LABORATORY MANUAL

SEMESTER - FIRST

B.TECH

ENGINEERING PHYSICS - I

Name of the Student ____

Registration No. ________ **Batch No.** ___________ **Branch** ____________________

School of Aeronautics (Neemrana)

I-04, RIICO Industrial Area, Neemrana, Dist. Alwar, Rajasthan

(Approved by Director General of Civil Aviation, Govt. of India , All India Council for Technical Education, Ministry of HRD, Govt of India & Affiliated to Rajasthan Technical University. Kota, Rajasthan)

School of Aeronautics (Neemrana)

CERTIFICATE

This is to certify that Mr./ Ms.______________________________

Registration Number ____________________________________

of B.Tech ( ) has satisfactorily completed the term of the subject, Engineering Physics Lab, prescribed by Rajasthan Technical University, Kota.

Dated: ____________

Signature of Faculty

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EXPERIMENT NO. 1

WAVELENGTH OF MONOCHROMATIC SOURCE OF LIGHT

AIM

To determine the wavelength of monochromatic source of light (sodium light) with the help of Fresnel's biprism.

APPARATUS USED

A sodium lamp, An optical bench, An adjustable slit, A bi-prism, A micrometer eyepiece, A convex lens.

INTRODUCTION

When rays from a slit, S, illuminated by a monochromatic light, such as sodium light are made to be incident on the plane face of the biprism (PQR), the emergent rays from the two halves of the biprism appear to diverge from two coherent virtual sources, S_1 and S_2 (Fig.1). If a screen (AB) is placed with its plane perpendicular to the plane containing the slit and the common base of the biprism, the emergent beams of light overlap on the screen producing alternate dark and bright fringes.

If d is the distance between the two virtual sources S_1 and S_2, D is the distance between the slit and the screen and λ is the wavelength of the monochromatic source of light, then the fringe width, β i.e, the distance between two consecutive dark or bright fringes is given by.

$$\beta = \frac{D}{d}\lambda$$

To determine d, a convex lens having such a focal length that the distance between the slot and the focal plane of the eyepiece exceeds four times the focal length is kept between the biprism and the eyepiece. The lens is adjusted so that for two of its positions the real images of the two virtual sources S_1 and S_2 are focused on the focal plane of the eyepiece. If d_1 and d_2 are the distance between the real images of S_1 and S_2 for two positions of the lens, then

$$d = \sqrt{d_1 d_2} \qquad \text{(i)}$$

FORMULA USED

The wavelength of the sodium light used in Fresnel's biprism can be obtained as

$$\lambda = \frac{\beta d}{D} \qquad \text{(ii)}$$

where β is the fringe width in cm.

d is distance between two sources in cm.

D is distance between slit and screen in cm.

PROCEDURE

1. Mount the gadgets on the optical bench. The optical bench is made horizontal using a spirit level.

2. Study all the movements on each stand.

3. Ensure that all the pieces (slit, biprism and eyepiece) are alighned at roughly the same height.

4. Remove the stand with the convex lens from the optical bench.

5. Bring the eyepiece close to the biprism.

6. Looking through the eyepiece you will see a bright vertical patch of light. A slight rotation of the biprism in its own plane will break up this patch into vertical equidistant fringes.

7. Adjust the slit width to get the best compromise between brightness and sharpness of the fringe pattern. Keep the slit as narrow as possible. Fix the eyepiece at such a position that the fringes appear sharp, neither excessively narrow nor excessively broad.

8. Read the main scale and circular scale and determine the least count.

9. Move eyepiece slowly away form the biprism along the optical bench to a distance of about 100 cms. Keeping the fringe pattern all the time in the field of view.

10. Keeping eyepiece at a distance of 100 cm from the biprism, measure of the fringe width by measuring the distance travelled by the eyepiece in crossing about 10 fringes using the main the circular scales on the eye piece.

11. Introduce the convex lens between the biprism and the eyepiece making sure that D>4f.

12. Move the lens along the optical bench till you locate two conjugate positions of the lens at which you can see real images of the double slit in the field of view of the eyepiece.

13. Without disturbing the positions of the slit, biprism and the eyepiece measure the double-slit image separations d_1 and d_2.

14. Using equations (1) and (2) calculate λ.

15. The distance between the slit and eyepiece gives D.

DIAGRAM

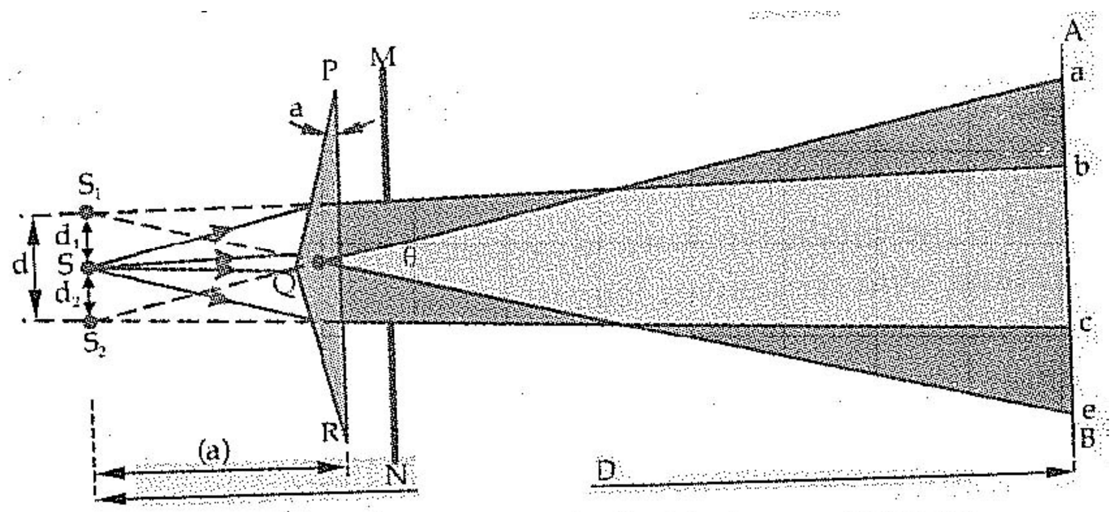
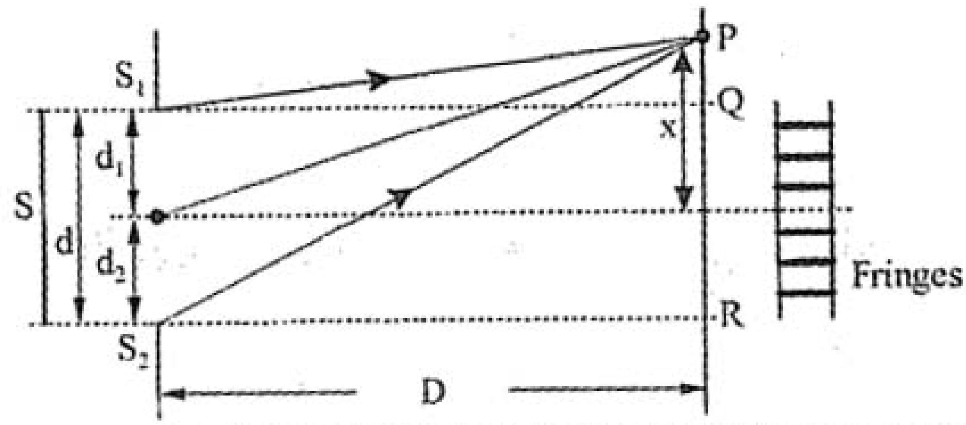


Diagram of Fresnel's biprism experiment

Fig. - 1



Fringe pattern due to interference of two waves

Fig. - 2

OBSERVATIONS

Vernier constant for the bench stand:
Least count of the micrometer screw of the eye piece: a/b = ...cm, where
a = value of one main scale division of micrometer = ...cm,
b = Total number of divisions on the circular scale = N

TABLE 1
Measurement of fringe -width β

(a) Position of the slit on the bench = ...cm.
(b) Position of the biprism on the bench = ...cm.
(c) Position of the eyepiece on the bench = ...cm.

WORK SHEET
Observation Table

Apparent distance between the slit & the eyepiece (cm)	**Direction of the eyepiece movement**	**Eye-Piece set at the fringes**	**Reading (mm) of micrometer screw**	**Width for 10 fringes W(mm)**	**Mean w (mm)**	**Meaning width** $\beta = \frac{w}{10}(mm)$
			MS. CS. TR.			
D_1	$L \to R$ $R \to L$	1 11 12 22 23 13 12 2				β_1
D_2	$L \to R$ $R \to L$	1 11 12 22 23 13 12 2				β_2

Table 2
Determination of D

Position of the slit on the bench = cm
Approximate focal length of the lens = cm
Position of the birpism on the bench = cm
Position of the eyepiece on the bench = cm

No. of Observation	Position of eye lens	Direction of eye piece movement	Readings (mm) of the micrometer screvo for Left image MS. CS. TR. (W_1)	Right image MS. CS. TR. (W_2)	Distance between the images =(W_1-W_2)mm	d_1&d_2 in (mm)	$d = \sqrt{d_1} d_2$
1	$L \to R$ $R \to L$ $L \to R$ $R \to L$					d_1=	
1	$L \to R$ $R \to L$ $L \to R$ $R \to L$					d_2=	
2	$L \to R$ $R \to L$ $L \to R$ $R \to L$					d_1=	
2	$L \to R$ $R \to L$ $L \to R$ $R \to L$					d_2=	

Table 3
Determination of wavelength

Fringe width β (cm) from table-1	Distance (cm) (from table -2)	Apparent distance D (cm) (from table-1)	$\lambda = \frac{\beta d}{d} A^0$

CALCULATION

d_1 = ...cm d_2 = ...cm

then $d = \sqrt{d_1 d_2}$ = ...cm

also D = ... cm, β = ... cm

then $\lambda = \frac{\beta d}{D}$

=.........cm

= .... $\overset{0}{A}$

RESULT

Standard value of wavelength for sodium light

$$\lambda = 5893 \overset{0}{A}$$

The wavelength of sodium light as observed by Fresnel biprism experiment

$$\lambda = ...\overset{0}{A}$$

$$\text{Percentage Error} = \frac{\text{Observed value - Standard Value}}{\text{Standard Value}} X\ 100$$

SOURCES OF ERROR

(i) The slit, biprism and the eyepiece may vary in height.
(ii) The slit may be wide and not accurately vertical.
(iii) The adjustment of the cross wire may not be in the centre of their bright fringe.
(iv) Micrometer screw may not be rotated in a single direction crating back cash error.

CONCLUSION

PRECAUTION

QUESTIONS

1. What is the SI unit of wavelength ? How is related to Angstrom?

2. What is meant by interference of light?

3. Is there any loss of energy in interference phenomenon?

4. Should interfering waves be of equal amplitude?

5. What do you mean by coherent sources?

6. Why is it necessary that the two sources must be coherent?

7. How are coherent sources obtained?

8. In the Fresnel biprism experiment, how are two coherent sources realized?

9. If, instead of a monochromatic light, white light is used in Fresnel biprism experiment, what will you see in the fringe system?

10. What type of fringes are produced in this experiment?

Prof./Assistant Prof. **Sig. of Teacher**

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EXPERIMENT NO. 2

NEWTON'S RING METHOD

AIM

To determine the wavelength of sodium light by newton's ring method.

APPARATUS USED

An optical arrangement for newton's ring with a plano-convex lens of large radius of curvature (nearly 100 cm) and an optically plane glass plate, A short focus convex lens, sodium light source, Travelling microscope, magnifying lens, reading lamp and a spherometer.

PRINCIPLE

When a plano-convex lens of large radius of curvature is placed with its convex surface in contact with a plane glass plane P, a thin wedge shaped film of air is enclosed between the two. The thickness of the point of contact is zero and gradually increases as we proceed away from the point of contact towards the periphery of the lens. The air film thus possesses a radial symmetry about of contact. The curves of equal thickness of the film will, therefore, be concentric circles with point of contact as the center.

FORMULA USED

The wavelength λ of the sodium light employed for Newton's rings experiment is given by:

$$\lambda = (D^2_{n+m} - D^2_n) / 4mR$$

where 'D_{n+m}' and 'D_n' are the diameter of $(n+m)^{th}$ and n^{th} bright rings respectively in cm^2, m being an integer number. 'R' is the radius of curvature of the convex surface of the plano-convex lens in cm.

PROCEDURE

1. Level the travelling microscope table and set the microscope tube in a vertical position. Find the vernier constant of the horizontal scale of the travelling microscope.
2. Clean the surface of the glass plate P, the lens L and the glass plate G. Place those in position as shown in figure 1. Place the arrangement in front of a sodium lamp so that the height of the center of the glass plate G is the same as that of the center of the sodium lamp. Place the sodium lamp in a wooden box having a hole such that the light coming out from the hole in the wooden may fall on the Newton's ring apparatus and adjust the lens L1 in between of the hole in wooden box and Newton's ring apparatus and adjust the lens L1 position such that a parallel beam of monochromatic sodium lamp light is made to fall on the glass plate G at an angle of 45°.
3. Adjust the position of the travelling microscope so that it lays vertically above the center of lens L. Focus the microscope so that alternate dark and brightly rings are clearly visible.
4. Adjust the position of the travelling microscope till the point of intersection of the cross wires (attached in the microscope eyepiece) coincides with the center of the ring system and one of the cross wires is perpendicular to the horizontal scale of microscope.
5. Slide the microscope to the left till the cross wire lies tangentially at the center of the 10th dark ring (figure 2) Note the reading on the vernier scale of the microscope. Slide the micro scope backward with the help of the slow motion screw and note that the readings when the cross wire lies tangentially at the center of the 10^{th}, 8^{h}, 6^{h}, $4^{h}$and 2^{th} dark ring respectively.

6. Keep on sliding the microscope to the right and note the reading when the cross wire again lays tangentially at the center of the 2^{th}, 4^{h}, 6^{h}, 8^{h} and 10^{h} dark rings respectively.
7. Remove the plano-convex lens L and find the radius of curvature of the surface of the lens in contact with the glass plate P accurately using a spherometer. The formula to be used is: $R = (l^2 / 6h) + h/2$
   Where l is the mean distance between the two legs of the spherometer, h is the maximum height of the convex surface of the lens from the plan surface.
8. Find the diameter of the each ring from the difference of the observations taken on the left and right side of its center. Plot a graph between the number of the ring on X-axis and the square of the corresponding ring diameter on Y-axis. It should be a straight line as given by equation. Tke any two points on this line & find the corresponding values of $(D^2_{n+m} - D^2_n)$ & m for them.
9. Finally calculated the value of wavelength of the sodium light source using the formula.

OBSERVATIONS

A) Determination of the least count of the horizontal scale of travelling microscope

1. Value of one division of the horizontal main scale of travelling microscope .....cm.
2. Total number of divisions on the vernier scale = ... which are equal to ... divisions of main scale of the horizontal scale of the travelling microscope.
3. Value of one division of the vernier scale = ...cm.
4. Least count of the horizontal scale of the microscope (given by the value of main scale / the value of one division of vernier scale) ..... cm.

B) Table for the determination of $(D^2_{n+m} - D^2_n)$ and m

Order of the ring	Reading of the microscope						Diameter of the ring (a - b) cm.	Diameter^2 $(a-b)^2$ cm^2.	$(D^2_{n+m}-D^2_n)$ for m=2 cm²	Mean value of $(D^2_{n+m}-D^2_n)$ for m=2 cm²
	Left hand side (a) cm			Right hand side (b) cm						
	M.S	V.S.	T.R.	M.S	V.S.	T.R.				
10									$D^2_{10}-D^2_8$= ...	
8									$D^2_8-D^2_6$= ...	
6									$D^2_6-D^2_4$= ...	
4									$D^2_4-D^2_2$= ...	
2										

C) Table for the determination of R (radius of curvature of the lens L) using a sphere meter

1. Value of one main scale division or pitch of the screw = ...cm.
2. Number of divisions on the circular head = ...cm.
3. Least count of the spherometer, (i) / (ii) = ...cm.

   Mean distance between two legs of the spherometer, l = ...cm.

Sr.No.	Spherometer reading on	H(a-b)cm.	H(a-b)cm.	Mean h cm.
	Plane glass plate (a)cm.	Convex surface of lens (b)cm.		
1.				
2.				
3.				

1. The radius of curvature R of the plane convex lens is $R = [l^2/6h + h/2]$ = ...cm.
2. The wavelength λ of the sodium light is

$$\lambda = (D^2_{n+m} - D^2_n) / 4mR = \text{............cm.} = \text{............Angstrom units.}$$

(i). m = ...cm.

(ii). Mean $D^2_{n+m} - D^2_n$ = cm^2.

(iii). $\lambda = (D^2_{n+m} - D^2_n) / 4mR$ = ...A°.

(iv). Percentage error = $\{(\lambda_{st.\ value} - \lambda_{obser\ value})\}$ X 100.

CALCULATIONS (from the graph (In fig. 5)

Plot a graph taking squares of the diameters, D^2_n along the Y-axis and the number of rings along the X-axis. The curve should be a straight line. Take two points P1 and P2 on this line and find the corresponding values of $D^2_{n+m} - D^2_n$ and m from it. calculate the value of wave-length of the sodium light from these values.

RESULT

The value of the wavelength of the sodium light source as calculated.

(A). Using the observations directly = ...A°.

(B). Using the graphical calculations = ...A°.

Mean value of wavelength of sodium light = ...A°.

Standard average value of the wavelength of the sodium light 5893 A°.

$$\text{Percentage error \%} = \frac{\text{(Standard value - Observation value) X 100}}{\text{Observed value}} = ...\%$$

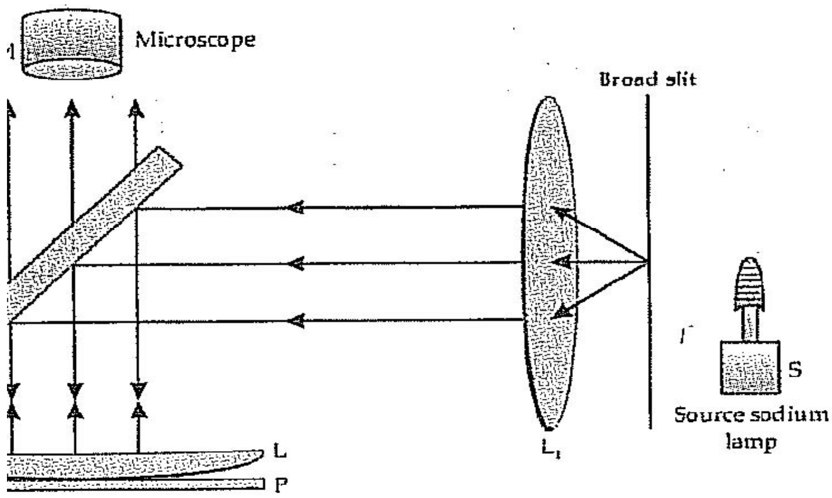
Sr.No.	Observed Quantity	Symbol	Unit	Standard Value	Standard Value	% Error
1	Wavelength of sodium light	λ	A°	5893A°	..........A°	

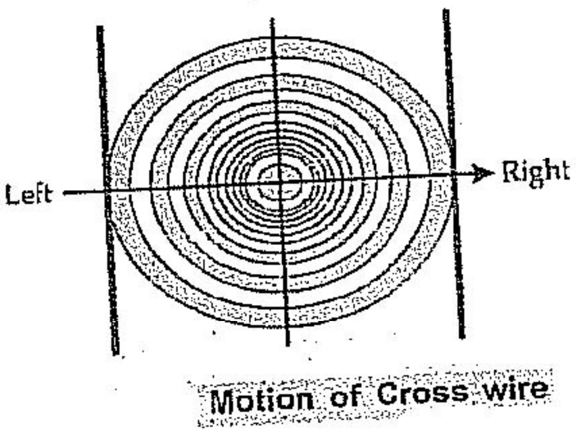
SOURCE OF ERRORS

1. The surfaces in contact may not be clean and optically plane.
2. The determination of 'h' may not be accurately done as it is a very small quantity.
3. Parallax between the cross-wire and the fringes may occur.
4. A plane convex lens of small radius night have been used.

DIAGRAM

Fig. - 1





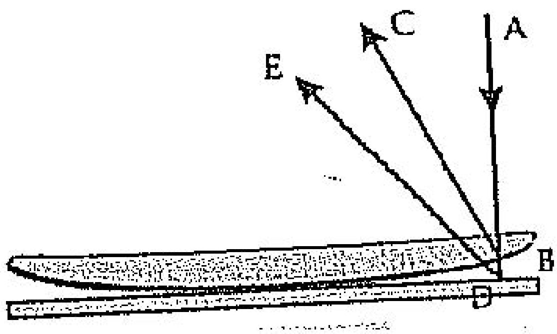


Fig. - 2

Fig. - 3

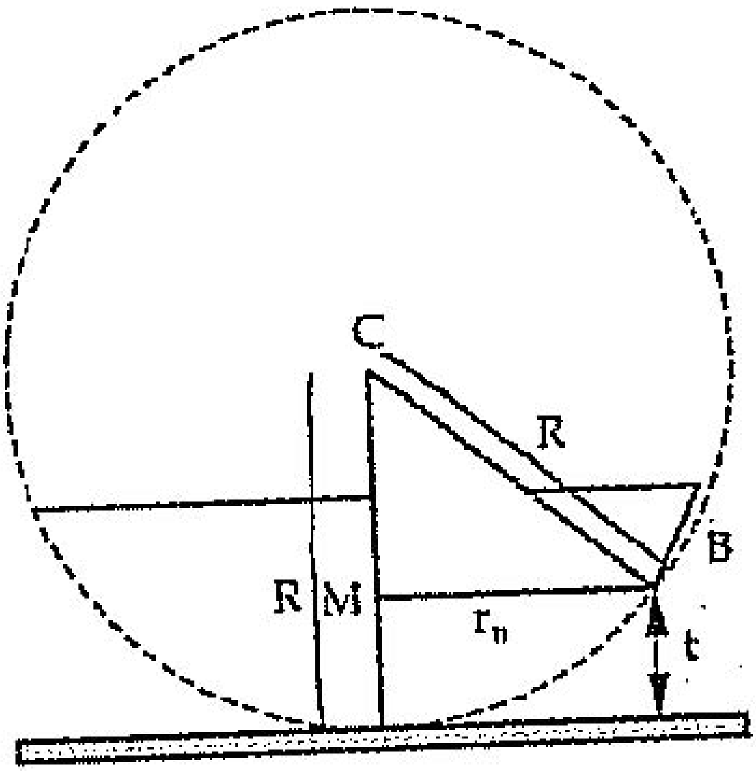

C
R
B
R
M
r_n
t

Fig. - 4

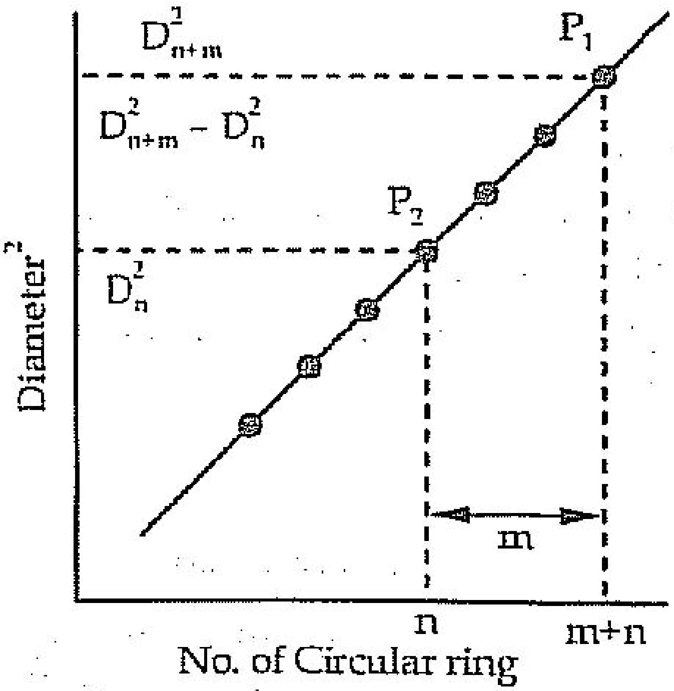

D^2_{n+m}
P_1
$D^2_{n+m} - D^2_n$
P_2
D^2_n
Diameter^2
m
n
m+n
No. of Circular ring

Fig. - 5

CONCLUSION

PRECAUTION

QUESTIONS

1. What do you understand by the interference of light?

2. What are essential conditions for obtaining interference of light?

3. What do you understand by coherent sources?

4. Why should the two sources be monochromatic?

5. Where have the fringes formed?

6. Why the Newton's are rings circular?

7. Are all rings equi spaced?

8. Why is an extended source used in this experiment?

9. How is the central spot in your experiment, bright or dark? Why?

10. Can you find out the refractive index of a liquid by this experiment?

Prof./Assistant Prof. **Principal**

EXPERIMENT NO. 3

SPECIFIC ROTATION

AIM

To determine the specific rotation of glucose solution using a polarimeter.

APPARATUS

Polarimeter, source of light : If bi quartz polarimeter use ordinary lamp / bulb; if laurents' half shade polarimeter use sodium lamp, glucose, measuring cylinder, common balance, beaker, stirrer and a weight box.

FORMULA TO BE USED

Specific rotation in case of solutions is given by

$$S = \frac{\theta}{lc}$$

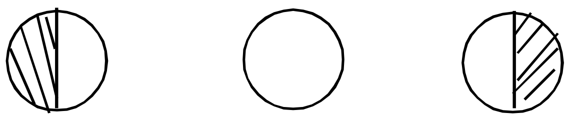
Where θ = angle of rotation in degrees

l = length of the tube in decimeters

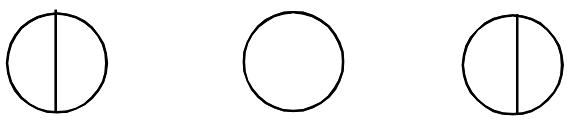
c = concentration of solution in gm / cm^3

PROCEDURE

1. Use white light source if biquartz plate polarimeter is used; and use monochromatic source of light sodium lamp if laurent's half shade device is used.
2. Determine the least count of circular scale attached to the eyepiece.
3. Fill the cleaned polarimeter tube with water and ensure that no air is enclosed in it. If air is there, bring the bubble in the centre of the tube (bubble trap) while placing the tube inside the polarimeter between the polarizer and the analyser.
4. Illuminate the polarizer by source of light and view it through eyepiece.
5. In the Laurentz half shade polarimeter the field of view has semicircular parts of un equal intensities, one half dark and other half bright. In biquartz, the two semicircular parts appear of different colours; one half pink and other half blue.
6. Rotate the position of the analyser gradually with the help of tangential screw till
   (i) In the laurentz device the semicirculars are illuminated with equal intensity
   (ii) In the biquartz device, the tint of passage appear where yellow light is quenched and blue and pink colours overlap and both halves of the field of view appear violet.
   In both cases if analyser is further rotated a bit, again the position of unequal intensities (colours of both halves) differ in order.



(a) (b) (c)



(a) (b) (c)

8. Rotate the analyser by 180^0 where a similar situation appears i.e. the analyser is again at the position of same intensity in half shade device or of same colour in biquartz device. Note the reading of the circular scale again.
9. Now prepare glucose solution by weighing 5 gm sugar in common balance and dissolving it in 100 cm^3 of distilled water kept in a measuring cylinder.
10. Using filter paper, make the solution clear.
11. Remove water from the polarimeter tube and rinse with solution them fill it prepared solution.
12. Observations are taken for this solution by following steps (3-9).
13. To make the concentration of the second solution just half of the previous one, pour 50cm^3 water in 50 cm^3 of previous solution.
14. Take observations for this solution by following steps (3-9).
15. The step 14 is repeated again and observations are taken for third solution of about one fourth concentration of the initial one.

OBSERVATIONS

A) Concentration of glucose solution

i) Initial solution

mass of watch glass = ...gm.

mass of watch glass & glucose = ...gm.

mass of glucose (m) = ... gm.

volume of solution V = 100 cm^3

Initial concentration of solution $c_1 = \frac{m}{V}$ = gm / cm^3

ii) Second solution

mass of glucose in 50 cm^3 of solution $m_2 = \frac{m}{2} = ...gm$

$\therefore$ concentration of second solution $c_2 = \frac{m_2}{V}$ = ... gm / cm^3

iii) Third Solution

mass of glucose in 50 cm^3 of second solution C3 = ...gm

$$\left(m_3 = \frac{m_2}{2} = \frac{m}{4} \right)$$

$\therefore$ concentration of third solution $C_3 = \frac{m_3}{V} = ...gm / cm^3$

B) Length of polarimeter tube = ... decimeter

C) Temperature of solution = ... ^oC

D) Lest count = ...

(E) Determination of angle of rotation.

S. No.	Reading of analyzer scale for tint of passage													Angle of rotation in degrees		
	First Position			Position after rotating by 180^0			Conc. of sugar solution	First Position			Position after rotating by 180^0					
	MSR	VSR	TR (a)	MSR	VSR	TR (b)		MSR	VSR	TR (c)	MSR	VSR	TR (d)	$\theta_1 = c - a$	$\theta_2 = d - b$	$\theta = \frac{\theta_1 + \theta_2}{2}$

CALCULATIONS

(i)

S. No.	Concentration c in (gm/cc)	Angle of rotation (θ) in (^{0})	θ / C	Mean ^{0}/gm/cc/ θ / C
1				
2				
3				

(ii) $$S = \frac{\theta}{lc}$$

(iii)

$$\% \text{ error} = \frac{\text{Standard value - observed value}}{\text{Standard value}} \times 100$$

RESULT

At .... ^{0}C, the specific rotation for sugar solution is
S = ...^{0}/dm/gm/cc

S. No.	Observed quantity	Symbol	Unit	Standard value	Observed value	% error
1.	Specific rotation	S	0/dm/gm/cc	S_1=66-0.00184(T-20)		

SOURCES OF ERRORS

1. The polarimeter tube may be not clean.
2. The glucose solution may not be clear.
3. Solution may be not pure glucose solution in distilled water.
4. There may be an air bubble in the solution filled in polarimeter tube.
5. Tube may not be properly rinsed with solution whenever solution is changed.
6. The position of equal intensity or tint of passage may not be accurately detected.
7. Position of analyser changes when it is turned through one complete revolution.

CONCLUSION

PRECAUTION

QUESTIONS

1. What is polarization?

2. What is the nature of light wave?

3. Defined plane of vibration and plane of polarization.

4. What is polarized light?

5. How does polarized light differ with unpolarized light or ordinary light?

6. Does the sound wave exhibit polarization?

7. What is plane polarized light?

8. Name the methods of producing plane polarized light?

9. What is angle of polarization?

10. What is double reflection?

Prof./Assistant Prof. **Principal**

EXPERIMENT NO. 4

AIM

To determine the wavelength of prominent spectral lines of mercury by plane diffraction grating with the help of spectrometer.

APPARATUS USED

Spectrometer, source of mercury light, plane transmission grating element, spirit level, magnifying glass, reading lamp.

FORMULA USED

The wavelength λ of a particular line in the spectrum of a source is given by:

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

where, λ is the wavelength of spectral line.

(a+b) is the grating element.

n is the order of spectrum.

θ is the angle of diffraction.

PROCEDURE

1. Adjust the spectrometer to obtain parallel light.
2. Mount the grating on the prism table normal to the axis of collimator and allow light to fall on central portion of grating.
3. Rotate the telescope to the left of direct slit image till the first spectral line in first order (n =1) spectrum is seen on the crosswire.
4. Coincide the vertical cross wire of telescope with each of the spectral line in first order (violet, green, yellow) and note the readings on both the verniers.
5. Rotate the telescope further in the same direction to obtain second order spectrum (n=2) and again adjust the vertical crosswire on each spectral line and note the readings of both the verniers.
6. Repeat the above procedure for first as well as second order spectrum in right side of direction image.
7. The difference of corresponding verniers V_1 and V_2 for the same color on both left and right gives 2θ. mean θ can be thus calculated.
8. Note the number of lines ruled per inch on the grating from its surface.

OBSERVATIONS

(A).

$$Grating\ element\,(a+b) = \frac{1\,Inch}{No.of\ lines\ per\ Inch} = \frac{2.54\,cm.}{15000} = 1.69\ X\,10^{-4}\,cm.$$

(B). Least count of vernier = Value of 1 main scale division

Total No. of division on vernier scale

= ---Degrees.

= ---Minutes.

Table for the determination of Angle of diffraction

S.No.	Spectral line	Vernier scale.	Spectrum on the						2θ = (x-y)	Mean θ
			Left side (x)			Right side (y)				
			M.S	V.S.	T.R.	M.S	V.S.	T.R.		
1. n =1	Violet	V_1 V_2								
	Green	V_1 V_2								
	Yellow	V_1 V_2								
	Red	V_1 V_2								
2. n=2	Violet	V_1 V_2								
	Green	V_1 V_2								
	Yellow	V_1 V_2								
	Red	V_1 V_2								

CALCULATIONS

(a) *Grating element* $(a+b) = \frac{2.54}{N} = \ldots\ldots\ldots\ .cm.$

(b) *For fisrt order*, $n = 1,\ a + b = \ldots\ldots\ldots\ \ldots\ldots\ cm.$

$$\lambda = (a+b)\sin\theta$$

$\theta_V = \ldots\ldots\ldots\ \ldots.,\ \lambda_V = \ldots\ldots\ldots\ .cm = \ldots\ldots\ A^0$

$\theta_G = \ldots\ldots\ldots\ \ldots,\ \lambda_G = \ldots\ldots\ldots\ .cm = \ldots\ldots\ A^0$

$\theta_Y = \ldots\ldots\ldots\ \ldots,\ \lambda_Y = \ldots\ldots\ldots\ .cm = \ldots\ldots\ A^0$

$\theta_R = \ldots\ldots\ldots\ \ldots,\ \lambda_R = \ldots\ldots\ldots\ .cm = \ldots\ldots\ A^0$

(c) *For* sec *ondorder*, $n = 2,\ a + b = \ldots\ldots\ldots\ \ldots..\ cm.$

$$\lambda = \frac{(a+b)\sin\theta}{2}$$

$\theta_V = \ldots\ldots\ldots\ \ldots.,\ \lambda_V = \ldots\ldots\ldots\ .cm = \ldots\ldots\ A^0$

$\theta_G = \ldots\ldots\ldots\ \ldots,\ \lambda_G = \ldots\ldots\ldots\ .cm = \ldots\ldots\ A^0$

$\theta_Y = \ldots\ldots\ldots\ \ldots,\ \lambda_Y = \ldots\ldots\ldots\ .cm = \ldots\ldots\ A^0$

$\theta_R = \ldots\ldots\ldots\ \ldots,\ \lambda_R = \ldots\ldots\ldots\ .cm = \ldots\ldots\ A^0$

RESULT

The wavelength of the various spectral lines of mercury light are:

<table>
<tr><th rowspan="3">Spectral line</th><th colspan="3">Wave length</th><th rowspan="3">% Error</th></tr>
<tr><th colspan="2">Experiment value</th><th rowspan="2">Standard Value</th></tr>
<tr><th>For I Order</th><th>For II Order</th></tr>
<tr><td>Violet</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Green</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Yellow</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Red</td><td></td><td></td><td></td><td></td></tr>
</table>

DIAGRAM

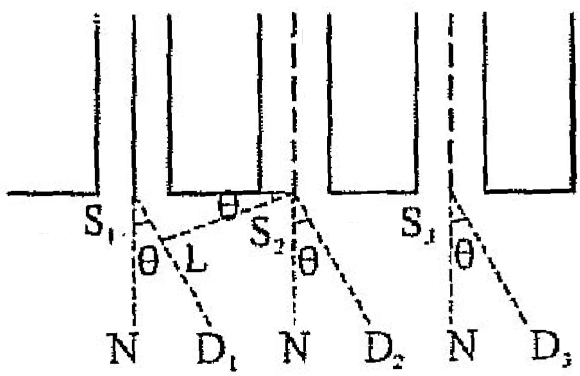


Fig. - 1

Diffraction due to multislits.

Fig. - 2

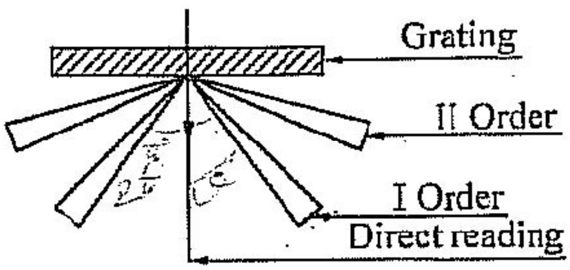


Fig. - 3

Diffraction pattern due to single slit

SOURCE OF ERROR

1. The slit must be narrow.
2. Readings of both verniers V1& V2 must be carefully taken.
3. The grating surface should be clean.
4. Hold the grating from the edges always.

CONCLUSION

PRECAUTION

QUESTIONS

1. What is diffraction?

2. What is difference between interference and diffraction?

3. What is plane transmission grating?

4. What is plane reflection grating?

5. What is grating element?

6. How many lines are ruled on grating?

7. What are the corresponding points on the grating?

8. Why do you adjust the grating normal to the incident light?

9. What happens if ruled surface faces the collimator?

10. How many orders can be obtained with the help of grating?

Prof./Assistant Prof. **Principal**

EXPERIMENT NO. 5

GALVANOMETER INTO AMMETER

AIM

To convert a given galvanometer into ammeter of desired ranges and to calibrate it.

APPARATUS USED

Galvanometer, ammeter, connection wires, shunt resistance, key.

WORKING PRINCIPLE

A galvanometer can be converted into ammeter by connecting a low resistance (shunt) wire parallel to it. Let the resistance of the galvanometers G and current required to produce full scale deflection in it be I_g. When a shunt resistance S is connected in parallel to the given galvanometer for conversion into ammeter of range I amperes, then I_g will flow in galvanometer and current $(I-I_g)$ flows through the shunt resistance as shown in figure 2 Applying KVL we have

$$(l-l_g)s = l_g G$$

$$s = \frac{l_g G}{(l-l_g)}$$

FORMULA USED

To convert a galvanometer into a ammeter of desired ranges, the resistance to be connected in parallel to it is given by. S = $I_g G / (I-I_g)$

Where, S = shunt resistance in ohms

G = Resistance of galvanometer in Ohms.

I_g = Current for full scale deflection in galvanometer in mA.

I = Desired range of ammeter in mA.

PROCEDURE

Determination of Galvanometer Resistance (G) and the value of i_g:

1. Take the circuit connection of figure in order to determine the resistance of the galvanometer by half deflection method.
2. Introduce some high resistance Rh in the high resistance box H.R.B. Close key K_1 and observe deflection in the galvanometer. If the deflection goes out of scale bring it within the scale by increasing the value of R_h. Adjust the deflection for even number of divisions on the scale. In this adjustment the key K2 should remain open.
3. Now close key K_2. Increase the value of R in low resistance box. Adjust the value of R such that the deflection in galvanometer becomes half of its previous value.
4. This value of R is equal to the galvanometer resistance i.e G = R.
5. Now change the value of deflection θ in the galvanometer by changing the value of R_h. For each value of R_h adjust the value of R for half deflection in the galvanometer. In this way take about five sets of readings.
6. Determine the value of G from each set and determine mean G.
7. Note that number of divisions on the galvanometer scale on one side of the zero.
8. Calculate the value of i_g for each set from its formula, and determine mean i_g.

Determination of Shunt Resistance (S) and its desired Length (l):

1. Determine the value of shunt resistance (S) using the value of galvanometer resistance

(G), i_g and the given range of ammeter. $S = \frac{\rho l}{\pi r^2}$

2. Generally the connecting copper wire is taken for shunt in the laboratory because of its low resistance. Its specific resistance and gauge (radius) are easily available in the laboratory. The radius of shunt wire can alternatively be determined with the help of screw gauge.
3. Knowing the values of radius of shunt wire and its resistivity, the desired length of shunt wire can be calculated using $l = \frac{\pi r^2 S}{\rho}$ =.....Ohm

Calibration of converted Ammeter:

1. Take the shunt wire of desired length and connect it across the terminals of the galvanometer. By doing so, the galvanometer is converted into an ammeter of range i.
2. Make circuit as shown in figure in order to calibrate the converted ammeter.
3. Close key K. Adjust the Rheostat R_h to get some current in the circuit. Note this value of current in the ammeter A. Simultaneously note the deflection of the converted ammeter in number of divisions.
4. Now change the position of the rheostat and again note the readings of the ammeter and the converted ammeter. In this way take sufficient number of the readings up to the full range of the ammeter.
5. If the reading of ammeter for a particular value of current in the circuit is i' and the number of divisions in the converted ammeter is n for the same value of current, then the value of current in the converted ammeter will be i'' = (n/N)i Amp.
6. Determine the difference of i'' and i' for various readings taken. The difference will be the error in the reading of the converted ammeter.
7. The graph plotted between i' and the error (i'' - i') will be calibration graph.

OBSERVATIONS

A) To determine the galvanometer resistance (G), current for full scale deflection in the galvanometer (ig) and shunt resistance (S):
   i) No. of divisions on the galvanometer scale N = ...
   ii) E.M.F. of the battery = ...volt.

S.No.	High Resistance R_h (Ohm)	Deflec tion in Galvanometer θ = n divisions	Resistance for half deflection R= G (Ohm)	Mean (Ohm)	$l = \frac{\pi r^2 S}{\rho}$ =.....Ohm	Mean $i_{g(}$ ampere
1						
2						
3						
4						
5						

(B) To determine the radius of wire (r) and its desired length (l):
   (i) Specific resistance of the material of wire (ρ) = ... Ω-cm.
   (ii) Measurement of the material of wire
      Pitch of the screw gauge = ... cm.
      Lest count of screw gauge = ... cm.

S.No.	Diameter in one direction (cm)	Diameter in perpendicular direction (cm)	Mean Diameter (cm)	Mean
1				
2				
3				
4				
5				
6				

(C) Calibration of the converted ammeter

S.No.	Ammeter reading i' (Amp)	No. of divisions deflection on galvanometer scale (n)	Current measured by converted ammeter i'' = (n/N)i Amp.	Error = (i"-i') (cm)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

CALCULATIONS

Range of converted galvanometer as ammeter (i) = ...Amp.
Resistance of galvanometer = ...Ohm.

(i) $I_g = \left(\frac{E}{R_h + G}\right)\left(\frac{N}{n}\right) Amp = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Amp$.

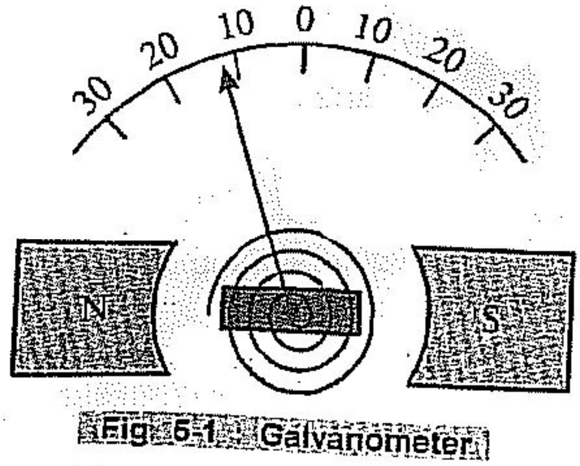
(ii) Shunt resistance $S = \frac{i_g G}{(i - i_g)}. = \ldots\ldots\ldots\ldots\ldots Ohm.$

(iii). Desired length of shunt wire $l = \frac{S\pi r^2}{\rho} = \ldots\ldots\ldots\ldots m$.

RESULT

(i) The resistance of given galvanometer G = ...ohm.
(ii) The given galvanometers converted into ammeter of range i = ...Amp. by connecting a shunt of resistance S = ...ohm whose desired length *l* = ...cm.
(iii) The calibration graph drawn between i' and error (i' - i') is obtained as shown in the attached graph paper

DIAGRAM



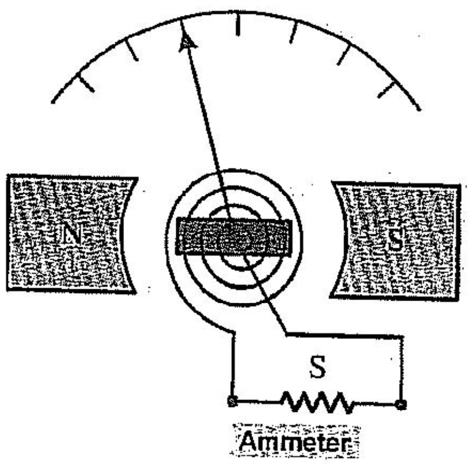
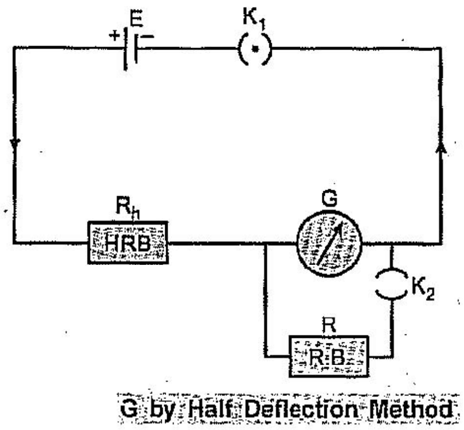


Fig. - 1

Fig. - 2



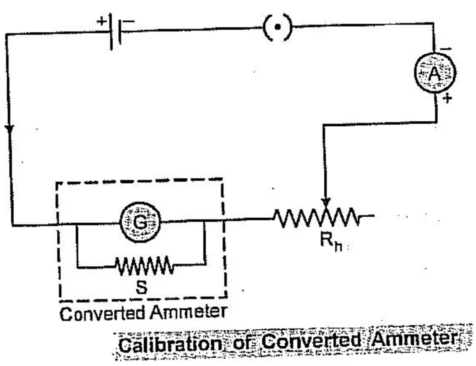


Fig. - 3

Fig. - 4

CONCLUSION

PRECAUTION

QUESTIONS

1. What is galvanometer?

2. What is an ammeter?

3. How can you convert a galvanometer into ammeter?

4. What is a shunt?

5. Can the range of an ammeter be changed?

6. How is ammeter changed into millimeter or micrometer?

7. How many types of galvanometer do you know?

8. What is the use of iron core in weston galvanometer?

9. By what methods the resistance of galvanometer be measured?

10. What do you mean by the current sensitivity of a galvanometer?

Prof./Assistant Prof. **Principal**

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EXPERIMENT NO. 6

GALVANOMETER INTO VOLTMETER

AIM

To convert a given galvanometer into voltmeter of desired ranges and to calibrate it.

APPARATUS USED

Galvanometer, voltmeter, Resistance box, Key, Battery, Connection wires.

WORKING PRINCIPLE

A galvanometer can be converted into voltmeter by connecting a high resistance wire in series with it.

Let the resistance of the galvanometer be G and current required to produce full scale deflection in it be I_g. When a high resistance R is connected in series with the given galvanometer for conversion into voltmeter of range V volts, then on applying a potential deference of V volts across (R+G) resistance the current I_g flows through the galvanometer for full scale deflection.

Thus:

$$V = I_g (R+G)$$
$$R = (V / I_g) - G$$

Using this formula the value of high resistance R can be calculated.

FORMULA USED

To convert a galvanometer into voltmeter of desired ranges, the resistance to be connected in series to it is given by.

$$R = (V / I_g) - G$$

Where, R = Series resistance to convert galvanometer into voltmeter in ohms

G = Resistance of galvanometer in Ohms.

I_g = Current for full deflection in galvanometer in mA.

V = Desired range of voltmeter in volts.

PROCEDURE

Determination of High Resistance R to be connected in series with galvanometer:

1. Introduction the calculated value of R in a high resistance box. Connect this resistance in series with the given galvanometer. On doing so, it gets converted into voltmeter of range V volt. If there are *N* divisions on the galvanometer scale, then each division will read (*V/N)* volt.
2. Make connections according to the circuit shown in figure in order to calibrate the converted voltmeter. Connect an accumulator of e.m.f., a key K and rheostat R_h in series. Now connect the converted galvanometer and a voltmeter of same range in parallel to $R_{H.}$
3. Close key K and adjust the rheostat for getting full scale deflection in the galvanometer. Simultaneously note the reading of the voltmeter. This reading should be equal to range of the converted volumeter.
4. Now go on changing the position of the rheostat and note for each position the voltmeter reading and the corresponding number of division deflection in the galvanometer. If the deflection in the galvanometer is n divisions, then the potential difference measured by it will be V'' = (V' /N)n. Also note simultaneously the corresponding voltmeter reading V'.
5. Determine the difference of V'' and V' for each reading.
6. Presuming the voltmeter reading to be correct, plot a graph between the error (V'' - V') and the voltmeter reading V'. This will be the calibration graph of converted voltmeter.

OBSERVATIONS

[A] To determine the galvanometer resistance (G) and the value of i_g:

(i) Total no. of divisions on the galvanometer scale N = ...

(ii) EMF of the battery E = ...volt.

Sr.No.	High Resistance R_h (ohm) R (ohm)	Deflection in galvanometer θ = n divisions	Resistance For half Deflection R = G (ohm)	Mean G (ohm)	$i_g = \left(\frac{E}{R-G}\right)\left(\frac{N}{n}\right)$	Mean i_g (Amp.)
1.						
2.						
3.						
4.						
5.						

[B] To determine the converted voltmeter.

Total number of divisions on the galvanometer scale N = ...

Sr.No.	Reading of voltmeter V' (volts)	Galvanometer reading n divisions	Reading of converted galvanometer V'' = (Vn/N) volts	Error =(V'' - V') Amp.
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

CALCULATIONS

The value of G by half-deflection method = ...ohm.

(i) $i_g = [\, E/\,(R_{\alpha} + G)\,(N/n)]$ = ...Amp

(ii) High resistance required for conversion

$R = (V/i_g) - G$........ohm.

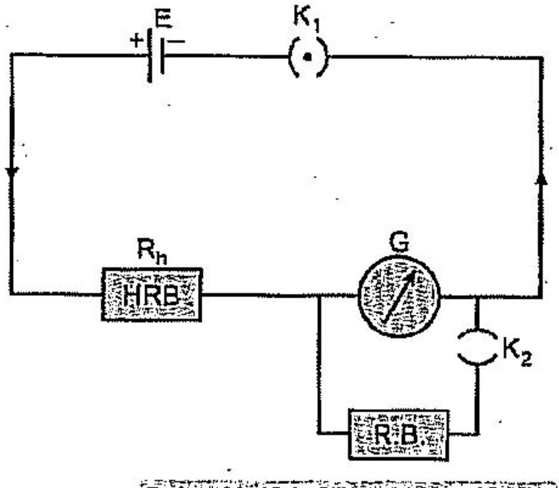
RESULT

(i) The value of high resistance R required to be connected in series with the galvanometer in order to convert it into volt meter of range V = ...ohm.

(ii) The graph plotted between voltmeter reading V and the error (V'' - V') is obtained as shown in the graph.

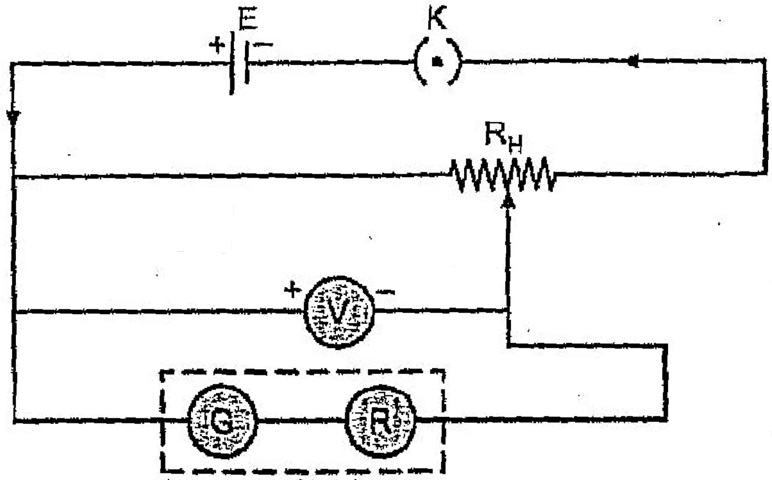
DIAGRAM

Fig. - 1

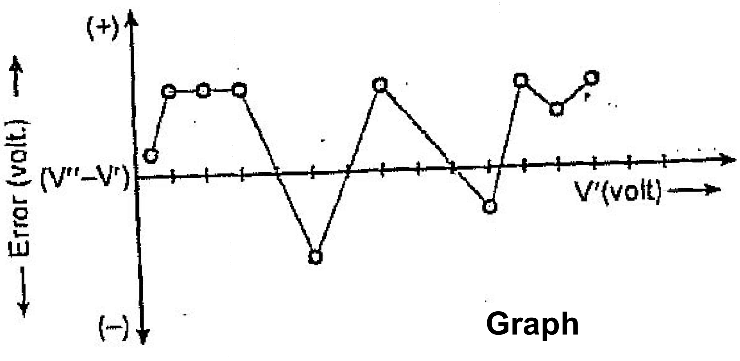


G by Half Deflection Method

Fig. - 2



Converted Voltmeter



Graph

CONCLUSION

PRECAUTION

QUESTIONS

1. What is voltmeter?

2. What is resistance of ideal voltmeter?

3. How can you convert a galvanometer into voltmeter?

4. If there any Instrument which acts as an Ideal voltmeter?

5. Why is a voltmeter always connected in parallel in an electric circuit?

6. How is range of voltmeter changed?

7. What will happen if the voltmeter is connected to any circuit in series?

8. What is milli voltmeter?

9. How you can change a voltmeter into milli voltmeter?

10. How can you decrease the resistance of voltmeter?

Prof./Assistant Prof. **Principal**

EXPERIMENT NO. 7
BAND GAP IN A SEMICONDUCTOR

AIM

To determine the band gap in a semiconductor using a PN-junction diode.

APPARATUS USED

PN junction diode, micro ammeter (0-50 μ A), battery of 12 volts, thermometer, oven or calorimeter with stirrer and heater, CCl_4

PROCEDURE

1. The electrical connections are made as shown in the diagram Fig. Connect positive terminal of the battery to N and negative terminal to P' terminal of the diode for reverse bias.

2. Liquid Carbon Tetrachloride CCl_4 is heated in a calorimeter upto 60-70^{0}C for Ge diode or 110^0 for Si.

3. Calorimeter is placed in the wooden box, now thermometer and diode are put in the heated CCl_4 such that the bulb of the thermometer is in contact with the diode.

4. The liquid is stirred continuously so that temperature remains uniform.

5. When the temperature becomes steady, note the temperature for various values of current as the diode cools down by every 5 degrees till room temperature.

6. A graph is plotted between (10^3/T) along X-axis and $\log_{10}$ I along Y-axis and the slope of the line is determined from the graph.

OBSERVATION TABLE

S. No.	Current I_S (μ A)	Temperature of diode T		10^3/T	$\log_{10} I_S$
		in °C	in K		
1					
2					
3					
4					
5					
6					
7					
8					
10					

CALCULATIONS

From the graph

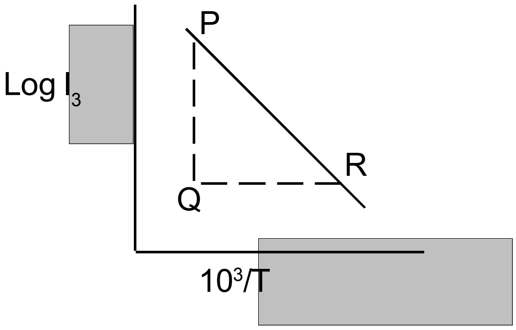


Fig. 1 - Graph between $\log_{10} I_S$ and $10^2/T$

Observed quantity	Symbol	Unit	Observed value	Standard Value	% error
Band gap of P.N. diode		eV	....		

Slope = $\frac{PQ}{QR}$

$\therefore$ Energy gap $\Delta E_g = 0.198 \frac{PQ}{QP}$

=..........................eV

$$\text{Percentage error} = \left(\frac{\text{Standard value - observed Value}}{\text{Standard Value}} X\,100 \right)$$

RESULT

The energy band gap for a given semiconductor

=........................ eV

Standard value for Germanium = 0.72 eV

Standard value of Silicon = 1.10 eV

Observed quantity	Symbol	Unit	Observed value	Standard Value	% error
Band gap of P.N. Junction diode	ΔE_g	eV			

SOURCE OF ERRORS

1. Diode may not be reversed biased.
2. Temperature of CCl_4 is not uniform as regular stirring may have not been done.
3. Reverse bias voltage is nearly equal to the turn over voltage of the diode.
4. The cooling may be rapid.

CONCLUSION

PRECAUTION

QUESTIONS

1. What are energy bands in solids?

2. Which energy bands in solids are important?

3. What are semiconductors?

4. What is forbidden energy gap?

5. Which type of material has the forbidden energy maximum?

6. What are holes?

7. What are the charge carries in semiconductors?

8. What are intrinsic and extrinsic semiconductors?

9. What are majority and minority charge carries in semiconductors?

10. What is PN junction diode?

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EXPERIMENT NO. 8
VARIATION OF THERMO E.M.F.

AIM

To study the variation of thermo e.m.f. of Iron-Copper thermocouple with temperature by potentiometer.

REQUIRED APPARATUS

A potentiometer, standard cell (Daniel cell), a battery, high, resistance box (RB), rheostat, a sensitive galvanometer, a one-way key, two way key, thermometer, ice bath, water pot (or sand bath), a thermocouple and P.O. Box.

FORMULA USED

The thermo-e.m.f. Developed in the thermocouple due to temperature difference T is given by

$$e = \frac{E_0 \rho l}{R}$$

Where E_0 = e.m.f. of a standard cell in volts

R = Resistance taken out from resistance box (R.B.) Across which the e.m.f. of the standard cells balanced in ohms.

ρ = Resistance per unit length of the potentiometer wire tin ohms / meter.

l = Balancing length on the potentiometer wire across which the thermo-e.m.f. is balanced in meter.

PROCEDURE

1. Make the electrical connections as shown the circuit figure-2.

2. Close key k1 and (i) of key k2. For accurate measurement the potential gradient should be as small as possible but at the same time potential drop across the wire should be greater than the thermo emf. to be measured. Since thermo emf. is of the order of 2 to 3 mV in the temperature range between 0^0C and 100^0C it is convenient to set a potential difference of 5 mV across the wire. Therefore for standardization of potentiometer insert a resistance of 1k ohms in the resistance box R_1 and adjust the resistance in the rheostat so that there is no deflection in the galvanometer.

3. Open (i) and close (ii) of key k_2 so that thermocouple is in the circuit.

4. Heat the water in the copper pot to about 90^0C and immerse the junction 1 of the thermo couple in it.

5. Determine the null point on the potentiometer wire and note the length of wire from the point A to the null point and the temperature of the hot junction.

6. Take similar observations of null point length and corresponding temperature of the hot junction at intervals of about 5^0C.

7. Calculate thermo emf. for all observations and plot a graph between thermo emf as ordinate and temperature of hot junction as abscissa.

OBSERVATIONS

i. E.M.F. of the standard cell (Daniel cell) = 1.08 volts.
ii. Resistance per unit length of the potentiometer wire = ... ohm / cm.
iii. Resistance R across which the emf of Daniel cell is balanced R = ... ohm.
iv. Potential gradient = (0.02). (10.8) / R .... mV /cm
v. temperature of the cold junction = ... ^{0}C.

S. No.	Temperature of the hot junction in ^{0}C	Balancing Length l of the potential wire (in cm)	Thermo emf. = $e = \frac{E_0 \rho l}{R}$ ....V/m.

CALCULATIONS

i. Potential gradient of potentiometer wire $x = \frac{E_0}{R} \rho = ...V/m$
ii. Thermo e.m.f. at a given tempt e = xl.
iii. % error = ...

RESULT

The graph between thermo emf and temperature of the hot junction is a straight line.

S. No.	Observed quaintly	Symbol	Unit	Standard value	Observed value	% error
1	Thermo emf Cu Fe thermocouple	e	mV			

SOURCE OF ERRORS

1. Connections of the potentiometer may not be tight.
2. The diameter of the potentiometer wire may not be uniform throughout the wire.
3. Resistance of wire will change if current flow through the potentiometer wire for long time as it will heat it up.
4. Contact resistance get developed at the places copper strips are soldered.
5. The battery in the main circuit is not fully charged.

DIAGRAM

Fig. - 1

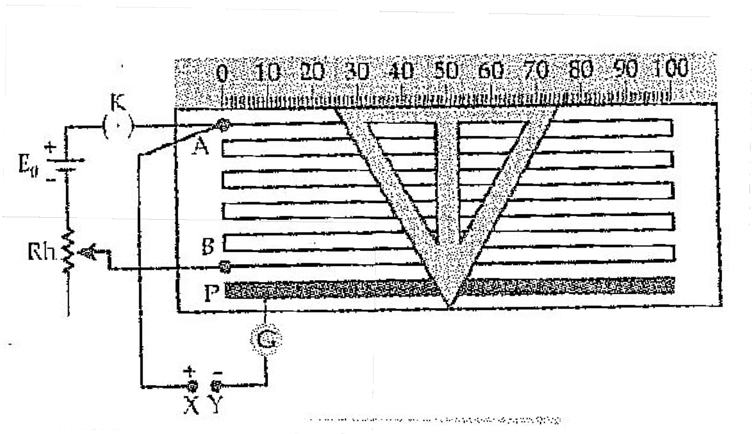


Fig. - 2

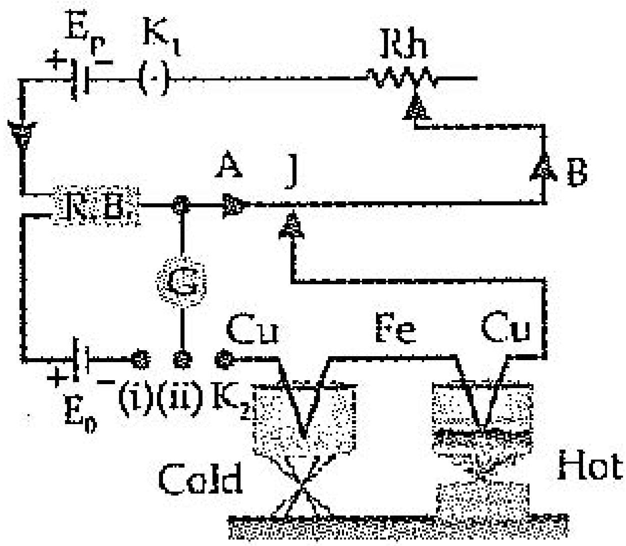
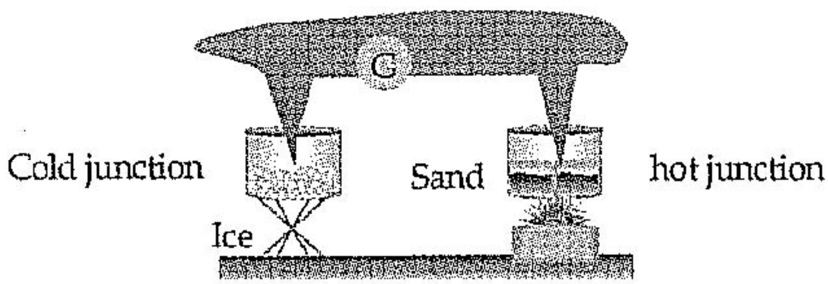


Fig. - 3



CONCLUSION

PRECAUTION

QUESTIONS

1. What is thermo e.m.f?

2. What is Setback effect?

3. What is thermocouple?

4. What is peltier effect?

5. What is Thomson effect?

6. What is thermo-e.m.f produced?

7. What is neutral temperature?

8. What is the order of magnitude of the thermo -e.m.f in a copper iron couple?

9. What do you obtained a straight line curve?

10. What is potentiometer?

Prof./Assistant Prof. **Principal**

EXPERIMENT NO. 9

COHERENT LENGTH AND COHERENT TIME

OBJECTIVE

To determine the coherent length and coherent time of a laser using He-Ne laser.

APPARATUS REQUIRED

He-Ne laser source, laser spectrometer with upright at ends: one end holds the laser source and the other to hold laser detector.

WORKING PRINCIPLE

The important feature that distinguishes laser from other sources of light 'coherence'. If the phase difference between the two fields is constant during the period of observations, the wave has temporal coherence. The average time interval during which the field remains sinusoidal i.e a definite phase, is called coherence time. The distance travelled by the wave train during coherence time is called coherence length.

If coherence time is denoted by Tc and light travel at speed c then coherent length l will be.

$$\Delta l = c\tau_c$$

$$\tau_c \text{ is reciprocal of frequency range } \Delta v, \text{ so that}$$

$$\Delta l = c / \Delta v$$

$$\text{For light waves } \lambda v = c \qquad \Rightarrow c/\lambda$$

$$\Delta v = -c\frac{\Delta\lambda}{\lambda^2}$$

$$v = c/\lambda$$

$$|\Delta v| = c\left(\frac{\Delta\lambda}{\lambda^2}\right)$$

$$\text{So that coherence length}$$

$$\Delta l = \frac{c\lambda^2}{c\Delta\lambda} = \frac{\lambda^2}{\Delta\lambda}$$

$$\text{and coherence time}, \tau_c = \frac{\lambda^2}{(\Delta\lambda)c}$$

PROCEDURE

1. Clamp the laser source on one upright and the detector on another upright, at same height.
2. Adjust the detector by slow motion screw such that digital voltmeter gives maximum reading.
3. Note the reading of the vernier scales V_1 and V_2 for this position.
4. Now move the detector on either side of this position till you obtain the first order spectrum.
5. Note the readings of this vernier scale V_1 and V_2 for which the meter gives maximum reading.
6. Repeat the procedure for higher order of spectrum on either side.
7. The difference between the two readings on either side of direct image for that order of spectrum gives double the angle of diffraction.

OBSERVATIONS

[A] Least count of the spectrometer:

(i) Value of one main scale division (x) = ...degree = ...min.

(ii) Total no. Of divisions on the vernier scale (N) = ...

(iii) Least count = x/N = ...degree = ...min.

[B] Grating element (a+b):

(i) No. of lines per Inch on grating (N) = ...per Inch.

(ii) Grating element = (1/N) =............................cm per line.

[C] Angle of diffraction:

Order of Spectrum	Vernier Scale	Reading of direct Image			Spectrum on the right side (B) left side (C) of direct Image						$2\theta = \frac{(B-A)+(C-A)^\circ}{2}$	θ°	Mean θ°
		MS	VS	TR°	MS	VS	TR°	MS	VS	TR°			

CALCULATION

$$(i)\quad \lambda = \frac{(a+b)Sin\theta}{n} = \frac{Sin\theta}{nN} = ...A^\circ.$$

For $n = 1,2$ *with corresponding* θ.

$$i.e.\quad \lambda_1 = \frac{Sin\theta_1}{N} = ...A^\circ$$

$$\lambda_2 = \frac{Sin\theta_2}{2N} = ...A^\circ$$

(ii) *Coherent length*

$$\Delta l = \frac{\lambda_1^2}{\lambda_1 - \lambda_2} = ...A^\circ$$

(iii) *Coherent time*

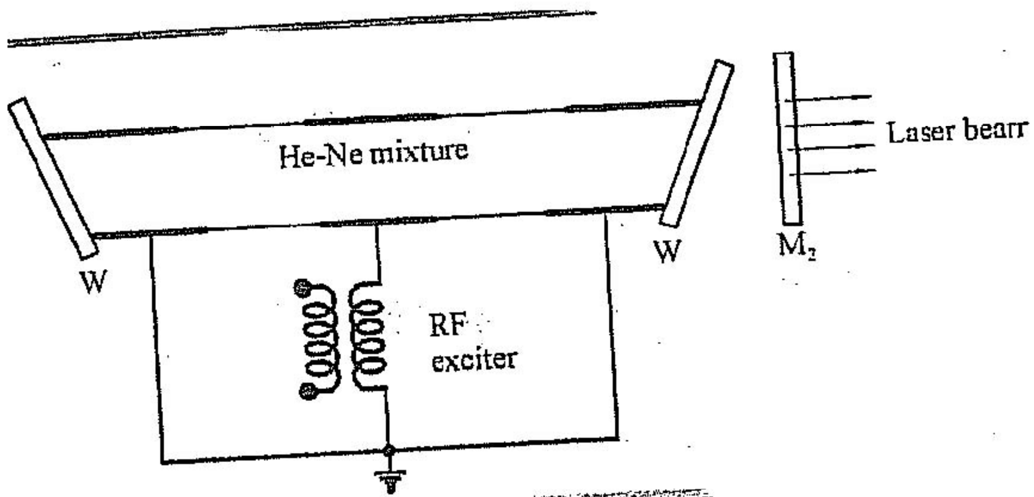
$$\tau_c = \frac{\Delta l}{c} = ...\text{sec}.$$

RESULT

The observed coherent length Δl = ...A° and coherent time (τ)sec for the given source of laser light of wavelength ....A°.

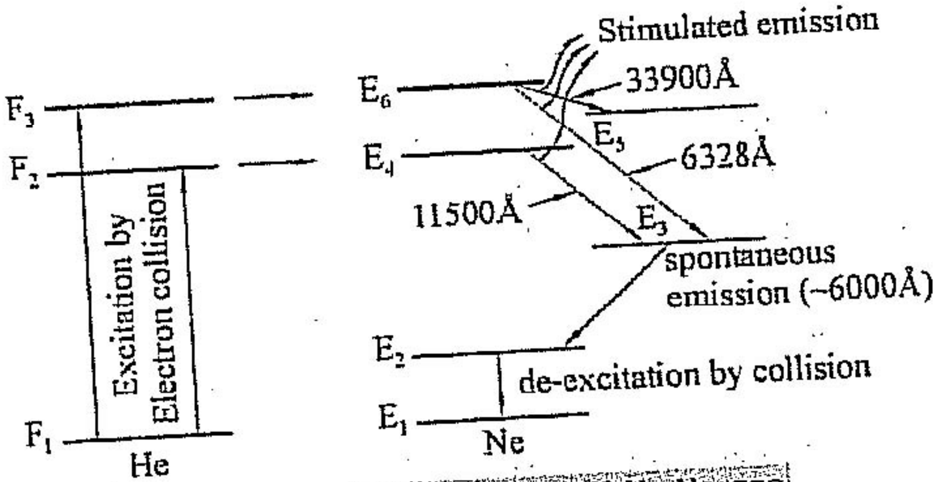
S.No. Error	Observed Quantity	Symbol	Unit	Standard Value	%
1.	Wavelength of given source	λ	A°		
2.	Coherent length	Δl	A°		
3.	Coherent length	τ_c	A°		

DIAGRAM



He-Ne Gas Laser

Fig. - 1



Energy levels of He-Ne gas

Fig. - 2

CONCLUSION

PRECAUTION

QUESTIONS

1. What are the characteristics of laser source?

2. Which type of laser source are you using?

3. What do you means by coherence?

4. What is solid angle?

5. What do you understand by monochromaticity?

6. Why are laser highly coherent?

7. What do you understand by directionality?

8. What is difference between ordinary light and laser in terms of intensity?

9. What are the conditions for LASER production?

10. What is population inversion?

Prof./Assistant Prof. **Principal**