

FORMULA:

Thickness of the thin wire,

$$t = l\lambda/2\beta$$

Where,

l = Distance between the edge of contact and the wire m

λ = Wavelength of sodium light m

β.. = Mean fringe width m

PRINCIPLE:

A wedge-shaped air film is formed when a thin wire is introduced between two optically plane glass plates. When a parallel beam of monochromatic light is incident normally on this arrangement, interference occurs between the two rays; one is reflected from the front surfaces and the other at the back. These two reflected rays produce a pattern of alternate dark and bright interference fringes.

PROCEDURE:

Two optically plane glass plates are placed one over the other and are tie together by means of a rubber band at one end. The given thin wire is introduced in between the two glass plates, so that an air wedge is formed between the plates as shown in fig.14 this set up is placed on the horizontal bed plate of the traveling microscope.

The sodium vapor lamp is used as a source and is rendered parallel by means of a condensing lens. The parallel beam of light is incident on a plane glass plate inclined at an angle of 450° and gets reflected. The reflected light is incident normally on the glass plate in contact. Interference takes place between the light reflected from the top and bottom surfaces of the glass plate and is viewed through the traveling microscope. Therefore, the number of equally spaced dark and bright fringes are formed which are parallel to the edge of contact.

For the calculation of the single fringe width the microscope is adjusted so that the bright or dark fringe near the edge of contact is made to coincide with the vertical cross wire and this is taken as the nth fringe. The reading from the horizontal scale of the traveling microscope is noted. The microscope is moved across the fringes using the horizontal transverse screw and the readings are taken when the vertical cross wire coincides with every successive 3 fringes. The mean of this gives the fringe width (β). The cross wire is fixed at the inner edge of the rubber band and the readings from the microcopies noted. Similarly reading from the microscope is noted keeping the cross wire at the edge of the material. The difference between these two values gives the value of '*l*'. Substituting the value and *l* in the equation then the thickness of the given thin wire can be determined.

BLOCK DIAGRAM:

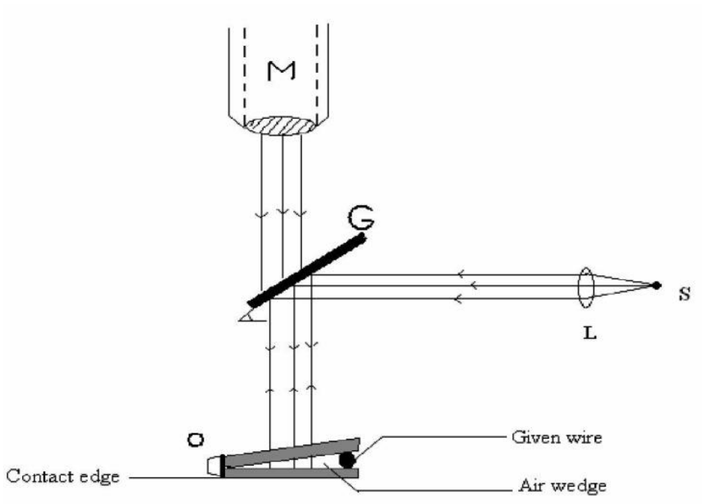


Figure:1

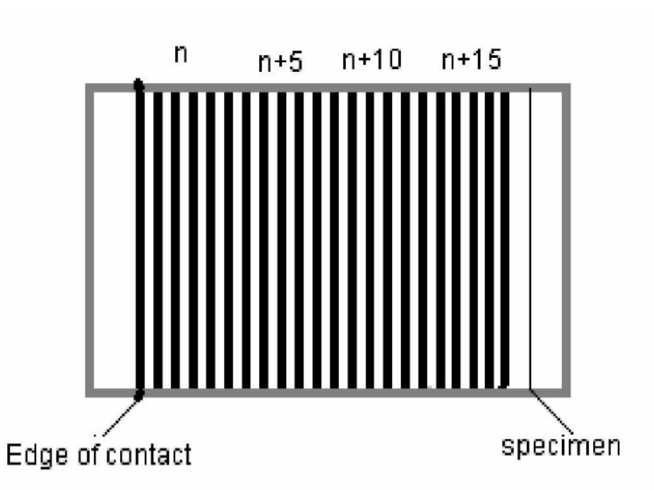


Figure:2

TABLE 1`: To determine the fringe with by traveling microscope Least count =0.001cm

Order of the fringe	**MSR Reading**			**Width of 10 fringe**	**Mean Width of 1 fringeβ**
	MSR	**VSR**	**Total**		
n					
n+5					
n+10					
n+15					
n+20					
n+25					
n+30					
n+35					

Mean β= x 10^{-2}m

CALCULATION:

Wavelength of the monochromatic light = 5893 Å

Distance between the edge of contact and the wire ***l*** = m Fringe width = m

Thickness of the wire, t =

RESULT:

Thickness of the given thin wire t = _____________x 10^{-2}m

6. DETERMINATION OF CAUCHY'S CONSTANTS

Aim:

To determine Cauchy's Constants using a prism and spectrometer.

Apparatus:

Glass prism, spectrometer and mercury vapour lamp.

Theory:

The wavelength dependence of refractive index of a dielectric medium can be approximated by

$$\mu = A + \frac{B}{\lambda^2}$$

where μ represents the refractive index at wavelength λ and A and B are constants. The above equation is known as Cauchy's formula and A and B are known as Cauchy's constants. As is obvious from the above formula, a curve between μ and $1/\lambda^2$ is a straight line whose intercept with the y axis gives A and slope with respect to the x-axis gives B. Thus we can easily find Cauchy's constants as discussed below.

A parallel beam of white light from a source (mercury lamp) is passed through a prism. One would observe a spectrum on the other side of the prism. The prism is then set in the position of minimum deviation and the angle of minimum deviations corresponding to different colors are measured with the help of the spectrometer. The refractive index at different wavelengths can be calculated using the following well known formula:

$$\mu = \frac{\sin\frac{A_0 + D_m}{2}}{\sin\frac{A_0}{2}}$$

Here A_0 is the angle of the prism and D_m is the angle of minimum deviation. [Note: The wavelengths of various lines observed in light from mercury vapour lamp are provided in the laboratory.]

Experiment:

A spectrometer consists of a collimator which is mounted on the rigid arm and a telescope mounted on the rotation table arm which can rotate in a horizontal plane about the axis of the instrument. A prism table of adjustable height is mounted along the axis of rotation of the telescope. A circular scale and vernier arrangement is provide to enable measurement of the angle through which the telescope arm or the prism table is rotated.

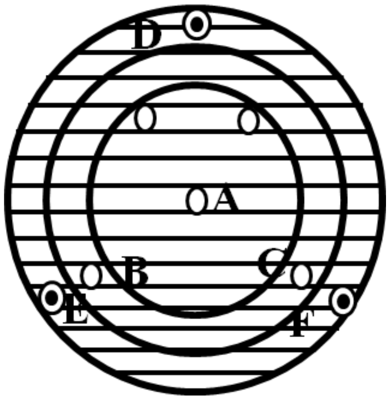


Figure 1: Top view of the prism table showing relevant details. A - rotation axis of the prism table. B,C - Threaded screw holes to fix grating stand. D,E,F - Leveling screws.

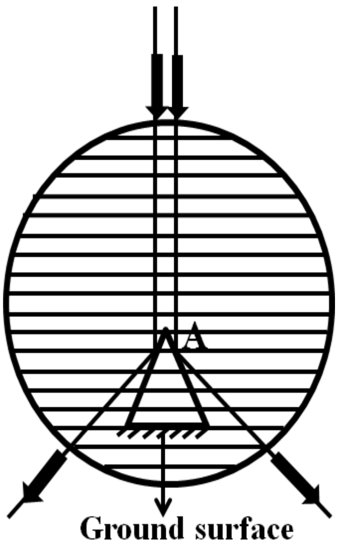


Figure .2: Positioning of the prism for optical alignment

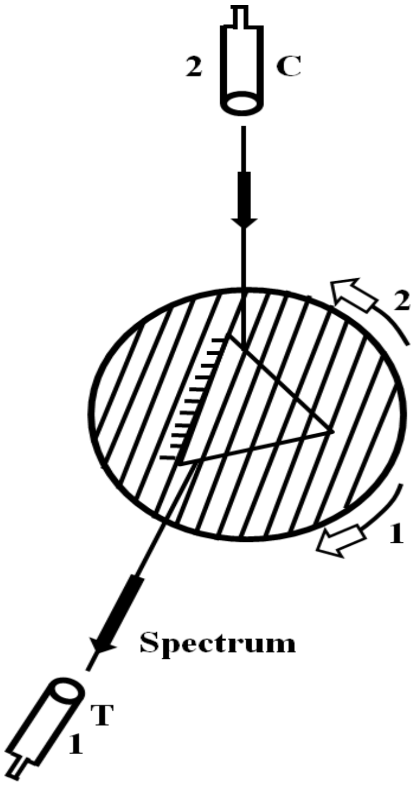


Figure 3: Top view of the set up for Schuster's method.

1. Setting the prism table

The prism table AB is made horizontal with the help of a spirit- level by adjusting the leveling screws D, E, F. To start with, the prism table is rotated about its axis and adjusted in such a way that the parallel straight lines along with the two screw E and F are perpendicular to the axis joining the collimator and the telescope pointing directly opposite. A three-way spirit level is kept on the prism table with its edge XY along the parallel lines

Further adjustment of the prism table is done using the method of optical alignment. The given prism is placed such that the ground surface is facing towards the telescope and is perpendicular to the axis of the collimator. Adjust the position of the prism such that the edge of the prism opposite to the ground surface lies approximately along the axis of the prism table as shown in Fig. If you now rotate the telescope arm, you would be able to see the reflected images of the slit appears symmetrically placed about the horizontal cross wire when viewed from both sides. The prism table adjustments are complete now.

1. Schuster's method of focusing a spectrometer for parallel light:

When a distant object is not available or the spectrometer is too heavy to be carried outside the dark room where the experiment is being performed, the setting of the spectrometer is done by the Schuster's method. the slit is kept facing the brightest portion of the mercury lamp and its width adjusted to permit a thin line of light to act as incident light.

Prism is now kept on the prism table with its ground face along the parallel lines ruled on the prism table. The prism table is rotated so as to obtain mercury light incident from the collimator on the prism. Telescope arm is moved to a suitable position to see the spectrum through it. the prism table is rotated to achieve the position of minimum deviation (of course, you will have to rotate the telescope arm also, as you rotate the prism table, to retain the spectrum in the field of view of the telescope). At this position, the spectrum which appeared to be moving in the telescope in one direction (say left to right) reaches an extreme limit and retraces its path on further movement of the prism table in the same direction.

Prism table is rotated away from this position of minimum deviation. bringing the refracting angle towards the telescope and the telescope is now focused on the image as distinctly as possible. Prism table is then rotated to the other side of the minimum deviation position towards the collimator and the collimator is focused to obtain a sharp image of the spectrum. The process is repeated till the motion of the prism does not affect the focus of the spectrum. The collimator and the telescope are then set for parallel light and their settings are not to be disturbed during the course of the experiment.

Measurements of angle of minimum deviation D_m and prism angle A_0:

The prism is again set in the position of minimum deviation as discussed above. Now measure the positions of various lines (colors) of the spectrum on the circular scale without disturbing the prism table. Now remove the prism from prism table and rotate the telescope to see the slit directly and measure its position. The difference between this last reading and the readings corresponding to various colors in the position of minimum deviation will give us the angles of minimum deviations for different colors.

This given prism is now again placed on the prism table such that the ground surface is facing towards the telescope and is perpendicular to the axis of collimator. Adjust the position of the prism such that the edges of the prism opposite to the ground surface lies approximately along the axis of the prism table. Rotate the telescope arm and measure the position of reflected images of the slit on both sides of incident beam. The difference between the two readings is equal to angle $2A_0$.

Observations:

Least count of the spectrometer=

Readings for the measurement of angle of minimum deviation:

Reading of telescope position for direct image of the slit: Left scale (θ_L):

Right scale (θ_R):

Sr. No.	color of light	Reading for telescope Position Left scale θ_1	$D_1 = \theta_L \sim \theta_1$ Right scale θ_2	$D_1 = \theta_R \sim \theta_2$
1.	Violet I			
2.	Violet II			
3.	Blue			
4.	Green			
5.	Yellow I			
6.	Yellow II			
7.	Red			

Readings for measurement of prism angle A_0:

Sr. No.	Position of telescope for reflected slit from		$A_0 = \frac{a \sim b}{2}$
	Left face (a)	Right face (b)	

Calculations:

Sr. No.	Color	$D_m = \frac{D_1 + D_2}{2}$	$\mu = \frac{\sin\frac{A_0 + D_m}{2}}{\sin\frac{A_0}{2}}$	$1/\lambda^2$

Using the above values draw a graph between μ and $1/\lambda^2$ and determine A and B.

RESULT:

The Cauchy's constants are A= , and B=

7.RESOLVING POWER OF GRATING

AIM:

To determine the resolving power of a plane transmission grating using spectrometer arranged for normal incidence.

APPARATUS:

Spectrometer, given grating, mercury vapour lamp, etc.

PRINCIPLE:

Resolving power of a grating is its ability to show two neighbouring spectral lines in a spectrum as separate. If λ and λ+dλ are wavelengths of two neighbouring spectral lines. The resolving power of the grating is the ratio $\frac{\lambda}{d\lambda}$.

By Rayleigh's criterion for resolution, when the two spectral lines are just resolved.

Resolving power of grating $\frac{\lambda}{d\lambda}$=nN_i where n is the order of spectrum and N_i is the total number of lines in the given grating.

If b is the mean width of an adjustable silt for the positions of just resolution and just unresolution, then resolving power $\frac{\lambda}{d\lambda}$=bnN where n is the order of spectrum and N is the number of lines per unit length of grating.

PROCEDURE:

The preliminary adjustments of the spectrometer i.e eye-piece adjustments, telescope adjustments and collimator adjustment are done. The spectrometer is now set up for normal incidence of light from a mercury lamp. Telescope is brought in a line with the collimator to observe the direct image. Now it is turned to either side of the direct image to observe the diffracted spectrum in the first order. The vertical cross wire is adjusted to coincide with the lines green, yellow I, Yellow II successively on the left side. The readings for each line both in vernier I and Vernier II are noted. Now the telescope is turned to the right of the direct image and vertical cross wire is adjusted to coincide with the lines successively. The readings for each line in both the verniers are taken. The difference between the readings in corresponding verniers on the left and the right give 2θ. Mean angle of diffraction θ for each line is calculated. The grating is standardized as follows. For a grating, sinθ=Nnλ. For first order (n=1), knowing wavelength of green lines(λ_g=5460x10^{-10}m), the number of lines per metre of the grating (N) is calculated from N=$\frac{sin\theta_g}{n\lambda_g}$ where θ_g is the angle of diffraction. Wavelength for each line is calculated from the above equation. sinθ=Nnλ.

Now a rectangular adjustable silt provided is placed vertically in the between the lens and the screen using a stand. Telescope is rotated to the left side of the direct image to observe the diffracted Yellow I and Yellow II lines of the first order. Looking through the telescope, the width of the adjustments silt is slowly reduced by operating its adjustable screw until the two yellow lines come closer and closer and finally merge together as a single line. Now the two lines are just and resolved. The silt is taken and it is focussed using a vernier microscope. It is width is measured correctly by making the vertical crosswire of the microscope coinciding with its left and right edges.

The silt is again replaced in its position looking through the telescope the width is slowly increased until the two yellow lines get separated. This is the condition for just resolution. The silt is taken and the width is at this resolution condition is again determined accurately has above. The mean width of the silt (b) is calculated. This is repeated for the lines and the right side also. Knowing this mean width resolving power can be calculated. This is repeated for second order spectrum.

OBSERVATIONS

1. Adjustments for normal Incidence

	Vernier I	Vernier II
Direct Reading		
Reading when telescope is turned through 90˚		
Reading when vernier table is turned through 90˚		

2. To find the least count (L.C)

Value of 1 main scale division = _________ minute

No. of vernier scale division n= _______

Least count (L.C) = 1 MSD/n = __________ minute

Total Reading = MSR+(VSRxLC)

3. To calibrate the grating

Wavelength of green λ_g =$5460 x 10^{-10}$m

Angle of diffraction θ_g =______

Order of the spectrum n = 1

Number of lines/m, $N = \frac{sin\theta_g}{n\lambda_g}$

4. to determine wavelength of lines

order	Line	Vernier	Diffracted reading						Difference	Mean	$\lambda = \frac{sin\theta}{nN}$
			Left			Right			2θ	θ	
			MSR	VSR	TR	MSR	VSR	TR			
	Green	V_1									
		V_2									
	Yellow I	V_1									
		V_2									
	Yellow II	V_1									
		V_2									

5. To calculate resolving power of grating

Wavelength of Yellow I λ_1= __________Å

Wavelength of Yellow II λ_1= __________Å

Mean wavelength $\lambda = \frac{\lambda_1+\lambda_2}{2}$ = ________Å

Change in wavelength $d\lambda = \lambda_2 - \lambda_1$=_______Å

Resolving Power $\lambda/d\lambda$= ________

Number of lines l meter N = ________

Length of grating i= _______m

Total number of lines in grating N_1 = __________________

Order of the spectrum n = ______________

Resolving Power = nN_1=___________

MICROSCOPE READING TO FIND WIDTH OF SLIT 'b'

Value of 1 main scale division = ______ cms

Number of vernier scale division n = ___________

Least Count = 1msd/n = ___________cms

Position of the telescope	Reading of Microscope						Difference R_2-R_1	Mean Width b
	On Left edge R_1			On Right edge R_2				
	MSR	VSR	TR	MSR	VSR	TR		
Unresolved position								
resolved position								

Resolving Power = bnN=_____

Result:

Resolving Power of the given grating =___________

8. DETERMINATION OF REFRACTIVE INDEX OF GIVEN LIQUID BY FORMING LIQUID LENS

AIM:

To determine the refractive index of a given liquid and the material of a lens by forming a liquid lens and by using mercury to find the radius of curvature of the lens.

APPARATUS:

A convex lens of focal length 10 or 15cms. Given liquid, a plane mirror, a pointer (a knitting middle or pin fixed on an eraser) arranged on a retort stand, mercury in a dish, scale etc.,

THEORY:

The relationship between the focal length, radii of curvature and the refractive index of lens is given by the len's makers formula

$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ -----------------(1)

Where f is the focal length, R_1 and R_2 are the radii of curvature of the lens and μ is the refractive index of the material of the lens. Applying sign convention R_1 is positive and R_2 is negative. Thus equation 1 becomes,

$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ -----------------(2)

$$\frac{1}{f} = (\mu - 1)\left(\frac{R_1 + R_2}{R_1 R_2}\right)$$

$$(\mu - 1) = \frac{R_1 R_2}{f(R_1 + R_2)}$$

Refractive Index of the lens,

$\mu = 1 + \frac{R_1 R_2}{f(R_1+R_2)}$-----------------(3)

The radius of curvature is determined by bias method when the image is formed side vy side of the object by the reflected light from the corresponding concave surface, the radius of the curvature is given by

$R = \frac{fd}{f-d}$-----------------(4)

Where, d is the distance between the lens and the object when the reflected image is formed side by side of the object and f is the focal length of the lens.

If a plano- concave liquid lens is formed in between the first face of the lens and plane mirror, as shown in figure. The radius of curvature of its upper side is $R=-R_1$ and that of the second face infinity. Then for the liquid lens equ 1 becomes,

$$\frac{1}{f_l} = (\mu_l - 1)\left(-\frac{1}{R_1} - \frac{1}{\infty}\right)$$

$$(\mu_l - 1) = -\frac{R_1}{f_l}$$

$\mu_l = 1 - \frac{R_1}{f_l}$-----------------(5)

Where, R_1 is the radius of curvature of that the face of the lens in contact with the liquid and fl is the focal length of the liquid lens. In experiments we usually find out the focal length of the combination of lens and the liquid lens. If it is F, We can write,

$\frac{1}{F} = \frac{1}{f} + \frac{1}{f_1}$-----------------(6)

$f_1 = \frac{Ff}{f-F}$-----------------(7)

PROCEDURE:

To determine the focal length of the convex lens

A plane mirror is placed horizontally on the base of a retort stand as shown in figure. A convex lens of 10 or 15cms is placed on the mirror strips with its marked face is in contact with the mirror. The pointer(object) IS arranged above the lens has shown in figure. Looking from vertically above with one eye closed, the lens and mirror arrangement is adjusted so that the tip of the object and tips of the image the coincide. The looking from above, move your head forward and backward (left and right). If the image gets separated from the object, the pointer is slowly lowered or raised till the image and the object does not get separated when you move your head forward or backward. There is only one position of the pointer of the given lens at which the object and the image moves together without parallax when you move your head forward or backward.

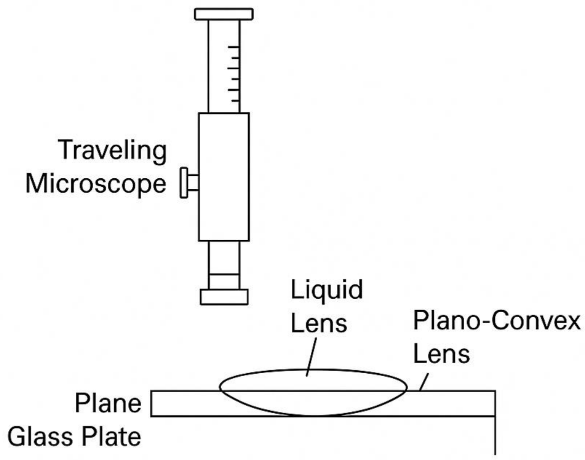
At this position the object is qat the principle focuses of the lens and the image as the same size as that of the object. The distance of the pointer from the top of the lens and the plane mirror(bottom of the lens) are measured. Their average gives the focal length of the lens. Repeat the entire process two or three times and the mean value of 'f' is determined

To determine the focal length F of the combination of the lens and the liquid lens

The convex lens is removed. Two or three drops of liquid are placed on a mirror. Then the convex lens is placed on the liquid drops with its marked face in Contact with the mirror. Now a plane of concave liquid lens is formed between the convex lens and the plane mirror has shown in figure. Tthe radius of curvature of its curved face is same as that of the marked face of the convex lens. The average focal length F of the combination is determined as described in the case of convex lens alone. The focal length of liquid lens f_l is calculated using equation 7

To determine the radius of curvature of their marked face and the other face using mercury

The radii of curvature of the convex lens are determined by boy's method. The method is as follows. The convex lens is floated in mercury, contained in dish, with the marked face of the lens in contact with mercury. The position of the pointer for which the images seen without parallax is determined as described in the case of convex lens alone. The height of the pointer from the top of the lens is measured. Adding to it half the thickness of the lens (obtained in the previous cases) we get the distance d. using d in equation 4 we get the radius of curvature of the marked face of the lens by similar method. The radius of curvature of the other face of the lens also is determined. The refractive index of the material of the lens is calculated using equation 3 and the refractive index of the liquid by equation 5



DETERMINATION OF REFRACTIVE INDEX
OF GIVEN LIQUID BY FORMING LIQUD LENS

When looking above you may see the image of the tip of the retort stand. So make sure that you are viewing the image of the pointer. We can identify the image of the pointer while moving the pointer to and fro side wise slightly. The image also moves you can identify it.

Observation and tabulation

To determine the focal length of the convex lens

Trial No.	Distance of the pointer from the top of the convex lens in cm	Distance of the pointer from the surface of the plane mirror in cm	Focal length of the convex lens 'f' in cm

Mean----------

Focal length of the combination of convex and liquid lens, F= _________cm = _______m

To determine the focal length of the combination of convex lens and liquid lens

Trial No.	Distance of the pointer from the top of the convex lens in cm	Distance of the pointer from the surface of the plane mirror in cm	Focal length of the convex lens ‘f’ in cm

Mean----------

Focal length of liquid lens $f_l = \frac{Ff}{F-F}$ = -----------cm = -------m

To determine the radii of curvature of the convex lens

	Distance of the pointer from the top of the convex lens in cm	Half the thickness of the lens in cm	D cm	Mean ‘d’ cm
Marked face of the lens in contact with mercury				
Other face in contact with mercury				

Radius of curvature of the marked face of the lens R_1 = $\frac{fd}{f-d}$= ---- cm =-----m

Radius of curvature of the other face of the lens R_2 = $\frac{fd}{f-d}$= ---- cm =-----m

Refractive index of the material of the lens μ= 1+$\frac{R_1 R_2}{f(R_1+R_2)}$

Radius of the curvature of the liquid lens(radius of curvature of marked face of the lens)

R_1= -------cm = -------m

Refractive index of the liquid, $\mu_1 = 1 - \frac{R_1}{f_l}$

RESULT

Refractive index of the material of the lens= ----------------

Refractive index of the given liquid = ----------------

Standard data

Material	Refractive Index
Water	1.33
Glycerin(glycerol)	1.473
Turpentine	1.48
Olive oil	1.48
Glass (crown)	1.48~1.61
Glass(flint)	1.53~1.96

9. DETERMINATION OF REFRACTIVE INDEX BY FORMING NEWTON RINGS

AIM:

To determine the refractive index (μ) of a liquid using the method of Newton's Rings.

APPARATUS:

Newton's rings setup (planoconvex lens placed on a flat glass plate), Traveling microscope Monochromatic light source (e.g., Sodium lamp), Liquid of unknown refractive index, Dropper Spirit level.

PRINCIPLE

Newton's Rings are formed due to interference of light between a convex lens placed on a flat glass plate. When a liquid of refractive index μ is introduced between the lens and plate, the fringe pattern changes.

The radius of the n^{th} *dark ring* in air is:

$$r_n = \sqrt{n\lambda R}$$

When the same experiment is repeated with a liquid in between, the radius becomes:

$$r_n' = \frac{\sqrt{n\lambda R}}{\mu}$$

Using this, the refractive index of the liquid can be calculated as:

$$\mu = \left(\frac{r_n}{r_n'}\right)^2$$

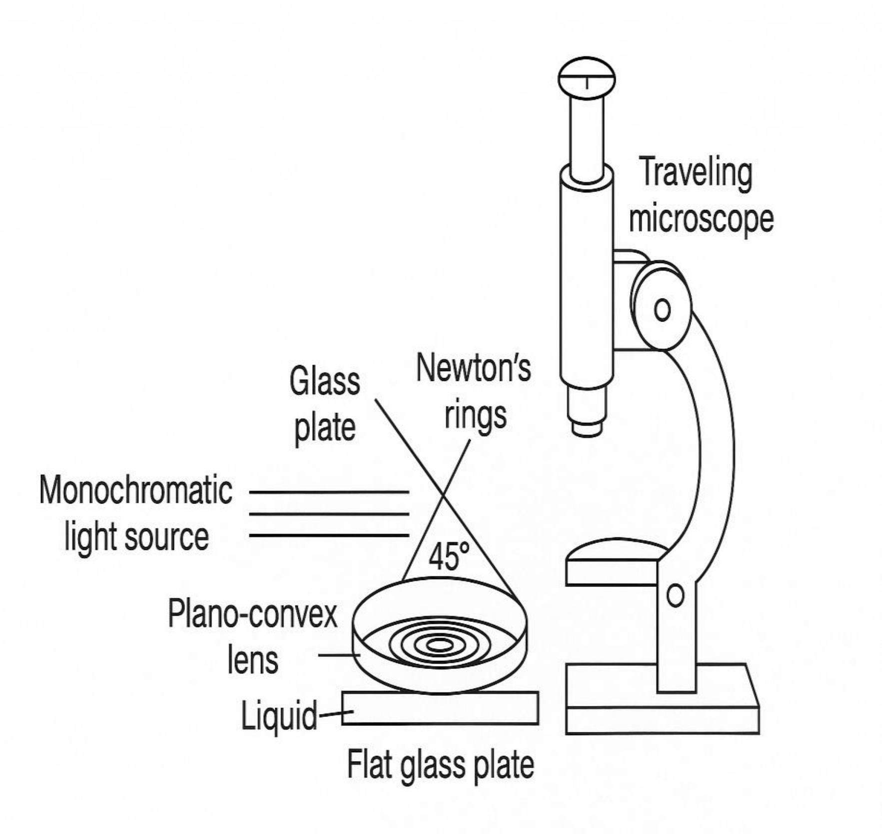
Where:

r_n = radius of n^{th} ring in air

r_n' = radius of n^{th} ring in liquid

λ = wavelength of light used

R = radius of curvature of the lens



PROCEDURE:

1. Set up the apparatus with the planoconvex lens on the glass plate and the sodium lamp directed onto it via a glass plate at 45°.
2. Focus the microscope on the central dark spot (point of contact).
3. Measure the diameters of several dark rings (say 5 or 6 rings on either side) and record the values.
4. Calculate the average diameter squared D_n^2 for each ring.
5. Now, introduce a drop of the liquid between the lens and the glass plate using a dropper.
6. Wait for the new set of rings to form and stabilize.
7. Again, measure the diameters of the same rings.
8. Use the formula to calculate the refractive index of the liquid.

FORMULA:

$$\mu = \frac{D_n^2(in\ air)}{D_n'^2(in\ liquid)}$$

Where:

D_n: Diameter of the nth dark ring.

TABULAR COLUMN

Ring no (n)	Diameter in Air (D_n)	D_n^2 in air	Diameter in Liquid (D_n')	$D_n'^2$	$\mu = \frac{D_n^2}{D_n'^2}$

RESULT:

The refractive index of the given liquid is found to be approximately _____.

10.SPECTROMETER - GRATING – OBLIQUE INCIDENCE - DISPERSIVE POWER

AIM:

To determine the wavelengths of the constituent colours of a composite light, using a plane transmission grating.

APPARATUS:

Plane transmission grating, Mercury vapour lamp, spectrometer etc.

Procedure:

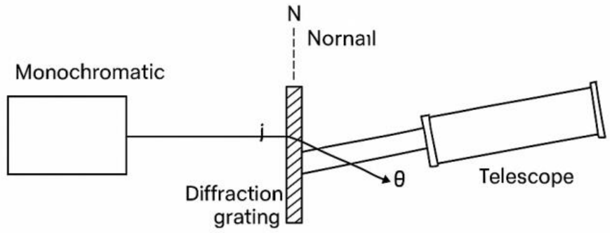
(a) Adjustment of the grating for normal incidence: the initial adjustments of the spectrometer are made. The plane transmission grating is mounted on the grating table. The telescope is released and placed in front of the collimator. The direct reading is taken after making the vertical cross wire to coincide with the fixed edge of the image of the silt which is illuminated by a monochromatic source of light. The telescope is then rotated through an angle of 90° and fixed. The grating table is rotated until on seeing through the telescope the reflected image of the silt coincides with the vertical cross wire. This is possible only when light emerging from the collimator is incident at an angle of 45° to the normal to the grating. The vernier table is now released and rotated by an angle 45° in one appropriate direction. Now light coming out from the collimator will be incident normally on the grating.

(b) Standardization of the grating: the silt is illuminated by sodium light of wavelength λ=5893Å. The telescope is released to catch the first order diffracted image on the left side of the direct image. The readings are taken. It is then turned to the right side to catch the first order diffracted image and the reading is again taken. The difference between the readings gives 2θ for the first order where θ is the angle of diffraction. The experiment is repeated for the second order image and the readings are tabulated. The number of lines on unit length of the grating (m) is determined using the formula

$$\sin\theta = mn\lambda$$

Where n is the order of the image and λ is the wavelength of light used.

$$\text{Therefore, } m = \frac{sin\theta}{n\lambda}$$



SPECTROMETER – GRATING –
OBLIQUE INCIDENCE – DISPERSIVE POWER

(c) Determination of wavelengths of different colour of the mercury spectrum: the silt is now illuminated by white light from mercury vapour lamp. The central direct image will be an undispersed image. But on the either side of the direct image, we will get dispersed diffracted images of the silt in the different regions, constituent colour corresponding to the different orders. The angles of diffraction for different colours are determined as in the standardization part for the first and second orders and the readings are tabulated.

The wavelength of a particular colour of light is determined using the formula sinθ = mnλ where θ is the angle of diffraction for that colour of light.

$$\text{Therefore, } \lambda = \frac{sin\theta}{mn}$$

Observations:

Standardization of the grating (sodium vapour lamp)

Order of Image(n)	Diffracted Image				2θ		θ		Mean θ	$m = \frac{sin\theta}{n\lambda}$
	Left		Right		V_A	V_B	V_A	V_B		
	V_A	V_B	V_A	V_B						

(2) Determination of wavelength of different colours (mercury light)

Order of Image(n)	Colour of light	Diffracted Image				2θ		θ		Mean θ	$\lambda = \frac{sin\theta}{nm}$
		Left		Right		V_A	V_B	V_A	V_B		
		V_A	V_B	V_A	V_B						
	Violet I										
	Violet II										
	Blue										
	Blue green										
	Green										
	Yellow-I										
	Yellow-II										
	Red										

RESULT:

The wavelengths of spectral lines are determined.

11.HORIZONTAL COMPONENT OF EARTH'S MAGNETIC FIELD USING TANGENT GALVANOMETER

AIM

To determine the horizontal component of the Earth's magnetic field using tangent galvanometer.

APPARATUS REQUIRED

Tangent galvanometer (TG), commutator, battery, rheostat, ammeter, key and connecting wires.

FORMULA

$$B_H = \frac{\mu_0 nk}{2r}\ Tesla$$

$$k = \frac{I}{tan\theta}\ (A)$$

where,

B_H → Horizontal component of the Earth's magnetic field (T)

μ_0 → Permeability of free space ($4\pi \times 10^{-7}$ H m^{-1})

n → Number of turns of TG in the circuit (No unit)

k → Reduction factor of TG (A)

r → Radius of the coil (m)

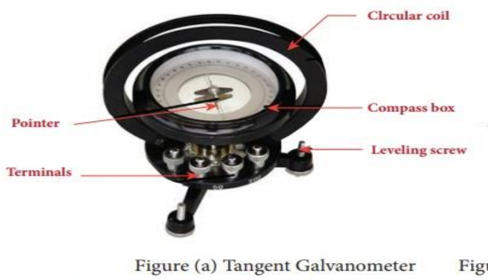
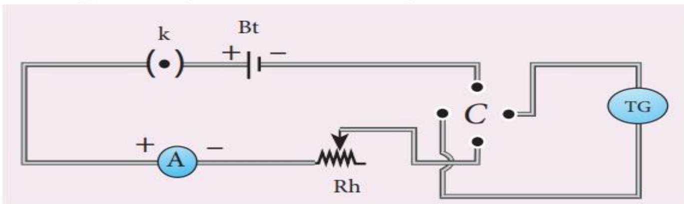


Figure (a) Tangent Galvanometer Figure (b) Number of turns



(c) Circuit diagram

PROCEDURE:

The preliminary adjustments are carried out as follows.

a. The leveling screws at the base of TG are adjusted so that the circular turn table is horizontal and the plane of the circular coil is vertical.

b. The circular coil is rotated so that its plane is in the magnetic meridian i.e., along the north-south direction.

c. The compass box alone is rotated till the aluminium pointer reads $0° - 0°$.

- The connections are made as shown in Figure.
- The number of turns n is selected and the circuit is switched on.
- The range of current through TG is chosen in such a way that the deflection of the aluminium pointer lies between $30° - 60°$.

A suitable current is allowed to pass through the circuit, the deflections θ1 and θ2 are noted from two ends of the aluminium pointer.

- Now the direction of current is reversed using commutator C, the deflections θ3 and θ4 in the opposite direction are noted.
- The mean value θ of θ_1, θ_2, θ_3 and θ_4 is calculated and tabulated.
- The reduction factor k is calculated for each case and it is found that k is a constant.
- The experiment is repeated for various values of current and the readings are noted and tabulated.
- The radius of the circular coil is found by measuring the circumference of the coil using a thread around the coil.

From the values of r, n and k, the horizontal component of Earth’s magnetic field is determined.

Commutator:

It is a kind of switch employed in electrical circuits, electric motors and electric generators. It is used to reverse the direction of current in the circuit.

OBSERVATION

Number of turns of the coil n =

Circumference of the coil ($2\pi r$) =

Radius of the coil r =

S.NO	Current I (A)	Deflection in TG(degree)				Mean θ (degree)	$k = \frac{I}{tan\theta}$
		θ_1	θ_2	θ_3	θ_4		

Calculation

$$B_H = \frac{\mu_0 nk}{2r} \ Tesla$$

RESULT

The horizontal component of Earth's magnetic field is found to be ________

12. SPECTROMETER -GRATING -OBLIQUE INCIDENCE-WAVELENGTH & MERCURY SPECTRAL LINES

AIM:

To determine the resolving power of a plane transmission grating using spectrometer arranged for normal incidence.

APPARATUS:

Spectrometer, given grating, mercury vapour lamp,etc.

PRINCIPLE:

Resolving power of a grating is its ability to show two neighbouring spectral lines in a spectrum as separate. If λ and $\lambda+d\lambda$ are wavelengths of two neighbouring spectral lines. The resolving power of the grating is the ratio $\frac{\lambda}{d\lambda}$

By Rayleigh's criterion for resolution, when the two spectral lines are just resolved.

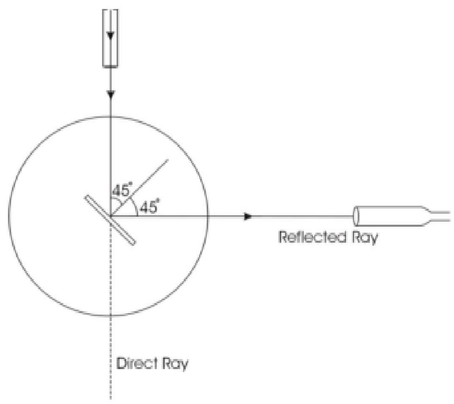
Resolving power of grating $\frac{\lambda}{d\lambda}=nN_i$ where n is the order of spectrum and N_i is the total number of lines in the given grating.

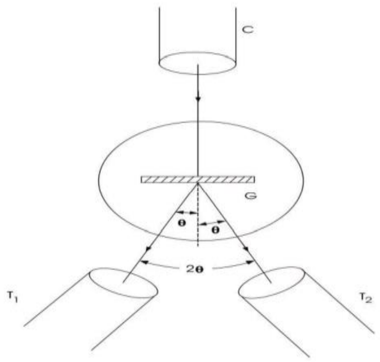
If b is the mean width of an adjustable silt for the positions of just resolution and just unresolution, then resolving power $\frac{\lambda}{d\lambda}=bnN$ where n is the order of spectrum and N is the number of lines per unit length of grating.

PROCEDURE:

The preliminary adjustments of the spectrometer i.e eye-piece adjustments, telescope adjustments and collimator adjustment are done. The spectrometer is now set up for normal incidence of light from a mercury lamp. Telescope is brought in a line with the collimator to observe the direct image. Now it is turned to either side of the direct image to observe the diffracted spectrum in the first order. The vertical cross wire is adjusted to coincide with the lines green, yellow I, Yellow II successively on the left side. The readings for each line both in vernier I and Vernier II are noted. Now the telescope is turned to the right of the direct image and vertical cross wire is adjusted to coincide with the lines successively. The readings for each line in both the verniers are taken. The difference between the readings in corresponding verniers on the left and the right give 2θ. Mean angle of diffraction θ for each line is calculated.

The grating is standardised as follows. For a grating, sinθ=Nnλ. For first order (n=1), knowing wavelength of green lines(λ_g=5460x10^{-10}m), the number of lines per metre of the grating (N) is calculated from $N=\frac{sin\theta_g}{n\lambda_g}$ where θ_g is the angle of diffraction. Wavelength for each line is calculated from the above equation. sinθ=Nnλ.





Now a rectangular adjustable silt provided is placed vertically in the between the lens and the screen using a stand. Telescope is rotated to the left side of the direct image to observe the diffracted Yellow I and Yellow II lines of the first order. Looking through the telescope, the width of the adjustments silt is slowly reduced by operating its adjustable screw until the two yellow lines come closer and closer and finally merge together as a single line. Now the two lines are just and resolved. The silt is taken and it is focussed using a vernier microscope. It is width is measured correctly by making the vertical crosswire of the microscope coinciding with its left and right edges.

The silt is again replaced in its position looking through the telescope the width is slowly increased until the two yellow lines get separated. This is the condition for just resolution. The silt is taken and the width is at this resolution condition is again determined accurately has above. The mean width of the silt (b) is calculated. This is repeated for the lines and the right side also. Knowing this mean width resolving power can be calculated. This is repeated for second order spectrum.

OBSERVATIONS

1. Adjustments for normal Incidence

	Vernier I	Vernier II
Direct Reading		
Reading when telescope is turned through 90°		
Reading when vernier table is turned through 90°		

2. To find the least count (L.C)

Value of 1 main scale division = ________ minute
No. of vernier scale division n= ______
Least count (L.C) = 1 MSD/n = _________ minute
Total Reading = MSR+(VSRxLC)

3. To calibrate the grating

Wavelength of green λ_g =5460x10^{-10}m
Angle of diffraction θ_g =______
Order of the spectrum n = 1
Number of lines/m, $N = \frac{sin\theta_g}{n\lambda_g}$

4. to determine wavelength of lines

order	Line	Vernier	Diffracted reading						Difference 2θ	Mean θ	$\lambda = \frac{sin\theta}{nN}$
			Left			Right					
			MSR	VSR	TR	MSR	VSR	TR			
	Green	V_1									
		V_2									
	Yellow I	V_1									
		V_2									
	Yellow II	V_1									
		V_2									

5. To calculate resolving power of grating

Wavelength of Yellow I λ_1= __________Å
Wavelength of Yellow II λ_1= __________Å
Mean wavelength $\lambda = \frac{\lambda_1+\lambda_2}{2}$ = ________Å

Change in wavelength $d\lambda = \lambda_2 - \lambda_1 =$ ________Å

Resolving Power $\lambda/d\lambda =$ _________

Number of lines l meter N = _________

Length of grating i= ________m

Total number of lines in grating N_1 = ____________________

Order of the spectrum n = ________________

Resolving Power = nN_1=____________

MICROSCOPE READING TO FIND WIDTH OF SLIT 'b'

Value of 1 main scale division = _______ cms

Number of vernier scale division n = ____________

Least Count = 1msd/n = ____________cms

Position of the telescope	Reading of Microscope						Difference R_2-R_1	Mean Width b
	On Left edge R_1			On Right edge R_2				
	MSR	VSR	TR	MSR	VSR	TR		
Unresolved position								
resolved position								

Resolving Power = bnN=_____

Result:

Resolving Power of the given grating =____________

13.BALLISTIC GALVANOMETER-ABSOLUTE CAPACITY OF A CAPACITOR

AIM:

To determine the capacity of the given condenser using BG.

APPARATUS:

The ballistic galvanometer, given capacitor, power supply, charge and discharge key, commutator key, ordinary key and three resistance boxes.

THEORY:

The principle of this experiment is to discharge the charged capacitor through the BG and find out the deflection in BG and from which the capacity is determined. The charge on thecapacitor is calculated as follows.

Current through R and S is $I = \frac{E}{R+S}$

Pd across C = Pd across R = $IR = \frac{ER}{R+S} = V$

Charge on C is q = CV=$\frac{CER}{R+S}$ ------------------------- (1)

Let ϕ be the deflection produced in the BG when this charged capacitor is allowed to discharge through the BG. Then by eqn. of the theory of BG we can write

q = Kϕ ------------------------------- (2)

Where K is the charge sensitivity and ϕ = $\phi_1 \left(\frac{\phi_1}{\phi_3}\right)^{1/4}$ is the corrected throw in the galvanometer.

But by equ of the theory

Charge sensitivity = $\frac{T}{2\Pi}$ $X\ current\ sensitivity$

$K = \frac{T}{2\Pi}$ ---------------------------- (3)

Using equs. 1 and 2,

$$\frac{q}{\phi} = \frac{Tk}{2\Pi} = \frac{CER}{(R+S)\phi}$$

$C = \frac{Tk}{2\Pi} = \frac{(R+S)\phi}{ER}$ --------------------------------- (4)

To find out 'k' we follow resistance P, Q, R and S are such that

P+Q = R+S = 10,000 ohm --------------------- (5)

Then by equ 5,

$$k = \frac{E}{(P+Q)G}\left(\frac{P}{\theta}\right) \text{ -------------------------- (6)}$$

Where θ is the steady deflection in BG when the voltage across 'P' is applied to BG

Using equ 4, 5 and 6 we get

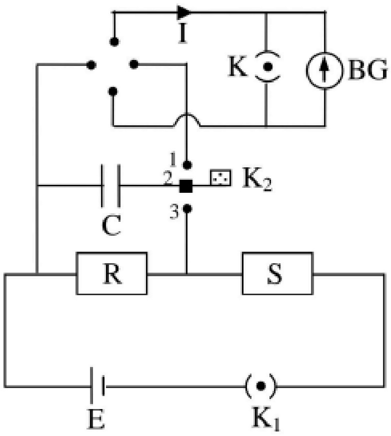
$$C = \frac{T}{2\Pi G}\left(\frac{P}{R}\right)\left(\frac{\phi}{\theta}\right) = \frac{T}{2\Pi G}\left(\frac{\phi}{R}\right)\left(\frac{P}{\theta}\right)$$

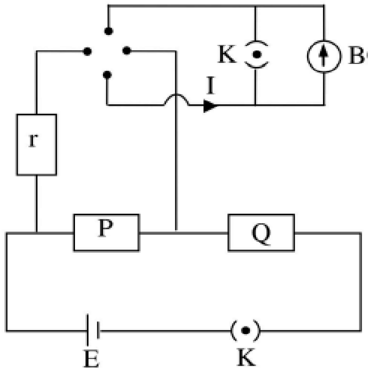
Procedure

To find out G and $\frac{P}{\theta}$:

Connections are made as shown in the fig. Introduce resistance in R and S such that R+S =10,000 ohm. R must be sufficiently large (1000 ohm) in this case. This is because we need sufficient potential difference across R so that the capacitor is charged enough to produce an appreciable throw in BG. To start with the experiment, press the charge discharge key K_2 so that terminals 2 and 3 are now in contact and thus the capacitor is connected across R. key K_2 is kept pressed for about 30seconds and is released. The arrangement of K_2 is such that when it is released it makes contact with terminals 1 and 2 and the capacitor discharges through the galvanometer. This charge produces a throw in the galvanometer. The first throw ϕ_1 and the next throw ϕ_3 of the spot of light on the same side are noted. The corrected throw is calculated as $\phi = \phi_1\left(\frac{\phi_1}{\phi_3}\right)^{1/4}$. Repeat the experiment after reversing the commutator. The entire experiment is repeated for different values of R and the mean value of $\frac{\phi}{R}$ is calculated.

To find out the period of free oscillation of BG the capacitor is again charged and is allowed to discharge through BG. Time for 20 oscillations are found for two times and the period of oscillation is calculated. C is calculated using equ.





PRECAUTIONS:

Ensure that P+Q = R+S = 10,000 ohm, since the required formula is derived on the assumption that P+Q = R+S = 10,000ohm.

Ensure that P is small 1,2,3 ……..ohm and R is sufficiently large of the order of 1000,2000,3000,…..ohm.

If the capacitance is large, the throw may not be within the scale for R = 1000Ω, 2000Ω, etc. in that case try with R=100Ω, 200Ω, 300Ω etc.

Ensure that before discharging the capacitor or sending current to BG the damping key K is made open.

The emf of the power supply must be the same for both the cases.

Observation and tabulation:

To find out G and $\frac{P}{\theta}$

Emf (open circuit voltage) of the power supply, E = …………… volt

P Ohm	Q ohm	Deflection θ in mm to			Resistance G for half detection			$\frac{P}{\theta}$ ohm/mm
		Left Mm	Right Mm	Mean mm	Left Mm	Right Mm	Mean mm	
Mean								

To find out $\frac{\phi}{R}$

R Ohm	S ohm	Throw in the Galvanometer						Mean ϕ mm	$\frac{\phi}{R}$ mm/ohm
		Left			Right				
		ϕ_1 mm	ϕ_3 mm	ϕ = $\phi_1\left(\frac{\phi_1}{\phi_3}\right)^{1/4}$ mm	ϕ_1 mm	ϕ_3 mm	ϕ = $\phi_1\left(\frac{\phi_1}{\phi_3}\right)^{1/4}$ mm		
1000	**9000**								
2000	**8000**								
3000	**7000**								
4000	**6000**								
5000	**5000**								
					Mean				

Determination of period of free oscillation

Time for 20 oscillations second			**Period T sec**
1	**2**	**Mean**	

$C = \frac{T}{2\Pi G}\left(\frac{P}{R}\right)\left(\frac{\phi}{\theta}\right) = \frac{T}{2\Pi G}\left(\frac{\phi}{R}\right)\left(\frac{P}{\theta}\right)$ = ………………farad

RESULT:

Capacity of the given capacitor, C = …………….farad.

14. BALLISTIC GALVANOMETER – COMPARISON OF CAPACITANCES (C_1 / C_2)

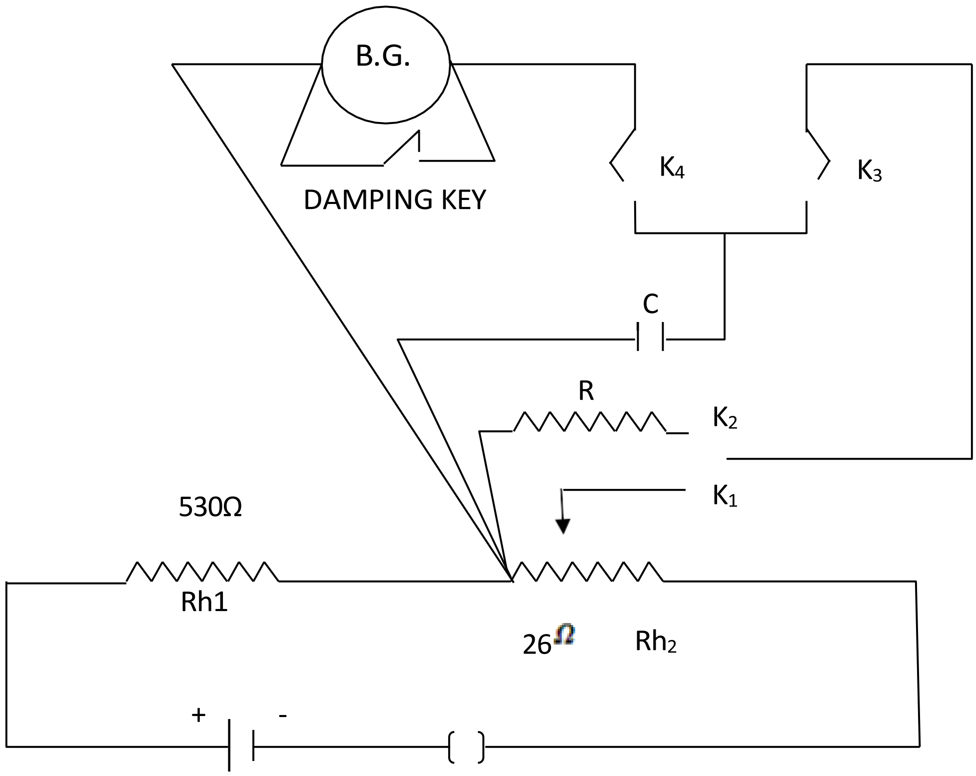
AIM:

To determine the high resistance by method of leakage of charge using a Ballistic galvanometer

APPARTUS:

A Ballistics galvanometer, a battery, two rheostats, a standard capacitor, stop watch, keys and a resistor whose resistance is to be determined.

DIAGRAM



FORMULA:

The resistance R of the given resistor is given by

$$R = \frac{t}{C.\log_e(\theta_0/\theta_t)} \text{ ohm}$$

Where,

T = time for which the charge on the capacitor is allowed to leak through the high resistance R

θ_0= first throw of the spot of light when the fully charged capacitor is discharged through the Ballistic Galvanometer.

θ_t= first throw of the spot of light when the fully charged capacitor is first discharged through the resistance R for a time t and then discharged through the Ballistics Galvanometer.

C= capacity of the given capacitor in farads.

PROCEDURE:

1. The spot of light of the Galvanometer is adjusted at zero of the scale
2. The connections are made as shown in the figure .Key k_1 is inserted and key k_3 is pressed. It will charge the condenser.
3. The key k_3 is released and k_4 is pressed. The first throw θ_0 is noted. The value of throw θ_0 is adjusted between 30 and 50 divisions with help of rheostat.
4. With the help of the damping key the motion of the spot is stopped. Key k_3 is pressed again to charge the condenser
5. Key k_1 is removed and k_2 is closed. Key $k_3$is pressed for a time t second, say 10 second. k_4 is pressed after releasing k_3. The first throw θ_t is noted.
6. For the same value of θ_0 , θ_t is observed for two more values of t.
7. For a different set, the value of $\theta_0$is changed by varying the resistance of the rheostat and θ_t is observed for three different values of t.

OBSERVATIONS:

S.No.	Initial throw in B.G. θ_0 (degree)	Leakage time t (sec)	Throw θ_t (degree)	θ_0/θ_t	$\log_e(\theta_0/\theta_t)$	$t/\log_e(\theta_0/\theta_t)$ (sec)
1 2 3						
1 2 3						

Mean $t/\log_e(\theta_0/\theta_t)$ = (sec)

CALCULATION:

C= (µF) ; $t/\log_e(\theta_0/\theta_t)$= (sec) ; R= (Ω)

RESULT:

Resistance of the given resistor= .... Ω

15. DETERMINATION OF REFRACTIVE INDEX UISNG LASER

AIM:

To determine the refractive index of a transparent material (e.g., glass or acrylic slab) using a LASER beam.

APPARATUS REQUIRED:

- LASER pointer or LASER source
- Transparent slab (glass or acrylic)
- Protractor
- Ruler
- White sheet of paper
- Pencil
- Pins (optional for ray tracing)

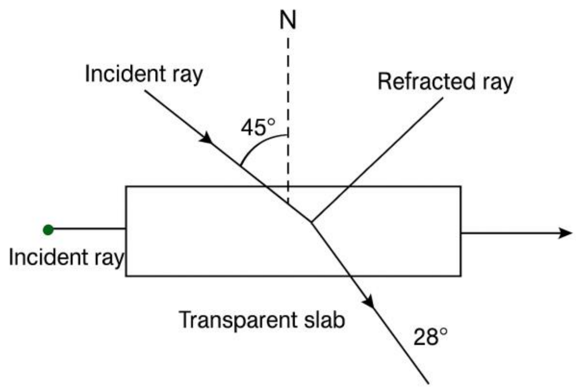
THEORY

When a LASER beam passes from air into a denser medium (glass), it bends towards the normal. This is called refraction. The refractive index (n) is given by Snell's Law:

$$n = \frac{\sin i}{\sin r}$$

Where:

- i = Angle of incidence
- r = Angle of refraction
- n = Refractive index of the transparent material



Procedure

1. Fix the glass slab on a white sheet and trace its outline.
2. Mark a normal line perpendicular to one side of the slab.
3. Use a protractor to draw an incident ray at a known angle (e.g., 30°, 45°, or 60°) to the normal.
4. Shine the LASER beam along this incident line.
5. Observe the refracted beam emerging from the opposite side of the slab.
6. Trace the refracted ray and extend the incident ray to meet at the slab interface.
7. Measure the angle of incidence (i) and angle of refraction (r).
8. Use Snell's law to compute the refractive index.

OBSERVATIONS AND CALCULATION

S.No	**Angle of Incidence (i)**	**Angle of Refraction (r)**	**Sin (i)**	**Sin (r)**	**Refractive Index** $n = \frac{\sin i}{\sin r}$
1	**45°**	**28°**	**0.7071**	**0.4695**	**1.506**

Repeat the experiment with different angles of incidence and calculate the average refractive Index.

RESULT:

The refractive index of the given transparent material is approximately 1.5 (for glass, typical value).